DWLBC REPORT

Review of South Australian State agency water monitoring activities in the Eastern Mount Lofty Ranges

2005/44

Government of South Australia
Department of Water, Land and Biodiversity Conservation

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Rehanna Kawalec and Sally Roberts

Knowledge and Information Division
Department of Water, Land and Biodiversity Conservation

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Knowledge and Information Division
Department of Water, Land and Biodiversity Conservation
25 Grenfell Street, Adelaide
GPO Box 2834, Adelaide SA 5001
Telephone National (08) 8463 6946
International +61 8 8463 6946
Fax National (08) 8463 6999
International +61 8 8463 6999
Website www.dwlbc.sa.gov.au

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FOREWORD

South Australia's unique and precious natural resources are fundamental to the economic and social wellbeing of the State. It is critical that these resources are managed in a sustainable manner to safeguard them both for current users and for future generations.

The Department of Water, Land and Biodiversity Conservation (DWLBC) strives to ensure that our natural resources are managed so that they are available for all users, including the environment.

In order for us to best manage these natural resources it is imperative that we have a sound knowledge of their condition and how they are likely to respond to management changes. DWLBC scientific and technical staff continues to improve this knowledge through undertaking investigations, technical reviews and resource modelling.

Rob Freeman
CHIEF EXECUTIVE
DEPARTMENT OF WATER, LAND AND BIODIVERSITY CONSERVATION

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River Murray Catchment Water Management Board

Kerri Muller	Senior Project Officer
Lyz Risby	Project Officer
Mardi van der Wielen	Project Officer
Mellissa Bradley	Catchment Development Manager

Editors

Rehanna Kawalec	Executive Officer, Catchment Management Subsidy Scheme, DWLBC
Gosia Natura	Technical Report Editor, Knowledge and Information Division, DWLBC

Major Contributors

Sally Roberts	Project Officer, Knowledge and Information Division, DWLBC
Kumar Savadamuthu	Senior Surface Water Hydrologist, Major Investigations, DWLBC
Steve Barnett	Principal Hydrogeologist, Strategy and Planning, DWLBC
Nick Souter	Senior Ecologist, Major Investigations, DWLBC
Dr Patrick O'Connor	O'Connor NRM
Chris Roberts	GIS Officer, Knowledge and Information Division, DWLBC
Judy Tan	GIS Officer, Knowledge and Information Division, DWLBC
Dragana Zulfic	Hydrogeologist, Major Investigations, DWLBC
David Duncan	Principal Advisor, Water Quality, EPA
Linton Johnson	Engineering Hydrologist, Hydrology, Bureau of Meteorology

Special thanks

Neil Power	Manager, Strategy and Planning, DWLBC
Caroline Michalski	Manager, NRM Integration, Knowledge and Information Division, DWLBC

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PREFACE

This report was written during 2005 and provides a useful record of water monitoring activities in the Eastern Mount Lofty Ranges at the time of writing.

The implementation of the South Australian Natural Resources Management Act 2004 and the subsequent publication of the South Australian Natural Resources Management Plan 2006 (NRM Plan) have resulted in fundamental changes in the frameworks for Monitoring and Evaluation in South Australia. This in turn has meant that the roles, responsibilities and constitution of State and regional agencies and organisations may have changed over time and these changes may not be fully reflected within this publication.

The findings of this report do not imply any commitment or obligation on any agency.

EXECUTIVE SUMMARY

Water resources in the Eastern Mount Lofty Ranges (EMLR) are managed to provide water for domestic, agricultural, horticultural, and industrial use while providing for the environmental requirements of water dependent ecosystems. This monitoring review is based on a desktop review of the current situation and seeks to stimulate discussion on the roles of State and regional agencies at a particular point in time. The review was conducted by the Department of Water, Land and Biodiversity Conservation (DWLBC) in partnership with the River Murray Catchment Water Management Board (RMCWMB).

The review covers information on the six themes of water resource data: surface water quantity, surface water quality, groundwater quantity, groundwater quality, aquatic ecosystems and catchment characteristics. These are convenient thematic divisions of the total resource for monitoring and fit the current division of responsibilities between agencies. However, one of the Goals of the South Australian Government's State Natural Resources Management Plan, 2006 (SA NRM Plan) is for:

> *"Communities, governments and industries with the capability, commitment and connections to manage natural resources in an integrated way".*

Monitoring, evaluation and reporting of water resources in the Eastern Mount Lofty Ranges is currently fragmented both within, and between Government agencies and community-based organisations. There is no coordinated plan for an integrated monitoring strategy and limited communication or exchange of data exists between the main monitoring networks.

Monitoring of a variety of aspects of water resources, including surface and groundwater quantity and quality, aquatic ecosystems, all occur in the Eastern Mount Lofty Ranges but to varying spatial and temporal scales, and with varying frequencies.

State and regional agreement is required to ensure that water monitoring programs:

1. Fulfill the basic requirements of the National Monitoring and Evaluation Framework and National Water initiative.
2. Meet the needs of the National Land and Water Resource Audit (NLWRA) and for Natural Heritage Trust (NHT) funded programs.
3. Comply with the State Monitoring and Evaluation Framework for Natural Resources Management.
4. Satisfy the requirements for regional resource conditions assessment and management.
5. Satisfy requirements of the State Environment Protection Act (1993).

The findings of this report are intended to guide the development of future monitoring programs to a greater level of integration and efficiency. However, no onus is allocated for implementation of the proposed actions, as these will be subject to priorities and budgets of individual stakeholder organisations.

This report was written during 2005 and includes references to bodies such as the SA State Water Monitoring Coordination Committee (SWMCC) that has now been superseded by new NRM Monitoring, Evaluation and Reporting groups that are required for the implementation of the SA NRM Plan. Of greatest relevance to this report is the Monitoring, Evaluation and Reporting Policy Group that has been formed to coordinate South Australian State Government agencies at the policy level and to promote consistency and cooperation between stakeholders at national, state and regional scales of interest.

SUMMARY OF PROPOSED FUTURE MONITORING

TO FILL MONITORING GAPS FOR THE EASTERN MOUNT LOFTY RANGES

These suggestions provide a guide to agencies developing monitoring programs in the future (further detail follows in the body of this report and Appendices). Response to these suggestions will depend on priorities and funding within stakeholder agencies. The suggestions may assist agencies to prioritise monitoring related actions and to seek funding where gaps have been identified.

Surface Water Quantity Monitoring

Monitoring	Gaps	Proposed Future Monitoring	Refer
Rainfall	Mypolonga Flat, Kakoonie, Preamimma Milendella, Long Gully, Bees Knees and Deep Creek catchments	Consideration be given to establishing rainfall gauging stations	Sections 5.5.1.1 and 5.6.1.1
Rainfall	Reedy Creek catchment	Establish rainfall monitoring in the higher rainfall upland area. If possible reopen “Tungkillo (Terlinga) BoM Met Station” (M023780)	Sections 5.5.1.1 and 5.6.1.1
Rainfall	Tookayerta catchment	Establish rainfall monitoring to aid in assessing yield of Cleland Gully Creek	Sections 5.5.1.1 and 5.6.1.1
Evaporation	Entire EMLR region	As there is currently no monitoring of evaporation for the EMLR it is suggested that monitoring of evaporation be established	Section 5.3.1
Levels and flow	Most catchments	Review levels and flow monitoring for the entire EMLR region	Sections 5.3.2 and 5.6.1.3
Levels and flow	Reedy Creek, Deep Creek	Establish levels and flow monitoring sites for Reedy and Deep Creek catchments as a first priority	Section 5.6.1.3 and App H
Levels and flow	Currency Creek	Re-open “Currency Creek @ near Higgins” (AW426530) as a first priority	Section 5.6.1.3 and App H

Monitoring	Gaps	Proposed Future Monitoring	Refer
Levels and flow	Tookayerta Creek	Continue operating test site "Tookayerta Creek @ d/s Nangkita Creek" (A4261020) as a levels/flow monitoring site as a first priority. Reopen AW426534 and carry out continuous water level monitoring and stream flow monitoring from ratings	Section 5.6.1.3 and App H
Levels - minor tributaries	Bremer River	New site d/s of AW426533 just downstream of confluence with S-W streams, to estimate flows from the two south-western streams as a first priority	Section 5.6.1.3 and App H
Levels - major tributaries	Angas River	Reopen AW426564 to include stream flow monitoring to monitor flow from major tributaries just downstream of confluence as a first priority	Section 5.6.1.3 and App H
Levels - major tributaries	Finnis River	Two new sites, downstream of stream flow gauging station, just downstream of confluence with unmonitored streams	Section 5.6.1.3 and App H
Levels and flow	Milendella Creek, Salt Creek, Preamimma Creek, Rocky Gully Creek and Sandergrove Plains catchments	Establish levels and flow monitoring sites in Milendella, Salt, Preamimma and Rocky Gully Creeks and Sandergrove Plains catchments as second priority locations	Section 5.6.1.3 and App H
Levels and flow	Long Gully Creek, Bees Knees Creek catchments	Consider these as third priority locations and establish levels and flow monitoring stations within that context	Section 5.6.1.3 and App H
Levels and flow	Flow monitoring in Saunders Creek catchment	Carry out gaugings to establish ratings for flow monitoring at "Saunders Creek @ Saunders Gorge" (A4261028) and "Saunders Creek @ Lenger Reserve" (A4261029) sites	Section 5.6.1.3 and App H
Levels and flow	Rocky Gully and Preamimma catchments	Consider reopening "Dry Creek @ Monarto" (AW426544) and "Preamimma Creek @ d/s Monarto" (AW426546)	Section 5.6.1.3 and App H
Stream flow gaugings for ratings	Up-to-date flow gaugings to establish ratings for flow calculations from levels	Annual flow gaugings to be carried out to establish ratings for calculating flow that relate to current flow regimes	Section 5.5.1.3 and App H
Catchment outflow	River Murray and Lake Alexandrina	Stream flow monitoring at/near catchment outlet	Section 5.6.1.2

Surface Water Quality Monitoring

Monitoring	Gaps	Proposed Future Monitoring	Refer
Salinity (continuous)	Most catchments	Consider expanding salinity monitoring especially at Currency Creek, Reedy Creek, Tookayerta Creek and Deep Creek	Section 5.6.2.1
Ambient	Most of the EMLR region	Expand pesticide studies - hotspot and passive sampling activities	Section 5.6.2.2

Groundwater Quantity Monitoring

Monitoring	Gaps	Proposed Future Monitoring	Refer
Surface water and groundwater interactions	Angas, Bremer and Finnis Rivers / Tookayerta Creek, Deep Creek, Currency Creek catchments	Investigate the surface water/groundwater interactions is these areas	Section 6.6.1
Farm dams	Lack of information on how farm dams impact groundwater recharge	Studies such as Surface water assessment of the upper Finnis catchment (Savadamuthu 2003) should be carried out	Section 6.6.1.1
Water use	Most of the EMLR catchments	Water use in relation to land use is to be monitored	Section 6.6.1.2

Groundwater Quality Monitoring

Monitoring	Gaps	Proposed Future Monitoring	Refer
Salinity	Most of the region, in particular for Saunders, Reedy, Tookayerta, and Currency and Deep Creeks	Expand monitoring for salinity in areas likely to be developed, and for those areas with groundwater dependent ecosystems of significance	Section 6.6.2
In general	Lack of Information on groundwater quality	Expand groundwater quality monitoring	Section 6.6.2

Aquatic Ecosystems

Monitoring Category	Gaps	Proposed Future Monitoring	Refer
Integrated monitoring program	EMLR region	Develop Calibrated Catchment model	Section 7.4.1
Stygofauna	No data	Basic research	Section 7.4.1.2
Significant aquatic ecosystems	Not identified	Identification of priority aquatic ecosystems for ambient monitoring is needed	Section 7.4.1.3
Riparian vegetation	Riparian vegetation is degraded	Monitor restoration of riparian vegetation	Section 7.4.1.4
Groundwater dependent ecosystems	Data on distribution and abundance; and impact of altered flow regime	Survey the distribution and abundance of groundwater dependent ecosystems. Research the impact of altered flow regime	Section 7.4.1
Ephemeral streams	Understanding of impact of altered flow regime	Research the impacts of altered flow regime on ephemeral streams	Section 7.4.1

Catchment Characteristics

Monitoring	Gaps	Proposed Future Monitoring	Refer
Changes in land use	Up-to-date data and information	Collect up-to-date data and information about changes in land use for all catchments	Section 8
Land use dataset	Land use dataset specifically designed for water resources assessment	Develop a land use dataset specifically designed to be used by agencies involved in water resource monitoring and management	Section 8
Projected urban growth	Linking information about projected urban growth to current and future land use and practices	Research predicted urban growth and link to land use practices with regard to future demands for water	Section 8

Data and Information Management

Monitoring	Gaps	Proposed Future Monitoring	Refer
All monitoring	Data quality, storage and accessibility	Review monitoring data across all monitoring themes for all agencies	Section 9

Roles and Responsibilities

Monitoring	Gaps	Proposed Future Monitoring	Refer
Integration between agencies	Coordination between State agencies and CWMBs to clarify State-scale and Catchment-scale responsibilities	Agencies and CWMB's coordinate with regard to reviewing, rationalising or expanding monitoring programs, to avoid duplications or gaps, e.g. macroinvertebrate and groundwater	General

1. INTRODUCTION

1.1 BACKGROUND

As part of achieving the objective of the Water Resources Act 1997 (now superseded by the Natural Resources Management Act 2004), the State Water Monitoring Coordination Committee (SWMCC) was established to conduct the State Water Monitoring Review and oversee the coordination of water monitoring in South Australia.

The State Water Monitoring Review involves investigation into current water resource monitoring activities for each catchment in South Australia and the development of proposed future water monitoring that will meet the State's core business needs and legislative responsibilities. Suggestions are seen as those that would fit into an ideal monitoring strategy to which stakeholders can refer in planning their water monitoring activities within their budgets.

As part of the State Water Monitoring Review this project has dealt with surface and groundwater resource monitoring for the Eastern Mount Lofty Ranges (EMLR), covering the following six major themes:

- Surface Water Quantity.
- Surface Water Quality.
- Groundwater Quantity.
- Groundwater Quality.
- Aquatic Ecosystems.
- Catchment Characteristics.

Marine and estuarine waters have not been considered as part of this review. Monitoring these systems is important and should be reviewed in a separate document.

1.2 AIM

The aim of this project is to provide key stakeholders with proposed monitoring that they can use in the development of water monitoring strategies. Suggestions have been made on an idealistic basis and not set within current budgetary constraints. This report serves as a reference for the development of subsequent water monitoring strategies into the future.

1.3 OBJECTIVES

The project is intended to meet the following specific objectives:

- Establish the monitoring requirements of key stakeholders.
- Develop an understanding of current water resource data collection, analysis programs and capabilities.

- Identify data and information gaps limiting critical water management decisions.
- Analyse the information on current monitoring programs to highlight commonalities.
- Propose ways of coordinating monitoring requirements to avoid duplication and improve cost-effectiveness.
- Provide stakeholders with an integrated water monitoring strategy proposal.

1.4 METHODOLOGY

This project has been conducted as a desktop review, using the following steps:

- Research regional water resource issues.
- Discern relevant roles and responsibilities of major stakeholders.
- Review current water monitoring information and metadata.
- Identify and map current water monitoring sites.
- Organise and facilitate workshops for key stakeholders, to identify the purpose of and agency responsible for current monitoring sites and to discuss future monitoring needs.
- Identify gaps and duplications in current monitoring.
- Propose suggestions for future water monitoring strategies.

In identifying monitoring gaps, comparisons have been made between existing ongoing monitoring and ideal models for monitoring, which can be found in Appendices D, E, F, and G. Surface water monitoring has been dealt with on a site-by-site basis. Groundwater monitoring sites have been dealt with by reference to networks due to their large numbers.

1.5 CONSULTATION

Under the auspices of the State Water Monitoring Coordination Committee (SWMCC) a range of agencies have had opportunities to provide input to the monitoring review process. State agencies have been broadly consulted and the key officers involved are listed in the Acknowledgements.

1.6 STUDY AREA

The Eastern Mount Lofty Ranges (EMLR) forms part of the River Murray Catchment Water Management Board's (RMCWMB) catchment area, which is part of the Murray-Darling Basin. The EMLR area lies east of South Para, Gawler, Torrens and Onkaparinga River catchments and west of the River Murray in South Australia.

The predominant landscape features of the EMLR are the hills that run from north to southwest at an elevation of 400–550 m, and the Murray Plains that surround the River Murray in South Australia. Further south, several streams discharge into Lake Alexandrina across the sandy deposits of the Milang Plain (Department for Environment and Heritage 2005, River health in the Eastern Mount Lofty Ranges http://www.environment.sa.gov.au/reporting/inland/rivers_streams/healthassess.html#eastern_lofty).

Rainfall in the EMLR is highly variable ranging from 850 mm in parts of the hills area in the west to less than 250 mm on the plains. Most of the rainfall enters the streams as runoff or is intercepted and used by vegetation through evapotranspiration.

1.7 STAKEHOLDERS

Key stakeholders for monitoring in the EMLR include (refer to Section 3 for further detail):

- The Department of Water, Land and Biodiversity Conservation (DWLBC).
- The Environment Protection Authority (EPA).
- The Department for Environment and Heritage (DEH).
- The South Australian Water Corporation (SA Water).
- The River Murray Catchment Water Management Board (RMCWMB).

2. CATCHMENT DESCRIPTION

2.1 SURFACE WATER RESOURCES

There are 13 major tributary catchments that drain from the ranges to the River Murray and Lake Alexandrina. These are the Marne River, Saunders Creek, Milendella Creek, Long Gully Creek, Reedy Creek, Salt Creek, Preamimma Creek, Rocky Gully Creek, Bremer River, Angas River, Finnis River, Tookayerta Creek and Currency Creek catchments. Some of the larger waterways in the region include the Angas, Bremer, Finnis and Marne rivers, and Currency Creek.

The major freshwater streams that flow from the Eastern Mount Lofty Ranges into the River Murray include the Marne River and Reedy Creek and their tributary streams. There are also a number of streams that rise in the ranges but do not persist as surface streams and contribute little water into the River Murray. They include Burra, Truro, Saunders, Preamimma, Salt and Mitchell creeks, and the Dry Creek-Rocky Gully system. Most of these streams are quite saline. The remaining streams in the region flow into Lake Alexandrina and include the Bremer River system which includes Dawesley, Nairne and Mount Barker creeks; the Finnis River which includes Meadows, Tookayerta Creek which includes Nangkita Creek; and Currency Creek (Department for Environment and Heritage 2005).

Generally, streams in the hills regions are ‘gaining streams’, and are ‘losing streams’ on the plains. This means that in the hills, groundwater discharges to the streams and sustains flow, whereas on the plains stream flow discharges to the underlying aquifers. Most of the EMLR streams are ephemeral, with the exception of Finnis River and Tookayerta Creek that gain summer baseflows from discharging groundwater from the hills.

2.2 GROUNDWATER RESOURCES

In the EMLR there are two different types of aquifer systems. Fractured rock aquifers occur in the hills where groundwater is stored and moves through joints and fractures in the basement rocks. Sedimentary aquifers occur in some valleys and beneath the plains of the Murray Basin, where groundwater flows through the pore spaces within the sediments.

Groundwater moves from the higher points in the landscape (which are usually basement rocks around the catchment boundaries in the hills) towards the lowest areas where discharge normally occurs to the streams. This discharge constitutes the baseflow of the streams that dominates flow for most of the year, particularly over the summer.

Recharge to fractured rock aquifers occurs directly from rainfall that percolates down to the watertable through the soil profile. Sedimentary aquifers beneath the plains are mostly recharged from stream flow, with small quantities recharged from rainfall.

2.3 AQUATIC ECOSYSTEMS

The Eastern Mount Lofty Ranges has a diverse range of aquatic ecosystems, due to the high variability in rainfall and differing levels of dependence of habitats on groundwater. The region's ephemeral and permanent streams support a diversity of habitats such as pools and riffles, riparian zones and floodplains. These habitats in turn support an important variety of flora and fauna. Macrophytes, sedges and reeds, and red gum forests may dominate, respectively, instream, riparian and floodplain environments. Plant and animal plankton communities, macroinvertebrates, fish, birds and mammals also play an important role in aquatic ecosystems.

A number of significant and threatened species are supported by water dependent ecosystems found in the EMLR. The wetlands support three nationally endangered plant species, namely Osborn's eyebright (*Euphrasia collina* ssp. *osbornii*), maroon leek orchid (*Prasophyllum frenchii*) and white-beauty spider-orchid (*Caladenia argocalla*), as well as a large number of species classified as threatened at the regional and State level. Threatened animal species include the endangered Mount Lofty Ranges Southern

Emu-wren (*Stipiturus malachurus intermedius*), the vulnerable Yarra pygmy perch (*Nannoperca obscura*) and the locally endangered southern pygmy perch (*Nannoperca australis*).

Important aquatic habitat in the EMLR also includes the critically endangered swamps of the Fleurieu Peninsula, the most common of which are shrub dominated freshwater peat swamps and sedge dominated freshwater swamps. The interactions between surface water and groundwater in this area are complex, with many of these habitats dependent either partially or wholly on groundwater. The region is also likely to support subterranean groundwater ecosystems.

2.4 LAND USE

Land use in the Eastern Mount Lofty Ranges is dominated by the grazing of modified pastures. Modified pastures consist of both annual and perennial pasture, and forage production, whereby a significant degree of modification or replacement of the initial native vegetation has occurred (The Bureau of Rural Sciences 2001). Examples of modified pastures include woody fodder plants (tagasaste), legumes, legume/grass mixes and sown grasses. Another significant land use is cropping, which uses around 11% of land area. Crops in this region include cereals, beverage and spice crops, hay and silage, oil seeds and olives.

The other significant land use is irrigation and about 12% of the EMLR region is currently irrigated. Irrigation activities include irrigated cropping, irrigated modified pastures and irrigated seasonal horticulture. Recently, there has been an increase in horticultural activities, particularly in viticulture. The water resources of many of the EMLR catchments are being developed to support the expansion of agricultural activities. Table 1 and Figure 1 identify all land use in the EMLR.

Figure 1: Land use in the Eastern Mount Lofty Ranges (EMLR) (2003)

LEGEND

EMLR Boundary

EMLR Landuse

- Cropping
- Grazing modified pastures
- Grazing natural vegetation
- Intensive animal production
- Intensive horticulture
- Irrigated cropping
- Irrigated modified pastures
- Irrigated perennial horticulture
- Irrigated plantation forestry
- Irrigated seasonal horticulture
- Lake
- Manufacturing & industrial
- Marsh/wetland
- Mining
- Nature conservation
- Other minimal use
- Perennial horticulture
- Plantation forestry
- Rehabilitation
- Remnant native cover
- Reservoir
- Residential
- River
- Services
- Transport & communication
- Utilities
- Waste treatment & disposal

N
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Produced By: Licencing Mount Lofty Ranges Resource Allocation Division DWLBC
Data Source: DWLBC
Projection: MGA z54
Datum: Geocentric Datum of Australia 1994
Date: 22/07/2005

Government of South Australia
Department of Water, Land and Biodiversity Conservation

0 3.75 7.5 15 Kilometers

1:430,000

Table 1. Land use in the Eastern Mount Lofty Ranges (DWLBC 2005).

Land Use Description	Hectares	% of Total Area
Cropping	31 360.47	11.02
Grazing modified pastures	180 561.32	63.47
Grazing native vegetation	11 329.66	3.98
Intensive animal production	98.10	0.03
Intensive horticulture	48.08	0.02
Irrigated cropping	2 139.54	0.75
Irrigated modified pastures	20 903.59	7.35
Irrigated perennial horticulture	9 898.35	3.48
Irrigated plantation forestry	10.36	0.00
Irrigated seasonal horticulture	813.95	0.29
Manufacturing and industry	154.22	0.05
Mining	506.78	0.18
Nature conservation	2 274.22	0.80
Other minimal use	889.10	0.31
Perennial horticulture	18.15	0.01
Plantation forestry	2 633.82	0.93
Rehabilitation	892.91	0.31
Reservoirs	16.99	0.01
Residential	8 112.91	2.85
Services	2 166.07	0.76
Transport and communication	7 351.98	2.58
Utilities	13.24	0.00
Waste treatment and disposal	69.72	0.02
Natural Features	**Hectares**	**% of Total Area**
Lakes	524.06	0.18
Marsh/wetland areas	1 356.24	0.48
Remnant native cover	85.50	0.03
Rivers	266.64	0.09
Total Ha	**284 495.97**	

2.4.1 IMPACT OF LAND USE ON WATER RESOURCES

Within the Eastern Mount Lofty Ranges region, rural and urban land management practices have significantly impacted upon the quantity and quality of surface and groundwater resources. These practices include native vegetation clearance, irrigation activities, agricultural chemicals, groundwater extraction, surface water storages, domestic wastewater disposal and industrial activities. Such land management practices present a risk to the sustainable use of water resources in the future.

Farm dam development alters the hydrology of a catchment by capturing water that would otherwise flow into streams and recharge aquifers. The current level of farm dam development, along with the potential for further development in some EMLR areas, poses a risk to surface water, groundwater and aquatic ecosystems flows. Extensive farm dam development and high demands for groundwater also have the potential to increase levels of surface water and groundwater salinity. High demands for groundwater supplies may also disrupt discharge to some streams, particularly during summer, with the potential to significantly impact on aquatic ecosystems.

The main contaminants identified as major risks to surface water and groundwater quality are sediments from stream erosion, overgrazing and intensive horticultural practices; pathogens such as *E. coli*, Cryptosporidium and Giardia from animal waste and septic tank effluent systems; nutrients including phosphorus, nitrogen and carbon from fertilisers, animal waste, sewage effluent and some industry discharge; and pesticides from forestry, agriculture and horticulture. Sediments can adsorb nutrients, pesticides and micro-organisms and transport them into waterways.

The extent and condition of indigenous riparian vegetation in the region is poor for many streams, with unrestricted livestock access being the highest threat. Increased use of groundwater, and overdevelopment of surface water resources, are additional threats to the availability of water for plants and animals dependant on aquatic ecosystems. It is essential that surface water and groundwater levels and quality are able to sustain aquatic ecosystems in both rural and urban areas.

2.4.2 CHANGES IN LAND USE

Changes in land use can have a significant impact on natural resources. It is important to consider current and changing land use in relation to monitoring needs and adapt monitoring activities to encompass the impact of changes in land use on water resources. An inventory of land use change is seen as imperative for the creation of an up-to-date water monitoring program. An inventory will also establish an historical perspective on the impacts of land use change over time, by providing historical records of water quantity and quality.

3. ROLES AND RESPONSIBILITIES OF STAKEHOLDERS

3.1 ROLES OF MAJOR STAKEHOLDERS

3.1.1 LEGISLATIVE REQUIREMENTS AND BUSINESS NEEDS

This section defines the roles and responsibilities for the major agencies involved in water monitoring Statewide. It does not necessarily mean that all of these agencies are involved in water monitoring in the Eastern Mount Lofty Ranges.

Two Acts define most of the State's legislative reporting and planning responsibilities associated with water resource management. These are the Natural Resources Management Act 2004 and the Environment Protection Act 1993 (refer App. A).

3.1.2 OVERVIEW OF AGENCY ROLES

There are numerous agencies and organisations carrying out water monitoring activities in South Australia at the local, State and Federal level. The State, primarily through DWLBC, EPA, the Department for Environment and Heritage (DEH), and the CWMBs carries out the function of monitoring the conditions and trends of both the quality and quantity of water resources. There are many other organisations or groups that have an interest in collecting water monitoring information or are interested in obtaining State Agency data. These groups include health, public works and planning departments in local governments, certain businesses and selected non-governmental environmental organisations, and some university and school programs. The Federal agencies serve as important partners, but with the exception of the Bureau of Meteorology (BoM), their focus is primarily on research and special projects, or on regional programs conducted in connection with Federal Agency missions.

This section focuses on those programs con ducted by DWLBC, EPA, SA Water, and CWMBs. It outlines the current roles of agencies and organisations involved in monitoring in SA, and identifies the key data and information needs of water resource programs. Detailed information about all the stakeholders, including mission statements, interests and responsibilities, can be found in State Water Monitoring Review: Monitoring Partnerships Paper (Kneebone, 2000).

3.1.3 MAJOR STAKEHOLDERS

DWLBC, EPA, SA Water, BoM, and CWMB have historically had important roles in water monitoring in South Australia. The roles of the key agencies are discussed below.

Environment Protection Authority (EPA)

As the State's principal environmental protection regulatory agency, the EPA's water monitoring interests are related to providing the information necessary to manage the State's pollution control programs, including:

- discharge permit development
- assessment of water quality standards
- verification of permit compliance
- protection of public health/safety
- remediation of spills/historical pollution problems
- determining the status of living aquatic resources
- community monitoring.

Department of Water Land and Biodiversity Conservation (DWLBC)

As the State's principal natural resources agency, DWLBC's water monitoring interests are focused on:

- status and trends of water quality and quantity
- identification of existing and future risks of damage to, or degradation of, water resources
- evaluating living resource habitat
- ensuring the environmental water requirements of water dependent ecosystems.

SA Water

SA Water is responsible for the storage, treatment and distribution of bulk water; the provision of reticulated, potable and public water supplies; and the collection, treatment and disposal of sewage.

SA Water's water quality monitoring program provides key information to assist the management of water supply systems and to ensure performance standards are met. It comprises both routine and event-based monitoring programs. The key objectives of the monitoring program are to:

- Determine the quality of water provided to customers.
- Determine compliance with guidelines and performance standards.
- Identify long-term trends in raw and stored water quality.
- Provide key information to facilitate effective operation of treatment systems.
- Provide key information to facilitate effective drinking water supply operation and distribution.
- Identify emerging issues with the total water system.

Bureau of Meteorology (BoM)

BoM is one of the major water resource data collection agencies in South Australia. Since 1988 it has been responsible for providing a flood warning service for non-flash flooding (i.e.

rivers that take more than six hours to flood) in South Australia. BoM also has a significant role in providing rainfall and general climate data for water resource purposes.

BoM has the following basic objectives:

- Climate record: to meet the needs of future generations for reliable homogeneous climatological data.
- Scientific understanding: to advance the science of meteorology and develop an integrated comprehensive description and scientific understanding of Australia's weather and climate.
- Community welfare: to contribute effectively to national goals through the development and provision of meteorological and related services.
- International cooperation: to meet Australia's international obligations and advance Australia's interests in and through international meteorology.

River Murray Catchment Water Management Board (RMCWMB)

The role of the Water Management Board is:

To manage the water resources of the River Murray catchment in South Australia. Working in partnership with catchment communities and stakeholders, the Board's objective is to achieve a sustainable balance between the economic, environmental and social needs of the catchment and its communities (RMCWMB Website).

Included in the Board's major responsibilities is the implementation of the River Murray Catchment Water Management Plan as well as Water Allocation Plans for prescribed water resources. Key strategies are identified in these plans and are formulated to ensure the long-term future of the River Murray catchment in South Australia. It is essential for the success of these plans that regional communities are involved in their implementation.

The RMCWMB aims to meet the following goals in relation to the EMLR:

- determine the environmental water requirements of water dependent ecosystems
- improve the sustainability of existing and future irrigation developments
- investigate and implement improved land management practices
- develop and implement plans for restoring and managing priority natural areas
- promote public awareness of water management issues in the region
- encourage active community management of water resources
- monitor the success of remedial programs funded by the Board.

3.2 RESPONSIBILITIES OF MAJOR STAKEHOLDERS

The current responsibilities for water monitoring of principle agencies are shown in Table 2 (adapted from Wen, 2005 – App. C). It also provides reference to other principle agencies carrying out related monitoring which can be used in determining information sharing opportunities.

Table 2. Current responsibilities for water monitoring of principle agencies.

Water Monitoring Category	Responsible Stakeholders [1]	Other Agencies Involved [2]
Surface Water Quantity		
Rainfall	BoM	DWLBC, SA Water, CWMB
Rainfall Intensity	DWLBC	BoM, CWMB, SA Water
Catchment Stream flow	DWLBC	EPA, CWMB, SA Water
Sub-Catchment Stream flow	CWMB	DWLBC, EPA, SA Water
Storm Water	CWMB	DWLBC, EPA
Farm Dams	DWLBC	CWMB, EPA
Water Use Efficiency	CWMB	DWLBC, SA Water
Surface Water Quality		
Pesticides, Organics, Metals, Nutrients, DO, pH, Turbidity, Temperature	EPA	DWLBC, CWMB, SA Water
Macroinvertebrates, indicator bacteria	EPA	DWLBC, CWMB, SA Water
Ambient	EPA	DWLBC, CWMB, SA Water
Groundwater Quantity		
Water allocation	DWLBC	EPA, CWMB, SA Water
Environmental Flows	DWLBC	EPA, CWMB, SA Water
Groundwater Quality		
Salinity	DWLBC	EPA, CWMB, SA Water
Ambient	EPA	DWLBC, CWMB, SA Water
Aquatic Ecosystems		
Water Quality	DWLBC	EPA, CWMB, DEH
Biological integrity	DWLBC	EPA, CWMB, DEH
Environmental Value assessment	DWLBC	EPA, CWMB, DEH

1 Responsible Stakeholder: Legislative mandate, responsible for: Developing monitoring strategy, plan and protocols; Data custodian, and supervising data quality assurance; and Support monitoring undertaken by other parties.

2 Other Agencies involved: Need information for business operation, contribute to monitoring through joint funding, advising etc.

4. CURRENT MONITORING SYSTEMS

4.1 OVERVIEW OF SURFACE AND GROUNDWATER MONITORING IN SA

4.1.1 WATER QUANTITY

Two critical components of water resources monitoring are the monitoring of stream-flow and the monitoring of groundwater levels. South Australia is fortunate to have a long history of stream flow and groundwater level monitoring. Stream-flow in major streams in the State has been monitored for about the last 50–150 years. For example, SA Water has been monitoring and recording the Torrens River since 1857, and the Murray-Darling Basin Committee has been measuring the water level along the Lower Murray River for over a century. The groundwater levels in some strategic aquifers in the state have been monitored since 1934.

4.1.2 WATER QUALITY

The DWLBC collects salinity data for surface water as well as groundwater. DWLBC currently has four stream-gauging stations which have the capacity to record electrical conductivity and temperature. Within the current Obswell network, 232 observation wells are instrumented for electrical conductivity measurement.

4.1.3 SURFACE WATER

Many federal, state, and local agencies in SA use streamflow data. Some of the many uses of streamflow data include:

- water supply assessment
- catchment management
- stream restoration
- bridge design
- flood warning
- sediment and contaminant loading
- recreational activities.

4.1.4 GROUNDWATER

Groundwater level data is used to:

- discern trends (both long and short term)
- provide warnings of unsustainable use
- inform the State's groundwater appropriation permitting process.

Groundwater data is also used during technical investigations (such as quantifying recharge); in environmental water requirement evaluations and in dryland salinity investigations.

4.2 DEFINITIONS OF WATER MONITORING

To 'monitor' is to 'maintain regular surveillance over' (Oxford Dictionary 1995). Brydges (2004) considers it to be essential that environmental monitoring programs take measurements at regular time intervals over a substantial length of time. There are two fundamental reasons for monitoring natural systems. The first is to establish baselines representing the current resource condition status. The second is to detect changes over time, particularly changes that are outside the natural variation of the baselines (Hicks and Brydges 1994). Alternatively, monitoring may be considered as a process that provides information used in management (Finlayson and Mitchell 1999). In this framework it is essential that monitoring be able to measure change in reference to a set of objectives (Baldwin et. al. 2005).

Monitoring can be categorised on the basis of management derived objectives (Downes et al. 2002) as either:

Monitoring for State-of-Environment reporting	Aims to provide instantaneous reporting of current conditions
Regulatory/compliance monitoring	Evaluates the impact of regulation or development, often as part of compliance with water management plans, statutory reporting, auditing or law
Project monitoring	Linked to project objectives, which may commonly include the collection of detailed data to support ambient monitoring
Ambient monitoring	Long-term monitoring to establish and continually assess resource state and detect any changes in condition. Ambient monitoring also includes long-term reference site monitoring

Monitoring programs undertaken to meet these objectives fall into four broad categories (adapted and modified from Brydges, 2004):

Simple monitoring	Records the values of a single variable (i.e. rainfall)
Multivariate monitoring	Records multiple variables (i.e. water quality, EC, pH, DO etc.)
Survey monitoring	Involves monitoring areas that are affected and unaffected by an observed stress. Survey monitoring is used in the absence of historical monitoring data
Surrogate or proxy monitoring	Uses surrogate measures to infer historical conditions or current impacts in the absence of actual measurements of the desired variable. Fossil diatom assemblages are often used to infer historical conditions and modelled flow volume may be used to infer ecological health
Integrated monitoring	Uses a range of variables (e.g. hydrological, climatic and biological) sampled over time in order to record changes in the environment and define reasons for those changes

Monitoring undertaken in the Eastern Mount Lofty Ranges has been instigated to meet one or more of the management derived objectives and fits into one or more of the five monitoring types.

Water monitoring is also considered as the process of collecting samples or data. In defining monitoring, however, there are other aspects that should be addressed, including: data acquisition (network design, quality assurance/quality control, laboratory analysis, data handling, data analysis), data utilisation, communication and coordination. Saunders and others (1985) summarised those aspects of monitoring as below.

Data editing	Preparation of raw data for entry to databases or for analyses
Data verification and entry	Ensuring that data looks 'reasonable' based on what is known about the system
Data storage, security and accessibility	Data should be stored effectively in a secure, maintained database and available to researchers or the public
Evaluation	Analysis of data to produce information
Regular review	Adequacy of the water information system (including but not limited to the monitoring network): Is the information being provided sufficient to meet foreseeable needs?; Are any gaps or redundancies emerging?

As a management tool, water monitoring is identified as a starting point of the management process and as a feedback mechanism to identify how management efforts have affected water conditions. At times, monitoring may serve only a single purpose - either in terms of identifying water conditions or as feedback to a management decision. From the management point of view, the following types of monitoring can be defined (after MacDonald et al., 1991):

Trend monitoring	Measurements are made at regular, well-spaced time intervals in order to determine the long-term trend in a particular parameter
Baseline monitoring	Used to characterise existing water quality conditions and to establish a database for planning or future comparisons
Implementation monitoring	Assesses whether activities were carried out as planned
Effectiveness monitoring	Used to evaluate whether the specified activities have had the desired effect
Project monitoring	Assesses the impact of a particular activity or project
Validation monitoring	Deals with the quantitative evaluation of a proposed water quality model to predict a particular water quality parameter
Compliance monitoring	Used to determine whether specified water-quality criteria are being met

4.3 MONITORING METHODS EMPLOYED

4.3.1 SURFACE WATER QUANTITY

The DWBLC is the State agency primarily responsible for collecting, analysing and sharing data on surface water quantity (availability and use). In particular, the DWLBC is the main collector of stream flow data, which measures the volume of water flowing through a stream using stream gauges. The DWLBC collects data through its State stream-gauge network, which continuously measures the level and flow of rivers and streams at 80 stations Statewide. This data is available to the public via the Internet: the Surface Water Archive (http://e-nrims.dwlbc.sa.gov.au/swa/mapindex.htm). The South Australian Government maintains a network of approximately 200 hydrometric stations across the State. Data collected by other agencies, such as SA Water, is stored in the HYDSTRA data management and reporting system, which is maintained by the Hydrographic Unit of DWLBC.

The stream-gauging stations include a range of instream structures designed to channel stream flow, or discharge in a manner that produces a relationship between water level and discharge. The stations are equipped with electronic sensors and data loggers. By electronically recording water level at these structures a mathematical relationship can be used to continuously measure discharge.

In line with its business requirements, the DWLBC has classified the stream-gauging stations into six types (App. B). Each station type has an assigned priority level, its unique purposes and minimum parameter requirements.

4.3.2 SURFACE WATER QUALITY

The EPA is responsible for assessing the condition of surface waters on a Statewide basis in accordance with the SA Environment Protection Act. The EPA conducts ambient water quality monitoring programs including the Rivers and Streams program, an inland waters (lakes) program and groundwater program. These programs are designed to:

- provide a qualitative and quantitative assessment of South Australia's surface water quality
- determine statistically significant changes or trends in the key characteristics of water quality
- provide data to assess the long-term ecologically sustainable development of surface waters.

The parameters monitored in these programs can be classified as physical, chemical or biological. The choice of water quality parameters is based on those required to support the designated environmental values of the target water body.

Physical parameters measured include turbidity, conductivity (salinity) and temperature. Chemical parameters can be divided into pH and dissolved oxygen, metals (total Cu, Pb, Ni, Hg, Zn and Cd) and nutrients (NOx, NH3, TKN and total P). Biological parameters include an estimate of algal biomass (chlorophyll a), microbiological parameters (*Escherichia coli* and *enterococci*) and macroinvertebrates. Some of the parameters (i.e. DO, EC, Temperature and pH) are measured in the field when samples are taken. The others are analysed in NATA accredited laboratories, such as Australian Water Quality Centre. The macroinvertebrate sampling is consistent with AusRivAS methodology (see Section 7.2.2).

The current focus of DWLBC surface water quality monitoring is on salinity. However, DWLBC can also establish and operate automatic water quality samplers designed to collect data on nutrients, pesticides and pathogens entering SA Water's urban supply reservoirs. Water salinity is monitored at many hydrometric stream flow gauging stations using an electrical conductivity (EC) probe. Along with temperature, the probe continuously measures EC.

4.3.3 GROUNDWATER

Fluctuations in groundwater levels reflect changes in groundwater storage within aquifers. Two main groups of fluctuation have been identified as: long-term, such as those caused by seasonal changes in natural replenishment and persistent pumping; and short term, for example, those caused by the effects of brief periods of intermittent pumping and tidal and barometric changes. Because groundwater levels generally respond rather slowly to external changes, continuous records from water level recorders are often not necessary. Systematic observations at fixed time intervals are adequate for the purposes of most monitoring networks. Where fluctuations are rapid, a continuous record is desirable, at least until the nature of such fluctuations has been determined.

Groundwater monitoring may be divided into three main stages:

- Reconnaissance, with the objective of a preliminary appraisal of the available water resources.
- General investigations, to obtain information for planning future urban, industrial, and agricultural development.
- Intensive studies of the aquifer(s). This level of the investigation requires the greatest effort and is necessary for areas of present or potential intensive development.

During each stage of the groundwater investigation, the information required includes:

- spatial and temporal variations of the piezometric heads, resulting from natural and man-made processes
- hydraulic constants of the aquifer
- geometry of the aquifers and aqueducts
- rates of natural replenishment and outflow
- rates of abstraction and artificial recharge
- water quality.

The data on piezometric heads and water quality are obtained from measurements at observation wells and analysis of groundwater samples. Observation wells are either existing wells, carefully selected from those already drilled in the area, or are drilled and specially constructed for the purposes of the particular study. One of the main costs in groundwater studies is drilling observation wells. Whenever possible, existing wells should be carefully selected and incorporated into the observation network.

In South Australia, monitoring bores have been established to monitor trends in groundwater and/or salinity levels for all areas of the State by a variety of organisations. By law, all wells require the issuing of a permit from DWLBC and details from the drilling operation are submitted as a condition of the permit. This data is then recorded in the

SA Geodata database. Where the well is to be used for monitoring purposes, the observation bores are grouped together into ‘networks’ that delineate a region in the State, a particular organisation doing the monitoring, or a specific aquifer. In theory, any group that maintains and reads monitoring bores provides the information to DWLBC for entry onto the State database.

The timeframes for forwarding the information to DWLBC head office for entry into the database vary. For example, some groups may forward the information immediately after wells are read. Other groups may collate results and forward them periodically, say, on an annual basis. There are also situations where the information is provided on a purely informal fashion, having been collected for another organisation.

The Obswell searchable interface is linked to SA Geodata and provides access to monitoring bore information. Information on the networks and individual bores associated with each of these networks is available on the Obswell website: http://applications01.pirsa.sa.gov.au:102/new/obsWell/MainMenu/menu.

Water level and salinity monitoring data is available for users to view and download free of charge. Elevation data, well coordinates and basic construction details are also available.

The major Obswell monitoring networks throughout the region are listed in the text. Bores are read periodically at intervals specific to the bore or network.

4.3.4 AQUATIC ECOSYSTEMS

Assessing the health of aquatic ecosystems is currently carried out either directly or indirectly. Direct monitoring is carried out by assessing a component of the ecosystem, such as monitoring the distribution and abundance of macroinvertebrates and fish. Indirect monitoring is carried out using a surrogate measure of ecosystem health such as pool depth as a measure of the health of groundwater dependent ecosystems.

AusRivAS (Australian River Assessment System) is a rapid prediction system used to assess the biological health of Australian rivers. AusRivAS was developed under the National River Health Program (NRHP) by the Federal Government in 1994, in response to growing concern in Australia for maintaining ecological values.

AusRivAS uses Bioassessment and physical assessment methods in their monitoring. These correspond with rapid biological assessment protocols and rapid geomorphic, physical and chemical assessment protocols respectively.

The Bioassessment method uses data obtained by the sampling of macroinvertebrate communities from the basic habitat types (riffles and edge). Representative samples are identified to species level where possible and physico-chemical characteristics of the site are also measured.

The AusRivAS model works by evaluating the measurements of physical and chemical parameters and, by incorporating the conditions at the site, predicts which families should be present. A ratio of observed to expected animals provides an indication of the ecological condition of the subject site.

4.3.5 COMMUNITY MONITORING

Waterwatch

This program is largely education-based monitoring and community capacity building. The Government resourced, community-based Water Watch program run by the catchment boards has sites throughout the State. School or community groups or individuals are encouraged to adopt sites for regular surveys. Participants are encouraged to sample quarterly, although more or less frequent or irregular sampling may occur depending on interest and availability.

Physical and chemical parameters (turbidity, phosphorus and nitrogen concentration, pH, temperature and salinity) are measured to produce a pollution index. Macro-invertebrates are sampled to provide an overall species diversity score.

Frog Census

This program is also community based and is coordinated by the EPA (until 2005–06 when it will be transferred to DEH). The protocol involves the identification of frog species present through identifying their calls. Tape recordings of frog calls are made by volunteers during the second week of September each year and returned for analysis along with site details. Whilst the Census is not quantitative, information on the distribution and abundance of frogs in South Australia is gleaned from the census.

5. SURFACE WATER MONITORING

The surface water resources of the Eastern Mount Lofty Ranges (EMLR) support agricultural, domestic/stock, industrial and ecosystems water requirements. Hence, monitoring of the resources is critical for assessment of its capability to provide for the current and future water requirements.

Monitoring programs or frameworks are designed based primarily on monitoring needs (requirements/objectives) and prioritisation of those needs.

5.1 MONITORING OBJECTIVES

The needs for surface water monitoring could be varied viz. for water allocation purposes, for assessing impact of catchment management activities and for ongoing assessment of resources, to name a few. Surface water monitoring in the EMLR can be grouped into three major categories based on their objectives and are listed in Table 3. Further description on the categories are provided in Appendix B.

Table 3. Surface water monitoring types (Source: Greenwood, 2001).

Monitoring Type	Objective
Ambient Monitoring	Long-term monitoring for ongoing assessment of the resource
Regulatory/Compliance Monitoring	To evaluate impacts of regulation and/or development as part of compliance with Legal/Statutory requirements
Project Monitoring	Monitoring linked to specific project objectives

5.2 PRIORITISATION OF OBJECTIVES

Once the needs/objectives are identified they need to be prioritised to design an achievable monitoring program or framework. Surface water monitoring can be prioritised based on the resource condition viz. availability, reliability, use and risk to the resource. For this purpose, catchments in the EMLR can be grouped into three broad categories, namely high-yield, medium-yield and low-yield catchments. Typical catchment characteristics and surface water resource conditions for the categories are listed in Table 4.

5.3 CURRENT SURFACE WATER QUANTITY MONITORING

Surface water quantity monitoring involves collection of data representing key processes of the hydrological cycle i.e. rainfall, evaporation, water level, stream flow, storage and water use. The primary purpose of such data collection is to obtain a water balance for a catchment, in other words, to quantify the surface water resources within a catchment.

This section provides a brief description of the surface water quantity parameters monitored and a list of the sites in the EMLR where those parameters are monitored (Table 4). Further details on each monitoring site are provided in Appendix C.

Table 4. Surface water catchment classification (see Fig. 2)**.**

Catchment Type		Catchments and Description
High Yield	*Catchments*	*Marne, Reedy, Bremer, Angas, Finniss, Tookayerta, Currency*
	Topography	Upper reaches of catchment in the "Hills zone" (elevation greater than 350 m)
	Rainfall	Rainfall in Upper reaches greaten than 600 mm
	Streamflow	Well defined stream network – (3rd order or higher)
	Resources	Availability - Highly reliable and less variable in the hills zone
		Use – High in the Hills zone
Medium Yield	*Catchments*	*Saunders, Millendella, Salt Creek, Preammima Creek, Rocky Gully Creek, Sandergrove Plains, Deep Creek*
	Topography	"Undulating", Elevation of upper reaches not less than 200 m
	Rainfall	Rainfall in Upper reaches – 450–600 mm
	Streamflow	Minimal stream network – (2rd order)
	Resources	Availability - Highly variable and less variable
		Use – Lower than "High-yield" catchments
Low Yield	*Catchments*	*Kakoonie, Long Gully, Mypolonga Flat, Ferries-McDonald*
	Topography	Most of the catchment in "Plains Zone"
	Rainfall	Maximum rainfall less than 450 mm
	Streamflow	No clearly defined stream network (braided streams)
	Resources	Unreliable, none/very little availability and use of surface water resources

5.3.1 RAINFALL AND EVAPORATION

Rainfall is monitored (a) on a daily timescale by manually read rain gauges and (b) on an instantaneous basis by automated pluviometers. In the EMLR most of the rainfall monitoring stations are operated by the BoM for long-term monitoring purposes. A few monitoring stations have also been established in the recent past by DWLBC, RMCWMB and PIRSA.

Evaporation is generally monitored by daily-read Class 'A' Pans (with bird guard) and by automated weather stations. In the EMLR there are no evaporation monitoring stations currently operational.

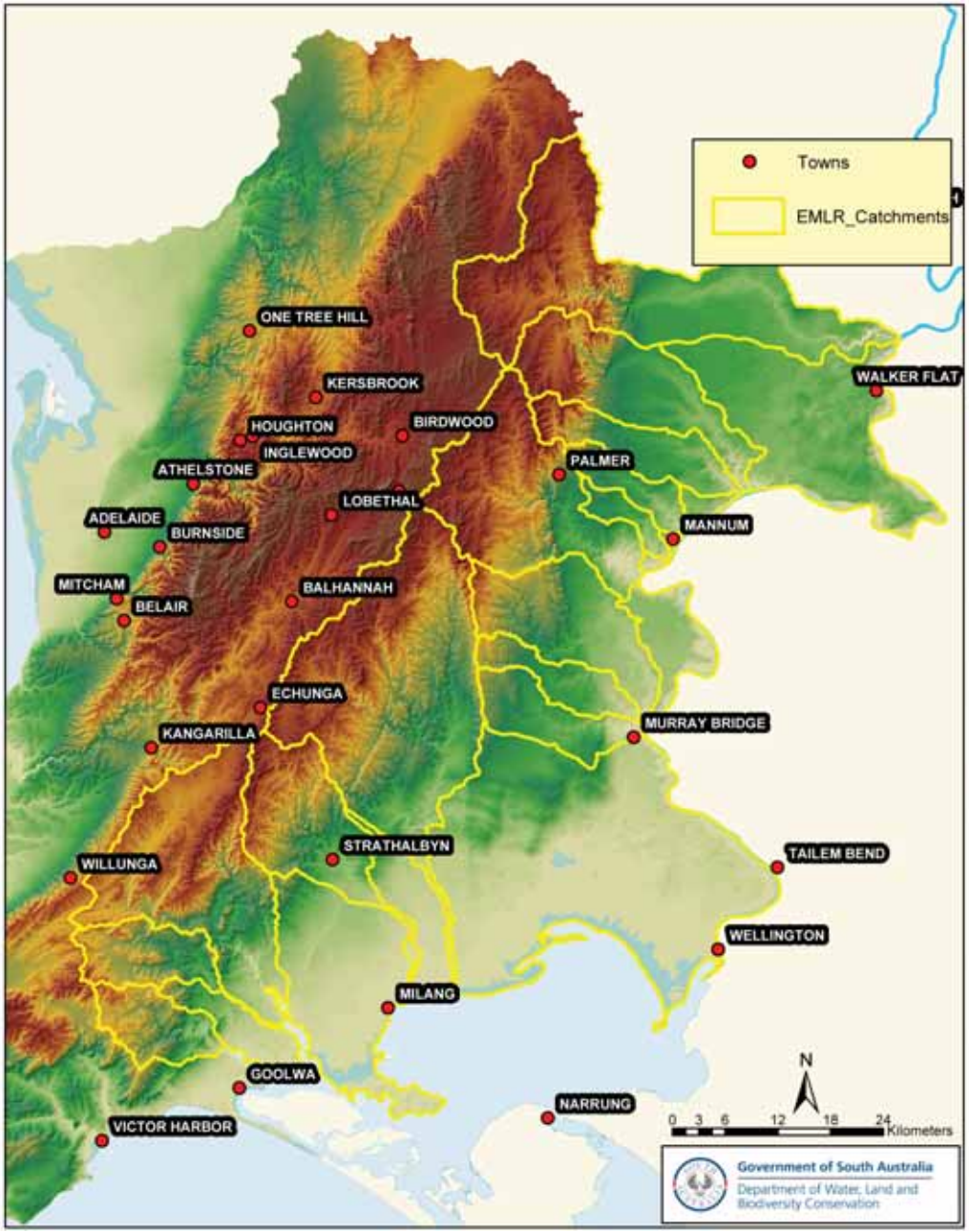
5.3.2 WATER LEVEL

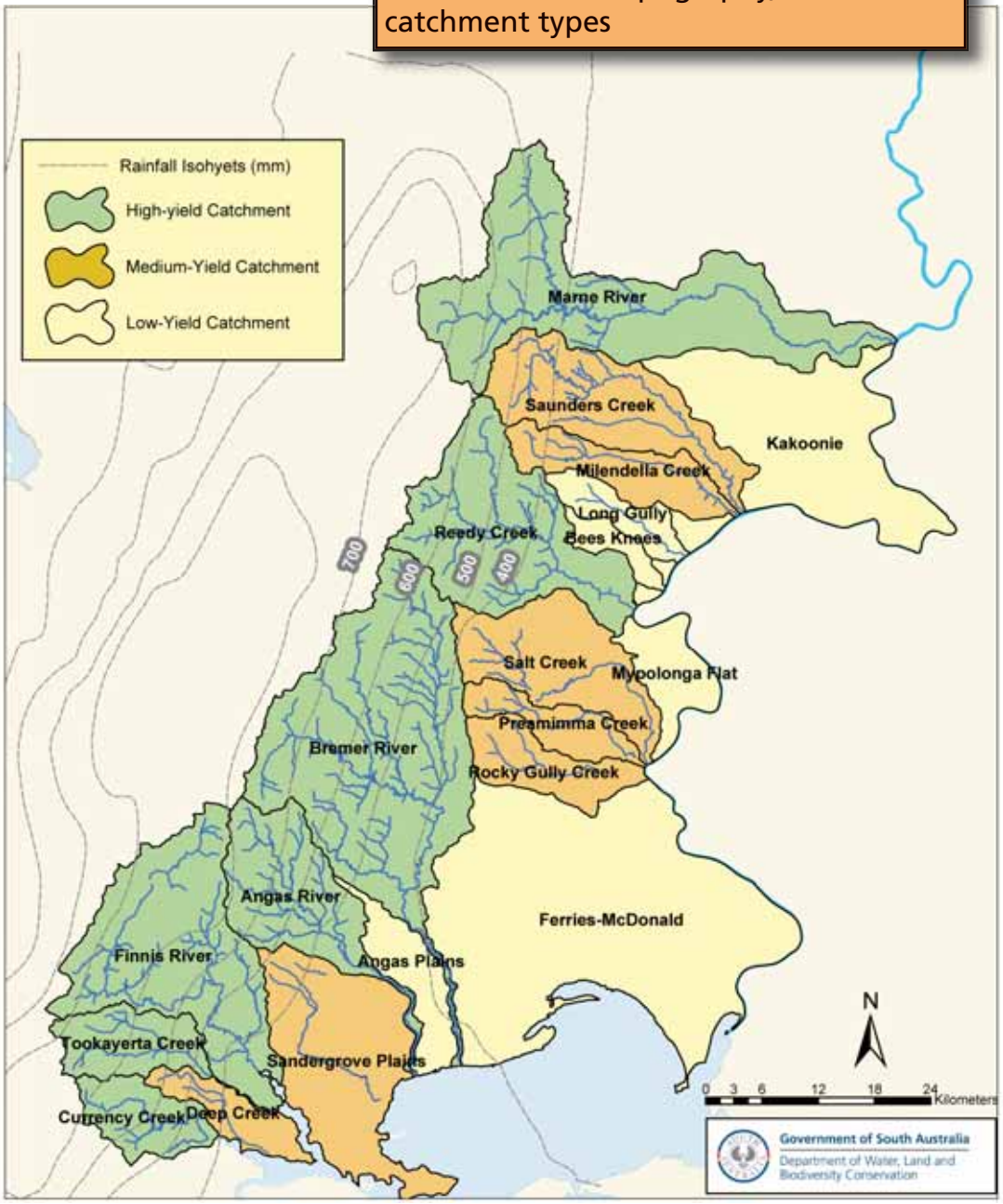
Water level is monitored in streams to calculate stream flow, and in pools in streams for ecological assessment purposes. In the EMLR, water level is monitored at all the stream flow monitoring sites operated by DWLBC. Water level monitoring sites in pools (in streams) were established in the recent past by the RMCWMB in some of the catchments.

5.3.3 STREAM FLOW

Stream flow monitoring is primarily carried out to determine the catchment yield, which is the volume of water leaving the catchment area and to characterise the flow regime.

Figure 2: EMLR catchment characteristics - surface water: topography, rainfall and catchment types





Stream flow gauging stations in the EMLR are operated by DWLBC in the Marne, Bremer, Angas, and Finnis River catchments. They were initially set up with the objective of long-term stream flow monitoring from the major yielding sections of the catchments (Ambient Monitoring Type, as defined in Table 3).

Catchments in the EMLR are currently under a 'Notice of Prohibition' and may eventually be prescribed. Once prescribed, data from the stream flow stations will be used for preparing Water Allocation Plans for the catchments. Hence, monitoring in those stations might be for 'Regulatory/Compliance' purposes in addition to their current 'Ambient Monitoring' purpose.

Stream flow monitoring involves:

- continuous monitoring of water level in the stream
- establishment of a 'rating' (water level to stream flow relationship) for the site
- periodical monitoring of stream velocity to establish and update the 'rating' for the site.

5.3.4 STORAGE AND USAGE

Some of the surface water runoff is stored in farm dams and used for domestic, stock and irrigation purposes. Farm dam development in the higher rainfall uplands of the EMLR has considerably increased in the last few decades due to intensified agriculture and viticulture.

Spatial information (location and surface area) on farm dams in the EMLR was obtained from digitised ortho-rectified aerial photographs taken during 2001. Storage capacities of farm dams were estimated using a relationship between digitised surface area and farm dam capacity.

Water usage from farm dams (obtained from meter readings) is available for the Marne catchment for the 2002–03 and 2003–04 irrigation seasons. When the EMLR is eventually prescribed, water usage data will be available for all the catchments.

All data related to farm dams in the EMLR and water usage in the Marne catchment are available from DWLBC.

Table 5 provides a list of all categories of current surface water quantity monitoring. As shown in the table, rainfall is monitored in all the high-yield catchments, while there are no evaporation sites. Stream flow is monitored in four of the seven high-yield catchments, while water level for environmental purposes is monitored in most of them.

5.4 CURRENT SURFACE WATER QUALITY MONITORING

The major water quality issues that have been identified are salinity, nutrients and turbidity.

Water quality monitoring is occurring in various ways by various agencies. Such as continuously recorded salinity and Composite and Ambient water quality monitoring which use specific parameters for assessment of water quality. Physical, chemical and biological parameters are used together with macroinvertebrate and other biological monitoring indicators to provide information on the health of aquatic ecosystems (see also Section 4.4 Aquatic Ecosystems).

Table 5. Current surface water quantity monitoring sites in the EMLR.

Catchment	Current Monitoring Sites			
	Rainfall	*Evaporation*	*Streamflow*	*Eco-water level*
High-Yield Catchments				
Marne River	●		●	●●
Reedy Creek	●●			●
Bremer River	●●		●●	
Angas River	●●		●●	●●
Finnis River	●●		●	●●
Tookayerta Creek	●			●
Currency Creek	●			●
Medium-Yield Catchments				
Saunders Creek				●●
Milendella Creek				
Salt Creek	●			
Preamimma Creek				
Rocky Gully Creek	●●			
Sandergrove Plains	●●			
Deep Creek				
Low-Yield Catchments				
Kakoonie				
Long Gully				
Bees Knees				
Mypolonga Flat				
Ferries-McDonald	●●			
Angas Plains	●			

● – One Site.

●● – More than one site.

Refer to Appendix H for more details on each monitoring site.

5.4.1 CONTINUOUS SALINITY MONITORING

Continuously recorded salinity monitoring is carried out by the use of temperature and electrical conductivity (EC) sensors in the field.

Most continuously recorded salinity monitoring is carried out at sites funded by the RMCWMB for the Marne River and Saunders Creek catchments, almost all of which also feature water levels monitoring. Some salinity monitoring is also done by PIRSA in relation to the Brukunga mines monitoring sites and by DWLBC in the Bremer River catchment at sites where water levels monitoring also occurs.

Table 6. Outline of the current parameters being monitored by relevant agencies.

	Parameters		Agency
Continuously Recorded Salinity Monitoring	Electrical Conductivity		RMCWMB
	Water Temperature		DWLBC
Composite Monitoring	TDS	Lead	PIRSA
	pH	Zinc	
	Conductivity	Iron	
	Sulphate	Nickel	
	Cadmium	Aluminium	
	Chromium	Manganese	
	Copper		
Ambient Monitoring	*General Data*	Bicarbonate	EPA
	pH	Chloride	
	Temperature	Fluoride	
	Organic Carbon	Sulphate	
	Dissolved Oxygen		
	Total Dissolved Solids	*Nutrients*	
	Conductivity	Nitrate	
		Nitrite	
	Physical Char.	Soluble and Total Phosphorus	
	Turbidity	Total Kjeldahl Nitrogen (TKN)	
	Colour		
		Metals	
	Calcium	Aluminium	
	Magniesium	Copper	
	Potassium	Iron	
	Sodium	Lead	
		Zinc	
		Macroinvertebrates	

5.4.2 COMPOSITE WATER QUALITY MONITORING

Composite monitoring is carried out by extracting a set sample volume from the stream every time a predetermined volume of flow passes the sampling point. Each sample is placed in a single composite container and at the end of the sampling period (between 2–6 weeks) the container is stirred and one representative sample is removed for analysis. Loads are calculated by multiplying the average concentration of each parameter by the continuous flow record from that site.

Composite water quality monitoring is carried out by PIRSA at two sites that relate to the Brukunga Mine in the Bremer River Catchment and by the RMCWMB in the Angas, Bremer, Finnis and Marne Rivers.

5.4.3 AMBIENT WATER QUALITY MONITORING

The EPA carries out ambient water quality monitoring to satisfy legislative requirements to report on the state and condition of the State's waters and to identify trends (EPA, 2005) within the Angas River (d/s Strathalbyn), Marne River, Bremer River and Finnis River catchments.

5.5 GAPS AND OVERLAPS IN MONITORING

5.5.1 SURFACE WATER QUANTITY

Rainfall and Evaporation

Gaps identified in rainfall monitoring are grouped into two categories.

1. Catchments with no current rainfall monitoring – as shown in Table 5, there are no rainfall monitoring sites in most of the medium and low-yield catchments viz. Saunders Creek, Kakoonie, Milendella Creek, Long Gully Creek, Bees Knees Creek, Mypolonga Flat, Preamimma Creek and Deep Creek catchments; and
2. Catchments that require additional rainfall monitoring – these are catchments in which rain gauges are currently operational but are not sufficient to represent the high variation of rainfall within the high-yield catchments viz. Marne River, Reedy Creek, Tookayerta Creek and Currency Creek catchments.

There are no evaporation monitoring sites currently operational in any of the catchments in the EMLR region.

Stream Flow

Gaps identified in stream flow monitoring are grouped into the following three types:

1. Catchment Yield Data – stream flow data to determine catchment yields is available for the Marne River, Bremer River, Angas River and the Finnis River catchments. The remaining catchments in the EMLR are not monitored for stream flow for determining catchment yields.
2. Sub-catchment Yield Data – the existing stream flow gauging stations in the EMLR currently monitor flow from only a section (high-yielding) of the high-yield catchments.

Gaps identified are:

- Stream flow data for tributaries upstream of the existing gauging stations to determine sub-catchment yield, for example the Marne catchment; and
- Stream flow data to determine sub-catchment yield of other ungauged tributaries within a catchment, for example the Finniss, Angas and Bremer River catchments.

Data collected on a sub-catchment level is crucial for water allocation planning, particularly in the high-yield and medium-yield catchments.

3. Catchment Outflow Data – Currently there is no stream flow monitoring at/near the outlet of the catchments to determine the catchments' total yields and the quantity and frequency of flows from the catchments into the River Murray/Lake Alexandrina. Such

data is also required for regulatory purposes, as total catchment yields are required for water allocation purposes once the catchments are prescribed.

5.5.2 SURFACE WATER QUALITY

Continuous Salinity Monitoring

Currently, there is no continuous salinity monitoring in streams occurring within the following catchments: Reedy Creek, Salt Creek, Rocky Gully Creek, Ferries-McDonald, Angas River, Angas Plains, Sandergrove Plains, Finnis River, Tookayerta Creek, Currency Creek, Mypolonga Flat, Preamimma Creek, Kakoonie, Milendella Creek, Long Gully, Bees Knees and Deep Creek.

Ambient Water Quality Monitoring

No ongoing Ambient water quality monitoring is occurring in the Saunders Creek, Reedy Creek, Salt Creek, Rocky Gully Creek, Ferries-McDonald, Angas River, Angas Plains, Sandergrove Plains, Tookayerta Creek, Currency Creek, Mypolonga Flat, Preamimma Creek, Kakoonie, Milendella Creek, Long Gully Creek and Bees Knees Creek catchments for natural streams.

5.6 FUTURE DIRECTIONS FOR SURFACE WATER MONITORING

5.6.1 STRATEGIC ISSUES FOR DISCUSSION IN RELATION TO SURFACE WATER QUANTITY MONITORING

Proposed future directions for surface water quantity monitoring are presented in two sections:

1. Surface water quantity parameters that are required to be monitored, based on monitoring objectives defined in Section 5.1.
2. Prioritisation of monitoring of those parameters on a catchment-scale, based on prioritisation of objectives described in Section 5.2.

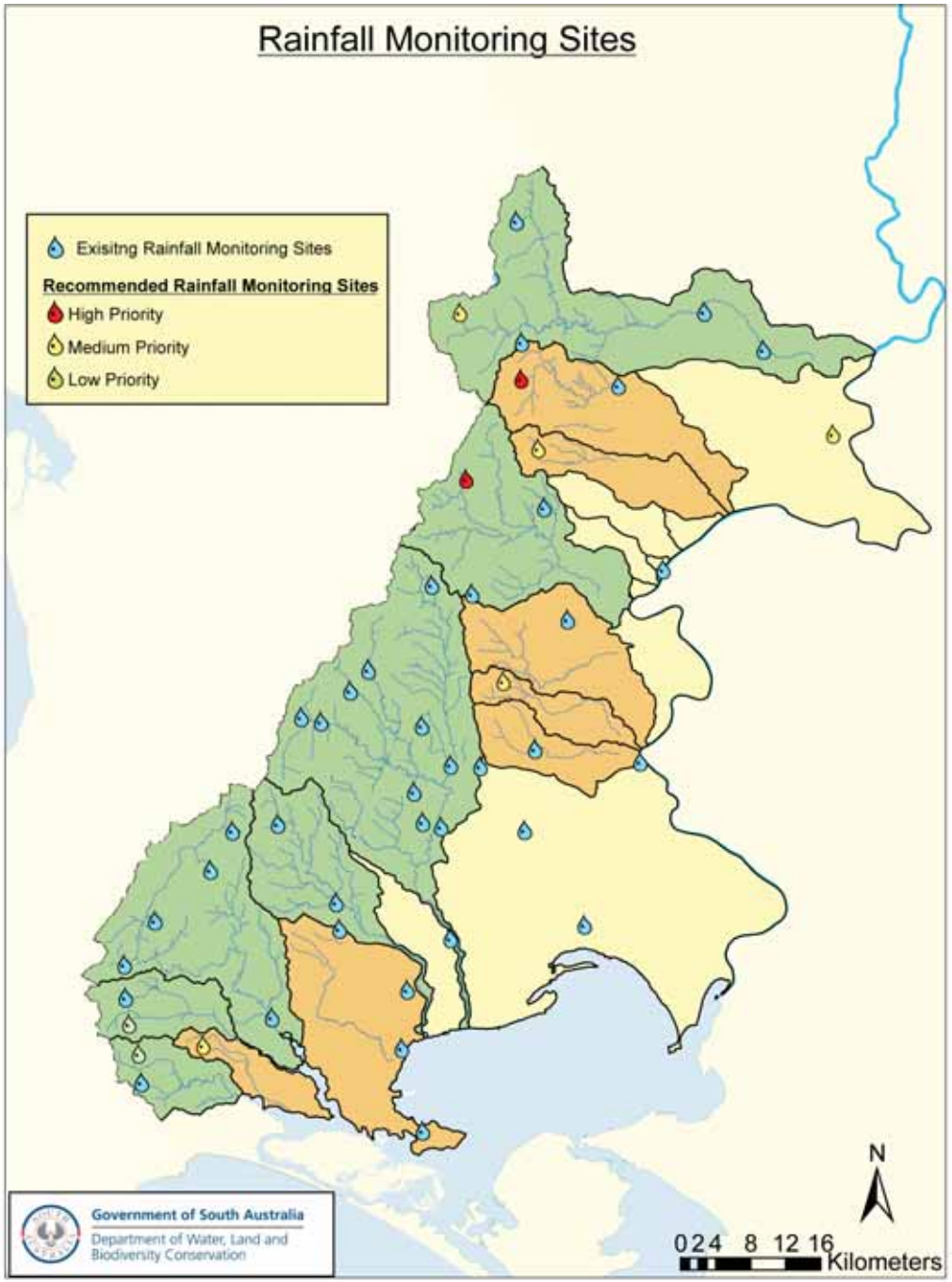
A description of the proposed surface water quantity parameters to be monitored is provided below (see Fig. 3).

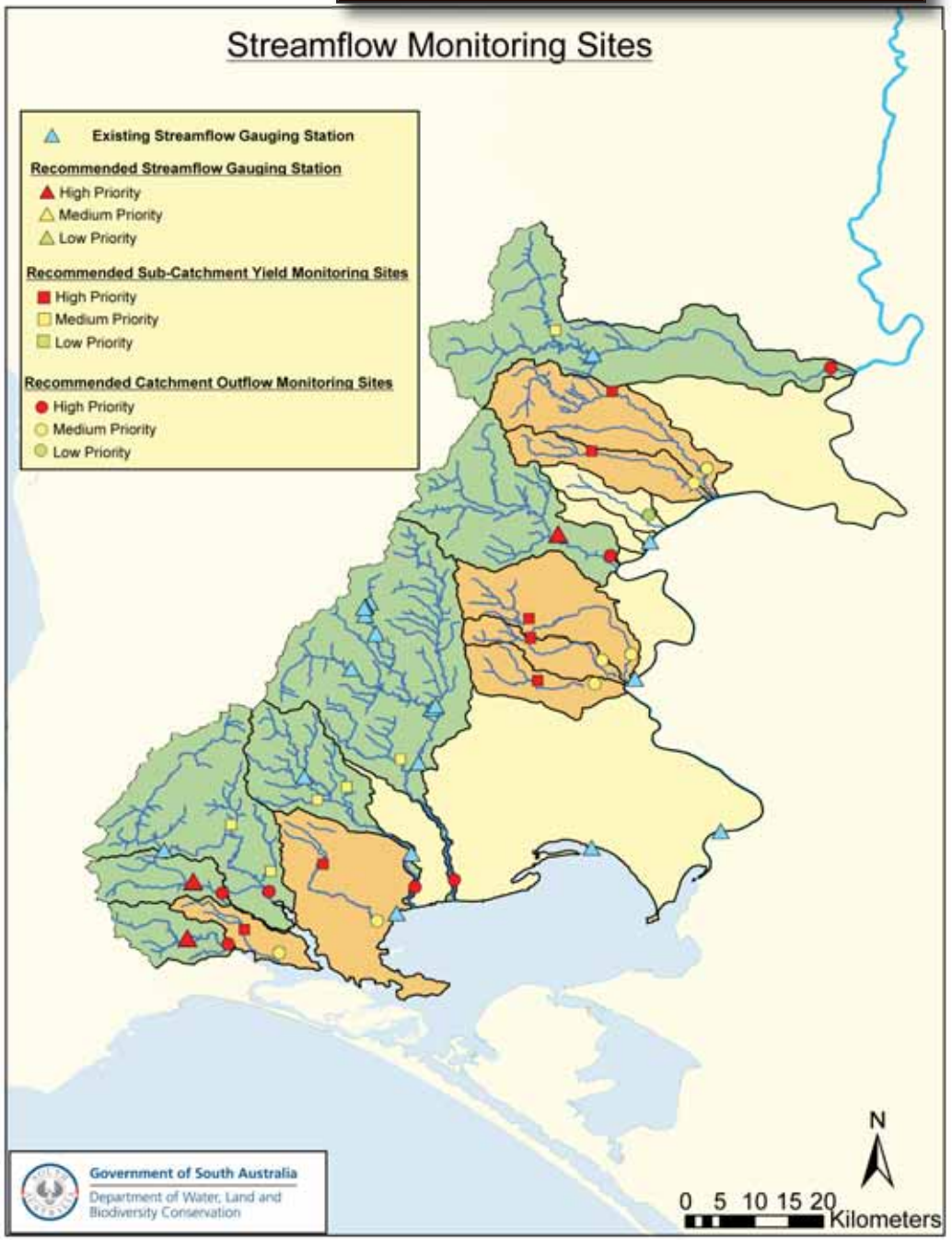
Rainfall

Primary Station

This refers to the minimum requirement of one rainfall monitoring station representing the high-yielding area of the catchment. While monitoring can be (a) on a daily time scale or (b) on an instantaneous timescale using a pluviometer, the latter is suggested as it also provides rainfall intensity data, for example in Saunders Creek catchment.

Figure 3: Proposed future surface water quantity monitoring sites





Distribution

This refers to the requirement for rainfall monitoring at different sites within a catchment to represent its variable distribution within the catchment. This would be in addition to the Primary Rainfall Station, and instantaneous recording with pluviometer is suggested, for example in low rainfall areas in most of the EMLR catchments.

Stream flow

Catchment Yield

The refers to the requirement for stream flow monitoring similar to the existing stream flow gauging stations, for example in the Reedy Creek catchment.

Sub-catchment Yield

This refers to the requirement for stream flow monitoring in:

High-Yield Catchments

In tributaries upstream of the existing gauging station(s) to determine sub-catchment(s) yield(s). For example Marne catchment in the North Rhine tributary upstream of the existing gauging station.

In other ungauged streams within the catchment, for example Finniss, Angas and Bremer River catchments in the tributaries downstream of the existing gauging station(s).

Medium-Yield Catchments

Medium-yield catchments downstream of the high-yielding 'hills zones' For example Saunders Creek catchment.

The primary purpose of sub-catchment yield monitoring is to get an estimate of the proportion of flows from different sub-catchments within a catchment. Hence, such monitoring sites do not necessarily have to be established with long-term stream flow gauging stations similar to the exiting ones (with a calibrated concrete weir and housing for equipment).

Short-term (maximum five years) monitoring involving (a) continuous water level monitoring with simple in-steam water level recorders and (b) stream flow gaugings covering the low, medium and high ranges is suggested at these monitoring sites.

This form of data on a sub-catchment level will enhance water allocation planning on a sub-catchment scale, which is particularly important in the high-yield and medium-yield catchments.

Catchment Outflow

This refers to the requirement to (a) determine the catchment's total yields (b) measure quantity and frequency of catchment flows into the River Murray/Lake Alexandrina (c) estimate stream losses/gains in the "Plains Zone" of the catchment and (d) better understand surface water – groundwater interactions in the "Plains Zone".

Monitoring methodology proposed for catchment outflow monitoring would be the same as explained previously in 'Sub-catchment Yield Monitoring' Section.

Prioritisation of Proposed Monitoring Parameters

Monitoring parameters defined in the previous section were prioritised based on catchment categorisation (high, medium or low-yield). Catchment categorisation, as explained in Section 5.2 Prioritisation of Objectives, was based on catchment characteristics and their resource condition. Monitoring requirements and priorities for catchments in the EMLR are listed in Table 7, referring to high (H), medium (M) and low (L) priorities and explained in Appendix H.

Table 7. Surface water quantity monitoring recommendations.

	Rainfall		**Streamflow**		
	Primary Station	*Rainfall Distribution*	*Catchment Yield*	*Sub-Catchment Yield*	*Catchment Outflow*
High-Yield Catchments					
Marne River		● M		● M	● H
Reedy Creek		● H	● H		● H
Bremer River				● M	● H
Angas River				● M	● H
Finnis River				● M	● H
Tookayerta Creek		● L	● H		● H
Currency Creek		● L	● H		● H
Medium-Yield Catchments					
Saunders Creek	● H			● H	● M
Milendella Creek	● M			● H	● M
Salt Creek				● H	● M
Preamimma Creek	● M			● H	● M
Rocky Gully Creek				● H	● M
Sandergrove Plains				● H	● M
Deep Creek	● M			● H	● M
Low-Yield Catchments					
Kakoonie	● M				
Long Gully, Bees Knees					● L
Mypolonga Flat, Ferries-McDonald, Angas Plains					

5.6.2 STRATEGIC ISSUES FOR DISCUSSION IN RELATION FOR SURFACE WATER QUALITY MONITORING

The EPA's Ambient and Macroinvertebrate monitoring programs are the only water quality monitoring in natural streams that analyses parameters other than salinity (apart from the PIRSA Composite sites in relation to the Brukunga Mine). It is therefore suggested that a complete revision of water quality monitoring for the EMLR Catchment be carried out.

Monitoring of the parameters pH, turbidity, *E. coli*, NOx (oxidised nitrogen), FRP (filterable reactive phosphorous), TP (total phosphorous), and reactive silica, should occur at selected sites. Salinity monitoring should be expanded within the catchment. Also, insecticides and herbicides should be monitored in terms of their impact on aquatic ecosystems and human health. The combination of increased nutrients and low flows create ideal conditions for algal bloom outbreaks to occur and relevant monitoring (i.e. chlorophyll and algal counts) should occur in conjunction with other water quality monitoring.

Continuous Salinity Monitoring

It is suggested that salinity monitoring be expanded for priority catchments where it is not currently occurring. High priority catchments for salinity monitoring are Currency Creek, Reedy Creek, Tookayerta Creek and Deep Creek. Second priority catchments would appear to be Milendella Creek, Salt Creek, Preamimma Creek, Rocky Gully Creek and Sandergrove Plains. Long Gully Creek and Bees Knees Creek were considered to be third priority catchments for salinity monitoring.

DWLBC was monitoring salinity (and water level) for the Angas River catchment at “Angas River at Angas Plains” (AW426629). However, due to severe erosion problems under the weir the station was closed. At ”Angas River at Angas Weir” (AW426503) DWLBC is monitoring water level. As this site is related to the closed site AW426629 in terms of fulfilling water levels monitoring, it is proposed that DWLBC also carry out salinity monitoring at this site to replace the salinity monitoring that was occurring at AW426629.

Within the Finnis catchment DWLBC is monitoring water levels at “Finnis River at 4 km East of Yundi” (AW426504). It is proposed that DWLBC include salinity monitoring at this site. Within the Tookayerta catchment, a new RMCWMB-funded site “Tookayerta Creek at d/s Nangkita Creek” (A4261020) is having flow velocity measured and DWLBC is testing flow sensors at this site. It is proposed that salinity be included in ongoing monitoring at this new site.

Ambient Water Quality Monitoring

The EPA has conducted a review of Ambient Water Monitoring in SA (EPA Water Quality Monitoring Programs, A Review EPA 2005). The report identifies pesticide study hotspot and passive sampling as a high priority activity. Medium priority activities include: an assessment of historical pollution loads in the lower River Murray, water quality requirements of unique habitats and macroinvertebrate response to land use pressures. The report also identifies that there should be additional fortnightly monitoring of *enterococci* and *E. coli* at Mannum and Murray Bridge. To enable more targeted monitoring programs, the EPA recommends that modelling of the River Murray is required; this would also lead to results being more adequately interpreted.

6. GROUNDWATER MONITORING

6.1 OVERVIEW OF CURRENT GROUNDWATER MONITORING

Aquifer systems vary throughout the EMLR ranging from fractured rock aquifers dominating the Hills Zone to sedimentary aquifers in the Plains Zone. In the hills area, groundwater trends usually follow winter rainfall where wet winters will cause a rise in the watertable and dry winters will result in a falling watertable. On the plains, recharge from stream flow is the main influence on groundwater levels due to low recharge from rainfall. About 75% of the EMLR region is underlain by aquifers with salinities too high and yields too low for irrigation. Groundwater quality does tend to improve around surface recharge areas, as in the case of the Angas, Bremer and Marne Rivers.

In areas with groundwater yields and salinity levels suitable for further development, those being in the western and southern sections of the region, the major risks of further uncontrolled development are declines in groundwater levels as well as increases in salinity as a result of lateral movement of more saline groundwater from nearby areas. In addition, the hydraulic properties of fractured rock aquifer systems are complex and not well understood and need investigation to aid in developing sustainable management strategies.

Several individual catchments where groundwater development is significant, are described below:

Angas-Bremer Prescribed Wells Area (PWA)

Extraction of groundwater from the confined limestone aquifer for irrigation of vines, fruit trees, vegetables and lucerne caused a steady decline in groundwater levels in this area until groundwater allocations were reduced by using water from Lake Alexandrina in 1996, thus reducing stress on the aquifer. The groundwater reserves that are of useful quality are managed under a Water Allocation Plan (WAP) that is designed to protect their availability and quality. It now appears that pressures are returning to a similar level to that of pre-irrigation times.

Marne River Catchment

Most of the groundwater extracted for stock, domestic and increasing irrigation in this catchment is limited to a narrow strip centred along the Marne River on the plains and is obtained from a limestone aquifer. A moratorium has been placed on the Marne River catchment's groundwater resources due to concerns over potential overuse and a lack of understanding of subsequent impacts upon aquatic ecosystems. A sustainable yield for the aquifers and a Water Allocation Plan are currently being developed.

Saunders Creek Catchment

The limestone aquifer on the plains is developed mostly for stock and domestic purposes, with groundwater extraction almost non-existent, mainly because of low yields. It is

considered that future groundwater development is unlikely due to high salinity levels and low yields in this catchment. Falling groundwater levels are the result of lack of recharge due to several dry years rather than over-pumping.

Tookayerta Catchment

The Tookayerta Catchment is surrounded by basement rocks forming resistant hills, with most of the lower parts of the catchment underlain by a thick sequence of the Permian Sand aquifer (>150 m). Because of the sandy soils, recharge is high resulting in very low groundwater salinity levels. A preliminary water balance indicates significant volumes available for development with the major constraints being slope and soil type.

Because of the close groundwater/surface water interaction and important wetlands in the catchment, conjunctive management is required to ensure that additional groundwater development does not significantly impact on groundwater dependent ecosystems. Although there was increasing pressure on the aquifer to irrigate dairy pasture, berries and vineyards in this area until the moratorium was established in 2004, groundwater levels in this catchment are relatively stable. The relationship between recharge, water use and surface water flows in relation to this groundwater systems is not fully understood.

Groundwater is extracted in the Tookayerta catchment to supply water to Mount Compass and is the only area in the EMLR where groundwater is extracted for a town water supply. SA Water carry out full chemical monitoring for both town water supply bores every six months, with bacteria testing every month.

Currency Creek Catchment

The Currency Creek catchment is dominated by fractured rock aquifers which form resistant hills. The broader valleys near the western and eastern boundaries of the catchment are infilled with the Permian Sand aquifer where low salinity groundwater can occur in areas of higher rainfall. Where significant thicknesses of Permian sediments occur, large yields can be expected, provided that the aquifer sands are not too fine-grained to be screened effectively. For the remainder of the catchment a limited potential exists for further development.

Finnis Catchment

The Finnis Catchment extends almost across to the western margin of the Mount Lofty Ranges and includes all major aquifers, fractured rock and sedimentary. The most intensively used aquifer is the Permian Sand along the Finnis River to the south of Ashbourne. Monitoring of water levels has shown no adverse impact from current development, however if demand was to increase, this resource could be potentially at risk of over exploitation.

Elsewhere in the catchment, where salinities and yields from the Permian Sand are suitable, irrigation has occurred (mainly for vineyards), especially on the eastern slopes of the ranges near the Finnis River. The main risk in these areas is the localised impact from concentrated extractions in areas of low salinity. Fractured rock aquifers are variable in salinity and yield with no current concentrated areas of irrigation.

Deep Creek Catchment

The confined limestone aquifer (the same aquifer developed in the Angas-Bremer PWA) extends beneath the catchment on the plains with moderate use currently for lucerne and vineyard irrigation. Further irrigation expansion could induce lateral inflows of more saline groundwater. Isolated occurrences of low salinity and good yield exist in the areas underlain by Permian sands on the eastern slopes of the ranges.

6.2 CURRENT GROUNDWATER QUANTITY MONITORING

DWLBC undertakes the majority of groundwater monitoring for levels which has occurred in areas of concentrated groundwater development (see Fig. 4). Groundwater levels are generally read on a six-monthly basis to obtain seasonal peaks and troughs. Networks are established in the Angas Bremer and Marne Saunders Prescribed Wells Areas, the Bremer River catchment (Mt Barker–Littlehampton area), Angas River catchment (Macclesfield area), Finnis River catchment (Ashbourne area), Tookayerta Creek catchment and the Deep Creek catchment.

It appears that the current groundwater monitoring program for levels has no significant deficiencies, but should be expanded to include new areas of groundwater development if they occur.

6.2.1 FARM DAMS

The impact of farm dams on reductions in surface flow, and hence reductions in groundwater recharge needs to be investigated. A report Surface Water Assessment of the Upper Finnis Catchment (Savadamuthu 2003) describes the results of a study of the impact of farm dams on surface water flows.

6.3 CURRENT GROUNDWATER QUALITY MONITORING

6.3.1 SALINITY

Groundwater salinity monitoring is currently being carried out by DWLBC in the Angas-Bremer and Marne-Saunders Prescribed Wells Areas, the Bremer River catchment (Mt Barker to Littlehampton area), Angas River catchment (Macclesfield area) and the Deep Creek catchment (see Fig. 5).

6.4 GROUNDWATER LEVELS AND DRYLAND SALINITY

Groundwater levels monitoring is also carried out in areas of shallow water tables to determine areas at risk to dryland salinity and biodiversity decline, as well as the effectiveness of mitigation strategies to reduce recharge. Catchment and LAP groups, and PIRSA have been monitoring isolated networks in several EMLR catchments on an irregular

Figure 4: Current groundwater quantity monitoring sites in the EMLR

Figure 5: Current groundwater quality monitoring sites in the EMLR

basis. This monitoring has occurred in the upper Marne River catchment (Keyneton), Reedy Creek catchment (Tungkillo), Bremer River catchment (Harrogate and sub-regional network), Finnis River catchment (Hope Forest) and on the plains of the Murray Basin (Sandergrove, Point Sturt and Brinkley).

6.5 GAPS AND OVERLAPS IN MONITORING

6.5.1 WATER USE

Groundwater extractions for irrigation are being metered in the Angas-Bremer and Marne-Saunders Prescribed Wells Areas. If and when the EMLR region is eventually prescribed, metering of such extractions will extend throughout the region.

6.5.2 WATER BALANCES

Water balances for most of the EMLR catchments are not available, mainly due to the lack of stream gauging information. This makes it difficult to properly assess the impacts of water use. Preliminary estimations of water balances have been calculated for parts of the Bremer, Angas and Finnis River catchments and Tookayerta and Currency Creek catchments as sufficient data exists for these areas. Results have been reported in Zulfic and Barnett (2003).

6.6 FUTURE DIRECTIONS FOR GROUNDWATER MONITORING

6.6.1 STRATEGIC ISSUES FOR DISCUSSION IN RELATION TO GROUNDWATER QUANTITY MONITORING

In relation to the Angas-Bremer Prescribed Wells Area, it is suggested that surface water/groundwater interactions be investigated for the Angas and Bremer Rivers to gain a better understanding of recharge rates from stream flow.

It is proposed that investigations into the relationship between surface water and groundwater for the aquifer system in the Tookayerta catchment be carried out to aid in understanding the local impacts of any further development on groundwater dependent ecosystems.

It is suggested that surface water/groundwater interactions be investigated for the Finnis River, Deep Creek and Currency Creek catchments, with consideration of the impacts of forestry on the groundwater systems and the impacts of groundwater development on groundwater dependent ecosystems.

Farm Dams

It is suggested that studies such as the 'Surface Water Assessment of the Upper Finnis Catchment' (which is a report that describes the results of a study of the impact of farm dams on the surface water resources of the Upper Finnis catchment), be carried out for all catchments with a significant number of farm dams or with large farm dams to determine their potential impacts on recharge to groundwater.

Water Use

It is suggested that water use in relation to the various land use practices should be monitored by DWLBC in partnership with PIRSA for the remainder of the catchment not covered by the previous suggestion. The approach has been to identify land use and an associated assumption about how much water is needed for irrigation, then look at surface water captured in farm dams and assume the remainder of water used comes from groundwater. However, there is much variability between application rates that needs to be studied more closely as well as a variation in land use practices between individual landholders growing the same crops.

Water Balances

It is proposed that appropriate monitoring and investigations be carried out to calculate water balances for all catchments. This will require the establishment of stream gauging stations in all appropriate catchments.

6.6.2 STRATEGIC ISSUES FOR DISCUSSION IN RELATION TO GROUNDWATER QUALITY MONITORING

Groundwater quality monitoring has been identified as an area that needs to be developed. The data is seen as a requirement of major stakeholders such as DWLBC, EPA, SA Water and RMCWMB in conducting their core business.

Impacts of poor groundwater quality are not limited to salinity and/or groundwater dependent ecosystems. Numerous surface waters receive baseflow from groundwater systems without being dependent upon these flows (for example Lake Alexandrina). Significant groundwater pollution may in turn have a considerable impact upon these systems and whilst the priority of this monitoring is likely to be low, it is important to recognise this risk.

It is suggested that salinity monitoring also be carried out in Saunders Creek, Reedy Creek, Finnis River, Tookayerta Creek, Currency Creek and Deep Creek catchments as these areas have groundwater dependent ecosystems of significance (Table 8) and some of these catchments may be subject to further development of groundwater due to the higher quality of the resource.

Monitoring for the eastern catchments that presently lack groundwater levels and salinity monitoring, i.e. Long Gully, Bees Knees, Salt, Preamimma and Milendella Creek catchments, is not considered necessary due to the high salinity levels and consequent lack of use of the resource in these areas. At least in terms of prioritisation of plans for monitoring and in relation to aquatic ecosystems monitoring, these areas also do not contain groundwater dependent ecosystems of significance.

Dryland Salinity

Monitoring of existing networks in the Keyneton, Tungkillo, Harrogate, Sandergrove and Point Sturt areas should continue. Networks should be established at Monarto and Callington, with a small network in the Brinkley area expanded to the east and west (Liddicoat and Dooley, 2004, 2005).

7. AQUATIC ECOSYSTEMS

7.1 OVERVIEW OF AQUATIC ECOSYSTEMS

Aquatic ecosystems support a diverse range of native flora and fauna, including numerous threatened species. Aquatic ecosystems comprise complex interactions between plants, animals and the physical, chemical and climatic characteristics of the environment in which they occur. The health of aquatic ecosystems is affected by, and thus provides a measure of, the health of the surrounding catchment. A number of methods can be used to monitor and assess the health of aquatic ecosystems. Biological indicators assess the numbers, health, ecological functions, or life cycles of living organisms. Living organisms are considered to be among the best indicators of ecosystem health as they integrate the many effects caused by changes in the physical and chemical characteristics of the environment (Lopez and Dates, 1998).

The following sections discuss commonly assessed indicators in the Eastern Mt Lofty Ranges region.

7.1.1 FISH

Fish have significant recreational, economic and social values and of all aquatic biota have the highest public profile (MDBC, 2004). Fish have a number of advantages as bioassessment tools which include: being relatively long-lived and mobile, fish provide good indicators of long-term and broad spatial impacts; fish communities include a range of trophic levels (herbivores, omnivores and carnivores) and the ecology of Australian fish is relatively well known (Harris 1995).

7.1.2 MACROINVERTEBRATES

Macroinvertebrates play a central role in the ecology of Australian aquatic ecosystems. They are ubiquitous and diverse (Williams 1980; Lake 1982; Pearson et al. 1986) and with their variety of feeding habits form many of the key links in aquatic food chains (Chessman 1986). Macroinvertebrates are generally sedentary and may live from a few weeks to a number of years (Marchant 1986) meaning that their communities recover slowly if damaged by disturbance (Chessman 1995). A diverse community of macroinvertebrates is often indicative of a healthy aquatic ecosystem. An ecosystem under stress will be home to a greater number of more stress tolerant (e.g. pollution) macroinvertebrate species, whereas a healthy ecosystem will have a more even distribution of tolerant and less tolerant species.

7.1.3 DIATOMS

Diatoms are microscopic phytoplankton that occupy a wide variety of habitat niches. They are abundant in almost all aquatic environments and the majority of diatom species are either: attached to a substrate, living on rock surfaces, larger plants, mud, silt and sand; or

less commonly, planktonic (Reid et al. 1995). Diatoms are used as indicators of water quality as they have distinct ecological requirements and are very sensitive to changes in water chemistry (Reid et al. 1995 and references therein). Changes in diatom communities are rapid in response to environmental changes and the response time of diatoms provides a useful intermediate between physico-chemical sampling and the response of higher organisms (Reid et al. 1995).

7.2 CURRENT AQUATIC ECOSYSTEMS MONITORING

7.2.1 FISH MONITORING

Fish monitoring has been carried out in the Eastern Mount Lofty Ranges as part of the Murray-Darling Basin Commission's Sustainable Rivers Audit (SRA). The primary aim of the SRA is to provide consistent information on the health of rivers over the entire Murray-Darling Basin. Fish sampling began in Autumn 2005 at six sites, two in both Currency Creek and Finnis River and one in both Nangkita and Meadows Creeks. Fish sampling will reoccur every three years as part of the ongoing six-year SRA cycle.

Further fish monitoring has been carried out to monitor threatened fish populations (Hammer 2001, 2004a) to assess environmental water requirements (Hammer 2002) and as inventories (Hammer 2004b; Conallin and Hammer 2003). A number of these sites have been re-sampled on an annual basis since at least 2002. Monitoring has included measurement of fish diversity, abundance and population size structure in order to monitor threatened species and to understand responses to flow and habitat change. This work is carried out by Native Fish Australia, in conjunction with the RMCWMB.

Fish monitoring undertaken in the EMLR has been both multivariate and integrated and has been undertaken for a number of purposes including project monitoring and ambient and reference site monitoring.

7.2.2 AusRivAS

AusRivAS is a part of the National River Health Initiative and was carried out by the EPA. This national program monitored river and stream health by studying the type and number of aquatic macroinvertebrates found in a particular river or stream, and comparing results with those obtained from a similar type of river or stream that has not been disturbed or affected by human activities. Macroinvertebrate and diatom samples, and a range of physico-chemical parameters were collected in the autumn and spring of 1994 from across South Australia to determine the condition of the State's rivers and streams. Eighty-one AusRivAS sites were sampled from the EMLR region. A subset of sites sampled for the AusRivAS program forms the basis of the EPA's Ambient and Macroinvertebrate monitoring program (see Macroinvertebrate Monitoring section below).

Results of the AusRivAS sampling can be found at http://www.environment.sa.gov.au/reporting/inland/rivers_streams/healthassess.html#eastern_lofty. AusRivAS used multivariate monitoring to provide State-of-Environment Reporting whilst also providing reference sites.

7.2.3 MACROINVERTEBRATE MONITORING

The EPA's macroinvertebrate monitoring uses an ambient, multivariate monitoring approach. The EPA carries out Ambient and Macroinvertebrate monitoring for the Marne (at Cambrai), Bremer (near Hartley) and Finnis (at Yundi) Rivers. Monitoring began in 1994 and has been carried out in autumn and spring, with the exception of 1996 when no samples were taken. Both edge and riffle samples are collected, however the sites on the Angus and Marne Rivers may be moved due to the recent reduction in riffle habitats (Peter Goonan, EPA, pers. comm.).

Macroinvertebrates are due to be monitored as a part of the SRA, beginning in autumn 2006.

7.2.4 FLEURIEU PENINSULA SWAMPS

A range of monitoring involving Fleurieu Peninsula swamps has been carried out by the Conservation Council of South Australia as part of the recovery program for the endangered Mt Lofty Ranges Southern Emu-wren. The majority of Emu wren populations are found in swamps and subpopulations have been monitored for their abundance since 1994 (ambient monitoring).

Swamp management experiments began in 1997 as a part of the Swamp Management Trial Project. The experiments have been monitored to determine the response of the swamp community to a variety of management perturbations including burning, slashing and grazing and a combination of these processes. This project monitoring has been undertaken using an adaptive management framework. The swamps of the Fleurieu Peninsula are listed under the Environment Protection and Biodiversity Conservation Act (1999) as critically endangered and thus will require a recovery plan. This plan is in draft form and will likely include a monitoring component to assess the long-term condition of the swamps. Further information can be obtained from: http://www.ccsa.asn.au/EmuWren/wren.html.

7.2.5 AERIAL VIDEOGRAPHY

Aerial videography involves capturing geo-stabilised and geo-referenced video data of a watercourse as flown by a helicopter. Aerial videography allows watercourse features to be identified and enables data on stream pool permanency and size to be recorded, along with an assessment of riparian vegetation extent and condition. Aerial videography has been flown for all third order or larger streams in the Eastern Mount Lofty Ranges. Aerial videography was flown in the autumn of 2003 as the location and extent of permanent pools is best identified during periods of low flow. Aerial videography was undertaken by the Knowledge and Information Division of the Department of Water, Land and Biodiversity Conservation and the River Murray Catchment Water Management Board. Aerial videography is a form of multivariate monitoring that has occurred once to provide a State-of-Environment report.

7.2.6 WATER RESOURCE AND ENVIRONMENTAL WATER REQUIREMENTS (EWR) ASSESSMENT FOR THE FLEURIEU PENINSULA

The aim of this DWLBC managed project is to increase the level of knowledge of the state of water resources in the Fleurieu Peninsula (which includes part of the Eastern Mount Lofty Ranges region) as it relates to water dependent ecosystems. The monitoring component of this project uses flow volume in streams as a surrogate measure of aquatic ecosystem health. Modelled flow volume is related to the availability of the resource and the current water regimes that support a number of water dependent ecosystems (Table 8).

Groundwater dependent ecosystems are either partially or wholly reliant on groundwater. Those found in the EMLR include riparian and floodplain vegetation communities, river baseflow systems and standing wetlands with subsurface linkages to the groundwater table.

Table 8. Groundwater dependent ecosystems of the Eastern Mt Lofty Ranges (EMLR).

Catchment	Groundwater dependent Ecosystems
Marne River	Marne Conservation Park Black Hill Springs
Saunders Creek	Lenger Reserve
Reedy Creek	Reedy Creek waterfall
Ferries McDonald	Saline wetlands
Bremer River	Red Gum swamps
Angas River	Springfed headwater for all tributaries
Angas Plains	Red Gums
Sandergrove Plains	Groundwater dependent vegetation
Finnis River	Black Swamp Fleurieu swamps
Tookayerta Creek	Black Swamp Fleurieu swamps
Deep Creek	Black Swamp Fleurieu swamps
Currency Creek	Black Swamp Fleurieu swamps

Monitored via modelled flow volume as a part of the project 'Water Resource and Environmental Water Requirements Assessment for the Fleurieu Peninsula'.

7.3 GAPS AND OVERLAPS IN MONITORING

No overlaps in aquatic ecosystem monitoring were identified in the compilation of this report. This is largely a result of the limited amount of aquatic ecosystem monitoring that has been undertaken to date. It is not surprising then that as little monitoring has taken place, considerable gaps are present. Baseline data was limited to macroinvertebrates, fish, diatoms and data obtained from aerial videography.

7.3.1 ENVIRONMENTAL WATER REQUIREMENTS (EWRS)

There is a lack of information on the environmental water requirements of the Eastern Mount Lofty Ranges aquatic ecosystems. Whilst some information is available such as assessments of EWRs for fish and EWRs were carried out by the River Murray CWMB for some streams, in general detailed ecological information is lacking. Even if these environmental water requirements were known, gaps in streamflow and water quality monitoring would not enable sustainable limits on water extraction, both ground and surface water, to be applied across the region.

7.3.2 GROUNDWATER DEPENDENT ECOSYSTEMS

Groundwater dependent ecosystems are known to be important components of the regions aquatic ecosystems. Whilst the location of some are known, there is a lack of data on the distribution and abundance of the regions groundwater dependent ecosystems. Also there is a lack of information on the extent to which these systems rely on groundwater for their survival, and consequently the extent to which they are affected by altered water regimes.

7.3.3 EPHEMERAL STREAMS

The majority of the streams in the Eastern Mount Lofty Ranges Catchment are ephemeral. Currently our knowledge of these systems is limited. For example there is a significant lack of understanding of the ecological processes and sensitivities of these ephemeral stream environments to altered flow regimes. This presents a significant knowledge gap.

7.3.4 STYGOFAUNA

Groundwater animals are collectively known as ‘stygofauna’. Sytgofauna diversity is high in many parts of Australia (Boulton et al. 2003) and many stygofauna species have restricted distributions and exhibit extreme endemicity (Marmonier et al. 1993). Stygofauna are important in aquifers as they help maintain groundwater quality through the maintenance of interstitial voids, modification of redox gradients, and the promotion of biofilm activity (Humphreys 2002; Gilbert and Deharveng 2002).

No data on the stygofauna of the Eastern Mt Lofty Ranges was found in the preparation of this report. This presents a significant knowledge gap, both to their conservation and the management of the resource.

7.4 FUTURE DIRECTIONS FOR AQUATIC ECOSYSTEM MONITORING

Monitoring will be required to determine if resource condition targets in the State and relevant regional NRM plans are being met. It is beyond the scope of this review to propose specific programmes in this area other than to highlight this need. However such monitoring may fit within the proposed monitoring framework presented as follows.

7.4.1 A CALIBRATED CATCHMENT

In order to adequately manage the aquatic ecosystems of the Eastern Mount Lofty Ranges, aquatic ecosystem monitoring should form part of what Brydges (2004) refers to as a 'calibrated watershed' integrated monitoring programme. In such a programme monitoring strives to develop a detailed balance of the inputs and outputs of water and chemicals along with intensive biological monitoring of the terrestrial and aquatic components of the catchment. The integrated monitoring should be carried out in conjunction with detailed research projects. The research projects themselves would most likely involve their own integrated monitoring component. Such a 'calibrated catchment (watershed)' program of integrated monitoring and research should be designed to detect change within the catchment and explain why such changes are occurring.

Research is required to define environmental water requirements for aquatic ecosystems if the proposed 'calibrated catchment' model were to be developed. Once these environmental water requirements were defined the information needed to meet them would also be known. This information; be it physical, chemical or biological; would have to be gathered via monitoring. In some areas this information may be currently available, in others not. Thus the quantified needs of aquatic ecosystems would determine the extent and type of monitoring required across the region.

In order to determine environmental water requirements in the Eastern Mt Lofty Ranges a number of projects related to monitoring programs are required. Whilst the current 'Water Resource and Environmental Water Requirements Assessment for the Fleurieu Peninsula' project uses modelled flow volume as a surrogate measure for the ecological health of groundwater dependent ecosystems, research is required to quantify the effects of altered water regimes, both surface flow and groundwater on the structure and function of aquatic ecosystems in the region.

Examples include:

- Determine the effects of altered flow regimes due to farm development on aquatic ecosystems. The impacts of farm dams on natural surface flow and therefore on aquatic ecosystems are expected to be greatest in the Angas River, Bremer River, Saunders Creek, and Currency Creek catchments where farm dam development is concentrated.
- An investigation of the impacts of groundwater extraction on the River Red Gum forest in the Marne Valley Conservation Park.
- Investigations into surface water/groundwater interactions may be important in relation to aquatic ecosystem health.

Stygofauna

Basic research is required to determine the composition of the areas stygofauna and the likely effects groundwater extraction will have on this community and the effect this will have on groundwater quality.

Significant Aquatic Ecosystems

Identification of priority aquatic ecosystems for ambient monitoring should be carried out across the catchment. This will integrate the need to monitor the endangered swamps of the Fleurieu Peninsula and Harding's (2005) recommendation that the health of priority wetlands be monitored.

Riparian Vegetation

Most of the native riparian vegetation in the EMLR Catchment is degraded and often dominated by pasture with no overstorey. If restoration of riparian vegetation is undertaken then monitoring will be required to assess its progress and success.

8. AQUATIC ECOSYSTEMS

There are a number of factors that influence the way water and sediment move within a catchment from upland areas into the main channel and then flow to its terminus. Many of these factors are interrelated and they can be used to make predictions of hydrological behaviour within a catchment as well as for making comparisons between catchments. They are an important component of monitoring, understanding and managing hydrological systems. According to Wen (unpublished) it is generally accepted that catchment characteristics affect both surface and groundwater quality, however there is no consistent definition and the list of catchment features can vary from study to study. Table 9, adapted from Gordon et al (2000), offers a number of characteristic definitions, their purpose and their source.

Table 9. Catchment characteristics (adapted from Gordon et al, 2000).

Characteristic	Purpose	Source
Catchment Area	Influences water yield and number and size of streams. Includes all upstream land and water surface area that drains to a particular point on a stream	Topographic Map Catchment Plan
Stream Length	Influences the amount of stream habitat area, travel time of water in a drainage system and availability of sediment for transport	Topographic Map Catchment Plan
Stream Patterns	Aids in the description of a catchment	Topographic Map Aerial Photography/ Videography
Stream Orders	The order number is indicative of the size of the contributing area, channel dimensions and stream discharge. It provides a means of ranking relative sizes of streams	Various methods available Most methods rank the smaller tributaries using a low number
Topography/ Relief Ratio	Drainage density and slope of the upland areas are influenced by the basin relief. Prediction of sediment yields is possible from the relief ratio	Mathematical Equation
Average Channel Slope	One of the factors controlling water velocity	Mathematical Equation
Average Catchment Slope	Influences surface runoff rates	Mathematical Equation
Longitudinal Profile	Describes the way in which stream elevation changes over distance	Mathematical Equation
Aspect	Influences vegetation type, rainfall patterns and wind exposure	Bearing taken in the downhill direction
Climate	Aids in the description of the catchment and influences components of the hydrological cycle	BoM
Characteristic	Purpose	Source
Vegetation Cover	Native and introduced vegetation types to aid in identifying location of habitats	Aerial Photography, Reports DEH, DWLBC
Soils	Water movement through soil, soil erosion, vegetation types	CSIRO, PIRSA
Geomorphology and Hydrogeology	For understanding the hydrological processes in groundwater systems	PIRSA, DWLBC, Department of Mines (now PIRSA)
Land use	Influences water quantity and quality	DWLBC, PIRSA
Demographics	Influences projected land use	Planning SA (now PIRSA)

9. DATA AND INFORMATION MANAGEMENT

9.1 DATA QUALITY

The quality of measurements used for water resource monitoring programs is dependent upon the accuracy of instrumentation, specific site characteristics that may affect readings and thoroughness of the collectors and processors of data. Instrumentation needs to be checked and maintained to obtain good quality data and information on any errors needs to be recorded. Therefore, regular attention to these issues by way of site visits and visual checking of data must occur.

9.2 STORAGE OF SURFACE WATER MONITORING DATA

There is a significant need to centralise surface water monitoring data for all major stakeholders. It is suggested that at least all ongoing monitoring that is done by DWLBC, CWMB, BoM, SA Water and EPA for both quantity and quality be kept on one database or at least provide a portal that links all databases for ease of access.

Ideally water quantity and quality monitoring carried out by other agencies, for example, Ambient and Macroinvertebrate monitoring by the EPA and Catchment Boards should be recorded in an appropriate area on the same database, as well as other forms of water monitoring carried out by major stakeholders.

9.2.1 HYDSTRA DATABASE

This database is managed by DWLBC and has great potential for providing information about surface water monitoring sites. However, there is a significant need to keep records in the database up-to-date which is currently lacking. This relates to metadata and data entered into HYDSTRA with regard to DWLBC monitoring sites as well as sites that relate to other agencies, including Catchment Water Management Boards, Bureau of Meteorology and SA Water. In many cases, stations that are not funded/managed by DWLBC do not have information about gaugings in HYDSTRA.

9.2.2 FREQUENCY OF DATA COLLECTION FOR STREAMFLOW

Monthly averages should be used for studying the seasonal variations in discharge, which are controlled by climate and channel and catchment characteristics. The average daily discharge gives a finer resolution and can be used for determining a relationship between mean daily discharge and ecological features such as fish assemblages. Daily data can also be used to calculate average annual discharge.

9.3 HEALTH OF AQUATIC ECOSYSTEMS DATA MANAGEMENT

Data on the health of aquatic ecosystems that is collected by various agencies including DEH, DWLBC, EPA, CWMBs and community groups needs to be accessible to all stakeholders and some level of integration of this data should be considered.

9.4 EPA LICENSING DATA

Access to EPA licensing data is currently available to stakeholders by request. To expedite access to data, it is proposed that stakeholders have direct access. It is recognised that some data may be commercially confidential and therefore not readily accessible.

9.5 GROUNDWATER DATABASES

Extraction rates of private bores needs to be monitored and the data and associated information entered into the SA Geodata/Obswell managed by DWLBC. In addition, water use information generally should be entered into Obswell. Also, this database should provide an indication of which aquifer is being monitored by relevant bores.

EPA's groundwater quality monitoring data should be available to other stakeholders and possibly integrated with DWLBC's groundwater monitoring database.

9.6 LAND USE DATASET

It is suggested that a standard land use dataset, that is suitable for water resource assessment, be developed by major stakeholders (PIRSA, CWMBs, EPA, DWLBC) and made available centrally.

9.7 INFORMATION ACCESS NEEDS OF STAKEHOLDERS

Agencies which require access to information about monitoring or resource assessment, part or all of which they do not carry out themselves, is presented in Table 10.

Table 10. Information access needs of stakeholders.

What	Who	Why
Surface Water Quantity		
Surface water quantity data	EPA	Relates to water quality monitoring and water for the environment
	Planning SA (PIRSA)	Development planning
	Transport SA	Design of Infrastructure
	Forestry SA	To assist in analysing water quality monitoring data
	RMCWMB	Planning of water allocation to provide for sustainable water use and protection of aquatic ecosystems
	SA Water	Potential impacts on potable water supplies
Water use	RMCWMB	Planning of water allocation to provide for sustainable water use and protection of aquatic ecosystems
	SA Water	Potential impacts on potable water supplies
Surface Water Quality		
Water quality data / assessments	Forestry SA	To monitor impacts of their industry
	Transport SA	Runoff from road surfaces
	Planning SA (PIRSA)	Development planning
	Local Government	Wastewater and stormwater
	RMCWMB	Planning of water allocation to provide for sustainable water use and protection of aquatic ecosystems
	DWLBC	Impacts on ecosystems, water allocation planning and use and sustainable water management generally
Ambient water quality	DHS	To fulfill their role in protection of human health in relation to potable and recreational water use
	DWLBC	To identify and report on risks of degradation of water resources
Point Source pollution	CWMBs	To indicate risks to water resources
	SA Water	To indicate risks to water resources
	DHS	To indicate risks to water resources
	DWLBC	For reporting on risks to water resources, water allocation planning and use and sustainable water management generally
Diffuse pollution assessments	SA Water	Impacts on reservoir water quality
	DWLBC	Impacts on water quality and ecosystems, water allocation planning and use and sustainable water management generally
Groundwater Quantity		
Water Quality Data	RMCWMB	Planning of water allocation to provide for sustainable water use and protection of aquatic ecosystems
Ambient	DHS	Drinking water supplies

What	Who	Why
Aquatic Ecosystems		
Indicators of ecological health of riparian zones	Planning SA	Development Planning
	Forestry SA	Impacts of forestry practices
	DHS	Impact on water quality of potable water supplies and water for recreational use
	DWLBC	For reporting purposes
Water quantity and quality for the environment	SA Water	To protect aquatic ecosystems and as a major water user to protect potential water supply
	DWLBC	To protect aquatic ecosystems
Community Monitoring		
State-wide community monitoring including Waterwatch, Frog Census	DWLBC	For reporting purposes
Catchment Characteristics		
Impacts of changes in land use	DWLBC	Policy development and reporting on water use and impacts upon ecological health
	EPA	Potential impacts on water quality and ecological health
Topography, aspect, stream characteristics, climate, vegetation cover, soils, hydrogeology, geomorphology, land use, demographics	All stakeholders	To assist in the interpretation of water monitoring data and making management decisions
Climate Change, as reported by BoM and CSIRO	All stakeholders	Impacts of water quantity, quality and ecosystems

APPENDICES

A. RELEVANT LEGISLATION

ENVIRONMENT PROTECTION ACT, 1993 (RELEVANT SECTIONS)

Objects of the Act include:

"(b) to ensure that all reasonable and practicable measures are taken to protect, restore and enhance the quality of the environment having regard to the principles of ecologically sustainable development" and

"(vii) to provide for monitoring and reporting on environmental quality on a regular basis to ensure compliance with statutory requirements and the maintenance of a record of trends in environmental quality."

STATE WATER PLAN 2000

The State Water Plan 2000 is the over-arching policy statement for achieving the object of the Water Resources Act 1997.

"The State Water Plan must (s90(3)):

- Assess the state and condition of the water resources of the State.
- Include an assessment of the monitoring of changes in the state and condition of the water resources of the State and include proposals for monitoring those changes in the future."

Table A1. Relevant core indicators for monitoring performance of policy outcomes.

Sustainable water resource allocation	Water resources (surface and groundwater) allocated within sustainable limits
Environmental water provisions implemented	Proportion of waterbodies where environmental water provisions have been implemented versus determined
Catchment health index	Measure of the state of a waterbody when macro-invertebrate assemblages, water quality, water quantity and riparian condition index trends assessed
The amount of water developed each year by industry sector	Trend over time of volume of water abstracted or developed, by industry sector,. This could include traditional and non-traditional water resources
Plan implementation	The degree to which strategies identified within approved plans have been implemented. This indicator can be expressed by type of plan (e.g. WAP, Catchment Plan, LWCMP etc) and presented as an index
Index of management effort	An index of a composite of management activities including policy implementation, monitoring schemes, government and community incentives, catchment management participation and RD&I. A trend over time for the index would reflect activity within each of the five categories
Consistency between planning and policy	Tallies of management plans or policies that are in conflict with one another across jurisdictions

Trend in community participating in monitoring programs	The number of people participating in monitoring programs over time, related to water resource management
Trend in licensing for activities	A tally over time of the number of granted applications by activity to provide information on future potential pressures
Catchments with appropriate data to assess resource sustainability	Trend over time of catchments with appropriate data (defined as sufficient quality data) to report the catchment health index
Roles and responsibilities for water quality monitoring	Progress of implementation of the agreed roles and responsibilities for water monitoring in South Australia

(Also refer to Report on the implementation of the State Water Plan, SA Government for reporting against these indicators).

NATURAL RESOURCE MANAGEMENT ACT 2004

Extracts From The Natural Resource Management Act 2004 (The Act)

An Act to promote sustainable and integrated management of the State's natural resources; to make provision for the protection of the State's natural resources; to make amendments to the Crown Lands Act 1929, the Dog and Cat Management Act 1995, the Dog Fence Act 1946, the Environment Protection Act 1993, the Groundwater (Qualco-Sunlands) Control Act 2000, the Local Government Act 1934, the Mining Act 1971, the National Parks and Wildlife Act 1972, the Native Vegetation Act 1991, the Parliamentary Committees Act 1991, the Pastoral Land Management and Conservation Act 1989, the Petroleum Act 2000, the River Murray Act 2003, the South Eastern Water Conservation and Drainage Act 1992 and the Subordinate Legislation Act 1978; to repeal the Animal and Plant Control (Agricultural Protection and Other Purposes) Act 1986, the Soil Conservation and Land Care Act 1989 and the Water Resources Act 1997; and for other purposes.

In summary, the objectives of the Act (Ch. 2, part 1) are to assist in the achievement of ecologically sustainable development in the State by establishing an integrated scheme to promote the use and management of natural resources. It provides for the protection and management of catchments and the sustainable use of land and water resources and, insofar as is reasonable practicable, seeks to enhance and restore or rehabilitate land and water resources that have been degraded.

Key principles for ecologically sustainable development (Ch. 2, part 1) of the Act include:

(3)(7)

(a) decision-making processes should effectively integrate both long-term and short term economic, environmental, social and equity considerations

(c) decision-making processes should be guided by the need to evaluate carefully the risks of any situation or proposal that may adversely affect the environment and to avoid, wherever practicable, causing any serious or irreversible damage to the environment.

The functions of the minister under the Act include (chapter 3, part 1):

(10)(1)

(a) to keep the state and condition of the natural resources of the State under review

(e) to compile, maintain and update information in relation to the State's natural resources

(f) to promote public awareness of the importance of the State's natural resources and to encourage the conservation of those resources.

The structure includes an NRM Council, eight regional NRM Boards and sub-regional NRM groups.

The functions of the NRM Council include (Ch. 3, division 2, part 2, division 3):

(17)(1)

(b) " to audit, monitor and evaluate the state and condition of natural resources across the State, and to evaluate and report on—

(i) the performance of the NRM authorities established under this Act

(ii) the integration of natural resources management practices on account of this Act."

The NRM Council must prepare and maintain a plan to be called the State Natural Resources Management Plan. The State NRM Plan is to set out principles and policies for achieving the objects of this Act throughout the State (Ch. 4, part 1).

(74)(3) In connection with the operation of subsection (2), the State NRM Plan must—

(a) —

(i) assess the state and condition of the natural resources of the State

(ii) identify existing and future risks of damage to, or degradation of, the natural resources of the State

(iii) provide for monitoring and evaluating the state and condition of the natural resources of the State on an ongoing basis

(b) identify goals, set priorities and identify strategies with respect to the management of the natural resources of the State

(c) set out or adopt policies with respect to the protection of the environment and the interests of the community through the operation of this Act, including through the control of pest species of animals and plants

(d) promote the integrated management of natural resources

(e) include or address other matters prescribed by the regulations or specified by the Minister.

(6) The NRM Council must review the State NRM Plan at least once in every 5 years.

A draft of *South Australia's Natural Resources Management (NRM) Plan (2005–2010)* has been released for consultation.

The Act also requires each NRM board to prepare a water allocation plan for each prescribed water resource in its region (Ch. 4, part 2, division 2,).

(76)(4) A water allocation plan must –

(a) include-

(i) an assessment of the quantity and quality of water needed by the ecosystems that depend on the water resource and the times at which, or the periods during which, those ecosystems will need that water

(ii) an assessment as to whether the taking or the use of water from the resource will have a detrimental effect in the quantity or quality of that is available from any other water resource

(b) provide for the allocation (including the quantity of water that is to be available for allocation) and use of water so that-

(i) an equitable balance is achieved between environmental, social and economic needs for the water

(ii) the rate of use of the water is sustainable.

B. MONITORING STATION CATEGORIES - SURFACE WATER MONITORING

(modified from Greenwood (2001) Surface Water Monitoring MLR report DWR)

Monitoring Type	Description	Station Type	Role	Minimum Parameters	Duration	Frequency of Data Collection	Priority
Ambient Monitoring	Long-term monitoring to establish and continually assess the state of river systems and detect any changes in their condition.	Base Station	To monitor and characterise streamflow from the major yielding section/s of the catchment, basin or region.	Water level / streamflow; salinity (EC and temperature). Possibly rainfall or other climatic parameters as required.	Ongoing (at least 25 years).	Continuous	High
Project Monitoring	Any monitoring linked to project objectives, which may commonly include the collection of detailed data to support ambient monitoring.	Representative Station	Streamflow from areas with particular hydrological characteristics arising from distinct features for example, vegetation types or land-use practices.	Water level / streamflow; salinity (EC and temperature).	Medium term (10 years).	Continuous	As per project priorities, but high to medium in supporting ambient programs.
		Environmental Station	Sites considered significant for monitoring the water requirements of aquatic ecosystems	Usually water level, possibly salinity (EC and temperature); other parameters as required.	Short / medium term (5–10 years).	Project specific	As per project priorities.
		Project Station	Any station designed to collect information for specific objectives, particularly outside the design scope of the “conventional” hydrological assessment network.	As required.	As required, typically 5–10 years.	Project specific	As per project priorities.

Monitoring Type	Description	Station Type	Role	Minimum Parameters	Duration	Frequency of Data Collection	Priority
Regulatory/ Compliance Monitoring	Monitoring to evaluate the impact of regulation or development, often as part of compliance with water management plans, statutory reporting, auditing or law.	System Inflow / Outflow	Relates to streamflow entering or released from heavily developed or regulated river systems and infrastructure, for example in and out of Prescribed Areas and upstream and downstream of reservoirs.	Water Level / streamflow; salinity (EC and temperature). May be subject to other parameters specified in management plan.	For duration of the development or as per the relevant management requirements (years - decades?).	Continuous	High, subject to resource management requirements.
		Basin Outflow Station	Streamflow leaving the catchment, for example, flows into the ocean, inland lakes or interstate. Could arguably be classified as Project type information to augment a conventional network.	Water Level / streamflow; salinity (EC and temperature).	As required for auditing and statutory reporting (5–10 years).	Continuous	High, subject to resource management requirements.

C. SYSTEMIC MODEL FOR WATER MONITORING

(Source: Wen, 2005)

Classification	Parameter	Purposes	Lead Agency	Collaborative Agency	Interested Agency
Water Availability	Rainfall	Analyse rainfall patterns, Climate change management, Forecast flood and drought, Calibrate computer models	BoM	DWLBC, CWMB, SA Water	EPA, PIRSA, DEH
	Rainfall Intensity	Catchment hydrological model, surface/groundwater relationship, climate change management	DWLBC	BoM, CWMB, SA Water	EPA, PIRSA, DEH
	Catchment stream flow	Water allocation; environment flow; aquatic ecosystem health assessment; water quality assessment	DWLBC	EPA, CWMB, SA Water	BoM, PIRSA, DEH
	Sub-catchment stream flow	Environment flow; aquatic ecosystem health assessment; water quality assessment	CWMB	DWLBC, EPA, SA Water	BoM, PIRSA, DEH
	Reservoir weir in/out flow	Reservoir operation	SA Water	NRMB, DWLBC	EPA, BoM
	Reservoir/ weir capacity	Reservoir operation	SA Water	CWMB, DWLBC	EPA, BoM
	Evapo-transpiration	Catchment hydrological model	BoM	DWLBC, NRMB, SA Water	EPA, DEH
	Storm Water	Additional water supplies; aquatic ecosystem health assessment; water quality assessment	CWMB	DWLBC, EPA	DEH, SA Water, BoM
	Soil Moisture	Catchment hydrological model	PIRSA	DWLBC, CWMB	EPA, DEH
	Groundwater levels	Water allocation; environment flow; groundwater dependent ecosystem health assessment; water quality assessment; dryland salinity management, Surface/groundwater relationships	DWLBC	EPA, CWMB, PIRSA, SA Water	DEH
	Climate Change	All aspects of natural resource management	BoM	PIRSA, DWLBC, DEH, EPA, CWMB, SA Water	

Classification	Parameter	Purposes	Lead Agency	Collaborative Agency	Interested Agency
Water Withdrawal	Extraction	Water allocation, environmental flow, catchment water budget	DWLBC	SA Water, CWMB	EPA, DEH
	Water use	Water allocation, environmental flow, efficient use of water resources, catchment water budget	CWMB	DWLBC, SA Water	EPA, DEH
	Farm Dam	Catchment hydrological model, environmental flow, water allocation	DWLBC	CWMB, PIRSA, EPA	SA Water, DEH
Return Flow	Irrigation drainage	Catchment hydrological model, environmental flow, Salinity management	PIRSA	DWLBC, CWMB, SA water, EPA	DEH
	Effluent	Additional water supplies; aquatic ecosystem health assessment; water quality assessment	SA Water	EPA, CWMB, DWLBC	DEH
	Deep drainage	Dryland salinity management, groundwater quality assessment	PIRSA	DWLBC, CWMB	EPA
Water Quality	Pesticides, Organics, Metals, Nutrients, DO, pH, Turbidity, Temperature, Structure of aquatic communities, Habitat, Macroinvertabrates, Indictor bacteria, Others	Classify water quality; Trend analysis; Pollution incident report; Assessment of water quality standards; Identify emerging problems	EPA	DWLBC, CWMB, SA Water	DEH PIRSA
	Salinity (surface and groundwater)	Water quality assessment, evaluation salt interception schemes; dryland salinity management	DWLBC	EPA, CWMB, PIRSA, SA Water	DEH
Aquatic Ecosystems (inland)	Water regime, Water quality, biological integrity	Environmental value assessment, ecosystem health assessment, environmental flow, surface/groundwater interaction	DWLBC	EPA, CWMB, DEH	PIRSA

- Lead agency: Legislative mandate, responsible for
  - Developing monitoring strategy, plan, and protocols;
  - Data custodian, and supervising data quality assurance,
  - Supporting monitoring undertake by other parties.
- Collaborative agency: Need information for business operation, contribute to monitoring through joint funding, advising, etc.
- Interested agency, in the best interests of the business that monitoring is undertaken.

D. COMPLETE LIST OF EMLR ONGOING SURFACE WATER MONITORING SITES

(Current and historic).

Site Number	Site Name	Type	Purpose / Comments / Related Stations	Parameters	Funding Agency	Data Collection	Data Custodian
Marne River							
3843	Marne River S of Cambrai at bridge	Natural Stream		Ambient Macroinvertebrate	EPA	EPA	EPA
M023339	Eden Valley 2 BoM Met Station	Meteorological Station	Closed	Daily Read 10.1 Rainfall SKM Disag + Infill 10.51 Rainfall	BoM	BoM	BoM
A4261012	Marne River at Main Road Bridge	Natural Stream	Environmental flow monitoring site in conjunction with the National Action Plan (NAP) to determine the state of health of our rivers and streams. AW426605, A4261007, A4261008, A4261009, A4261010, A4261011, A4261013, A4261014, A4261030.	[1]Recording: 100 Water Level 450 Water Temperature 816 Conductivity	RMCWMB	Hydro Tasmania	DWLBC
A4261011	Marne River at d/s Black Hill Springs	Natural Stream	Environmental flow monitoring site in conjunction with the National Action Plan (NAP) to determine the state of health of our rivers and streams. AW426605, A4261007, A4261008, A4261009, A4261010, A4261012, A4261013, A4261014, A4261030.	Recording: 100 Water Level 450 Water Temperature 816 Conductivity	RMCWMB	Hydro Tasmania	DWLBC
M024502	Black Hill BoM Met Station	Meteorological Station		Daily Read 10.1 Rainfall SKM Disag + Infill 10.51 Rainfall	BoM	BoM	BoM
A4261010	Marne River at Gum Park	Natural Stream	Environmental flow monitoring site in conjunction with the National Action Plan (NAP) to determine the state of health of our rivers and streams. AW426605, A4261007, A4261008, A4261009, A4261011, A4261012, A4261013, A4261014, A4261030.	Recording: 100 Water Level 450 Water Temperature 816 Conductivity	RMCWMB	Hydro Tasmania	DWLBC
A4261009	Marne River at Kings Park	Natural Stream	Environmental flow monitoring site in conjunction with the National Action Plan (NAP) to determine the state of health of our rivers and streams. AW426605, A4261007, A4261008, A4261010, A4261011, A4261012, A4261013, A4261014, A4261030.	Recording: 100 Water Level 450 Water Temperature 816 Conductivity	RMCWMB	Hydro Tasmania	DWLBC

Site Number	Site Name	Type	Purpose / Comments / Related Stations	Parameters	Funding Agency	Data Collection	Data Custodian
A4261008	Marne River at Kongolia Bridge	Natural Stream	Environmental flow monitoring site in conjunction with the National Action Plan (NAP) to determine the state of health of our rivers and streams. AW426605, A4261007, A4261009, A4261010, A4261011, A4261012, A4261013, A4261014, A4261030.	Recording: 100 Water Level 450 Water Temperature 816 Conductivity	RMCWMB	Hydro Tasmania	DWLBC
A4261007	Marne River at u/s Redbanks Road Ford Crossing	Natural Stream	Environmental flow monitoring site in conjunction with the National Action Plan (NAP) to determine the state of health of our rivers and streams. AW426605, A4261008, A4261009, A4261010, A4261011, A4261012, A4261013, A4261014, A4261030.	Recording: 100 Water Level 450 Water Temperature 816 Conductivity	RMCWMB	Hydro Tasmania	DWLBC
AW426605	Marne River at Marne Gorge	Natural Stream	A review of the report *Impact of water use in the Marne Catchment on the Water Resources* (BC Tonkin and Associates, November 1998) recommended a need for further hydrological data to be carried out along the Marne River. Part of proposals was for the installation of gauging weir to further upgrade data at the existing site AW426529. The installation of a low profile V crump concrete weir would better represent low to medium flows along the Marne River. A4261015, A4261021, A4261007, A4261008, A4261009, A4261010, A4261011, A4261012, A4261013, A4261014, A4261030.	Recording: 100 Water Level 450 Water Temperature 816 Conductivity	DWLBC	DWLBC	DWLBC
AW426529	Marne River at u/s Cambrai	Natural Stream	Station is now being used as a backup ONLY for AW426605. Future of station is uncertain. A new monitoring site (AW426605) with new weir and recording equipment constructed just upstream of this site. The new site and this existing site will be run concurrently to provide a basis for site calibration.	Recording; 100 Water Level [2]Ad Hoc Field Reading 100.9 Water Level 140.9 Stream Discharge 141.9 Stream Discharge 450.9 Water Temp. 800.91 TDS 806.9 pH 807.9 DO 821.9 Conductivity	DWLBC	DWLBC	DWLBC

Site Number	Site Name	Type	Purpose / Comments / Related Stations	Parameters	Funding Agency	Data Collection	Data Custodian
			Catchment Yield NLWRA: January 1978 - April 1989 gauged daily flow May 1989 - June 1992 monthly data estimated by cross basin correlation July 1992 - September 1992 gauged daily flow October 1992 - October 1994 monthly data estimated by cross basin correlation November 1994 - August 1996 gauged daily flow September 1992 - December 1997 monthly data estimated by cross basin correlation	198.72 Catchment Yield 198.73 Catchment Yield			
A4261014	North Rhyne River near Kappalunta	Natural Stream	Environmental flow monitoring site in conjunction with the National Action Plan (NAP) to determine the state of health of our rivers and streams. AW426605, A4261007, A4261008, A4261009, A4261010, A4261011, A4261012, A4261013, A4261030.	Recording: 100 Water Level 450 Water Temperature 816 Conductivity	RMCWMB	Hydro Tasmania	DWLBC
A4261013	Marne River at Jutland Road Crossing	Natural Stream	Environmental flow monitoring site in conjunction with the National Action Plan (NAP) to determine the state of health of our rivers and streams. AW426605, A4261007, A4261008, A4261009, A4261010, A4261011, A4261012, A4261014, A4261030.	Recording: 100 Water Level 450 Water Temperature 816 Conductivity	RMCWMB	Hydro Tasmania	DWLBC
A4261030	Marne River at 1 km d/s Jutland Road Crossing	Natural Stream	Environmental flow monitoring site in conjunction with the National Action Plan (NAP) to determine the state of health of our rivers and streams. AW426605, A4261007, A4261008, A4261009, A4261010, A4261011, A4261012, A4261013, A4261014.	Recording: 100 Water Level	RMCWMB	Hydro Tasmania	DWLBC
AW426637	Marne River Pluvio at Lartunga	Meteorological Station	Closed	Recording: 10 Rainfall	Closed	Closed	DWLBC
A4261021	Marne Catchment Pluvio at Moss Smith Road	Meteorological Station	The site is a joint venture between DWLBC and RMCWMB. RMCWMB provided funds to purchase the instruments, and DWLBC committed to install and operate the site for five years. This site together with the pluvio A4261015 has been selected to obtain a better understanding of rainfall runoff for the Marne/Saunders catchment areas.	Recording: 10 Rainfall	RMCWMB DWLBC	DWLBC	DWLBC
M023329	Springton (Herbigs) BoM Met Station	Meteorological Station	Closed	Daily Read 10.1 Rainfall [3]SKM Disag + Infill 10.51 Rainfall	BoM	BoM	BoM

Site Number	Site Name	Type	Purpose / Comments / Related Stations	Parameters	Funding Agency	Data Collection	Data Custodian
M023330	Springton (Roeslers) BoM Met Station	Meteorological Station	Closed	Daily Read 10.1 Rainfall SKM Disag + Infill 10.51 Rainfall	BoM	BoM	BoM
A4261015	Marne Catchment Pluvio at Keynes Hill	Meteorological Station	The site is a joint venture between DWLBC and RMCWMB. RMCWMB provided funds to purchase the instruments, and DWLBC committed to install and operate the site for five years. This site together with the pluvio A4261021 has been selected to obtain a better understanding of rainfall runoff for the Marne/Saunders catchment areas.	Recording: 10 Rainfall	RMCWMB DWLBC	DWLBC	DWLBC
M023725	Keyneton BoM Met Station	Meteorological Station		Daily Read 10.1 Rainfall SKM Disag + Infill 10.51 Rainfall	BoM	BoM	BoM
Saunders Creek							
M024529	Mannum (Sanderston) BoM Met Station	Meteorological Station		Daily Read 10.1 Rainfall SKM Disag + Infill 10.51 Rainfall	BoM	BoM	BoM
M024542	Mannum (Glen Saunders) BoM Met Station	Meteorological Station		Daily Read 10.1 Rainfall	BoM	BoM	BoM
A4261028	Saunders Creek at Saunders Gorge	Natural Stream	Environmental flow monitoring site in conjunction with the National Action Plan (NAP) to determine the state of health of our rivers and streams. A4261029	Recording: 100 Water Level 450 Water Temperature 816 Conductivity	RMCWMB	Hydro Tasmania	DWLBC
A4261029	Saunders Creek at Lenger Reserve	Natural Stream	Environmental flow monitoring site in conjunction with the National Action Plan (NAP) to determine the state of health of our rivers and streams.	Recording: 100 Water Level 450 Water Temperature 816 Conductivity	RMCWMB	Hydro Tasmania	DWLBC

Site Number	Site Name	Type	Purpose / Comments / Related Stations	Parameters	Funding Agency	Data Collection	Data Custodian
Reedy Creek							
M024565	Palmer (Leonora Farms) BoM Met Station	Meteorological Station	Closed	Daily Read 10.1 Rainfall SKM Disag + Infill 10.51 Rainfall	BoM	BoM	BoM
M024525	Palmer BoM Met Station	Meteorological Station		Daily Read 10.1 Rainfall SKM Disag + Infill 10.51 Rainfall	BoM	BoM	BoM
M023780	Tungkillo (Terlinga) BoM Met Station	Meteorological Station	Closed	Daily Read 10.1 Rainfall SKM Disag + Infill 10.51 Rainfall	BoM	BoM	BoM
M023812	Rockleigh (Black Heath) BoM Met Station	Meteorological Station		Daily Read 10.1 Rainfall SKM Disag + Infill 10.51 Rainfall	BoM	BoM	BoM
A4261069	Reedy Creek at South of Palmer	Natural Stream		Recording 100 Water Level 450 Water Temperature 816 Conductivity	RMCWMB	Hydro Tasmania	DWLBC
A4261026	Reedy Creek	Natural Stream	Abandoned	Recording 100 Water Level 450 Water Temperature 816 Conductivity	DWLBC	DWLBC	DWLBC
Salt Creek							
M024533	Tepko (Ardenvale) BoM Met Station	Meteorological Station		Daily Read 10.1 Rainfall SKM Disag + Infill 10.51 Rainfall	BoM	BoM	BoM
M024524	Pallamana Post Office BoM Met Station	Meteorological Station	Closed	Daily Read 10.1 Rainfall SKM Disag + Infill 10.51 Rainfall	BoM	BoM	BoM

Site Number	Site Name	Type	Purpose / Comments / Related Stations	Parameters	Funding Agency	Data Collection	Data Custodian
Rocky Gully Creek							
AW426544	Dry Creek at Monarto	Natural Stream	A-Type recorder removed. Site discontinued. Closed.	Recording: 100 Water Level Ad Hoc Field Reading 100.9 Water Level 450.9 Water Temp. 800.91 TDS 806.91 pH 821.9 Conductivity	Closed	Closed	DWLBC
AW426549	Rocky Gully Creek at Monarto	Natural Stream	A-Type recorder removed. Site discontinued. Closed.	Recording: 100 Water Level Ad Hoc Field Reading 100.9 Water Level 450.9 Water Temp. 800.91 TDS 806.91 pH 821.9 Conductivity	Closed	Closed	DWLBC
M024560	Monarto South BoM Met Station	Meteorological Station	Closed	Daily Read 10.1 Rainfall SKM Disag + Infill 10.51 Rainfall	BoM	BoM	BoM
M024582	Monarto Zoo BoM Met Station	Meteorological Station		Daily Read 10.1 Rainfall SKM Disag + Infill 10.51 Rainfall	BoM	BoM	BoM
M024568	Murray Bridge (The Ranch) BoM Met Station	Meteorological Station	Closed	Daily Read 10.1 Rainfall SKM Disag + Infill 10.51 Rainfall	BoM	BoM	BoM
M024549	Murray Bridge EXP. Farm BoM Met Station	Meteorological Station	Closed	Daily Read 10.1 Rainfall SKM Disag + Infill 10.51 Rainfall	BoM	BoM	BoM

Site Number	Site Name	Type	Purpose / Comments / Related Stations	Parameters	Funding Agency	Data Collection	Data Custodian
M024521	Murray Bridge BoM Met Station	Meteorological Station		Daily Read 10.1 Rainfall SKM Disag + Infill 10.51 Rainfall	BoM	BoM	BoM
Preamimma Creek							
AW426546	Preamimma Creek at d/s Monarto	Natural Stream	Closed	Recording: 100 Water Level Ad Hoc Field Reading 100.9 Water Level 450.9 Water Temp. 806.9 pH 807.9 Dissolved Oxygen % 821.9 Conductivity	Closed	Closed	DWLBC
AW426545	Preamimma Creek at u/s Monarto	Natural Stream	Closed	Recording: 10 Rainfall 100 Water Level Ad Hoc Field Reading 100.9 Water Level 450.9 Water Temp. 806.9 pH 807.9 Dissolved Oxygen % 821.9 Conductivity	Closed	Closed	DWLBC
Bremer River							
1824	Bremer River nr Hartley	Natural Stream		Ambient Macroinvertebrate	EPA	EPA	EPA
M023722	Harrogate BoM Met Station	Meteorological Station		Daily Read 10.1 Rainfall SKM Disag + Infill 10.51 Rainfall	BoM	BoM	BoM
M023798	Littlehampton BlakistonPk BoM Met Station	Meteorological Station	Closed	Daily Read 10.1 Rainfall SKM Disag + Infill 10.51 Rainfall	BoM	BoM	BoM

Site Number	Site Name	Type	Purpose / Comments / Related Stations	Parameters	Funding Agency	Data Collection	Data Custodian
M023739	Nairne BoM Met Station	Meteorological Station		Daily Read 10.1 Rainfall SKM Disag + Infill 10.51 Rainfall	BoM	BoM	BoM
M023733	Mount Barker BoM Met Station	Meteorological Station		Daily Read 10.1 Rainfall SKM Disag + Infill 10.51 Rainfall	BoM	BoM	BoM
M023792	Mount Barker (Auchendarroch) BoM Met Station	Meteorological Station	Closed	Daily Read 10.1 Rainfall SKM Disag + Infill 10.51 Rainfall	BoM	BoM	BoM
M023724	Kanmantoo BoM Met Station	Meteorological Station		Daily Read 10.1 Rainfall SKM Disag + Infill 10.51 Rainfall	BoM	BoM	BoM
M023769	Battunga BoM Met Station	Meteorological Station	Closed	Daily Read 10.1 Rainfall SKM Disag + Infill 10.51 Rainfall	BoM	BoM	BoM
M024508	Callington BoM Met Station	Meteorological Station		Daily Read 10.1 Rainfall SKM Disag + Infill 10.51 Rainfall	BoM	BoM	BoM
M023864	Red Creek (Burwood) BoM Met Station	Meteorological Station		Recording: 10 Rainfall	BoM	BoM	BoM
M023844	Archer Hill (Tanderra Park) BoM Met Station	Meteorological Station	Closed	Daily Read 10.1 Rainfall SKM Disag + Infill 10.51 Rainfall	BoM	BoM	BoM
M023863	Kanmantoo (Millbrae) BoM Met Station	Meteorological Station		Unknown	BoM	BoM	BoM

Site Number	Site Name	Type	Purpose / Comments / Related Stations	Parameters	Funding Agency	Data Collection	Data Custodian
M023822	Hartley (Bremer Farm) BoM Met Station	Meteorological Station		Daily Read 10.1 Rainfall SKM Disag + Infill 10.51 Rainfall	BoM	BoM	BoM
M023771	Bletchley BoM Met Station	Meteorological Station	Closed	Daily Read 10.1 Rainfall SKM Disag + Infill 10.51 Rainfall	BoM	BoM	BoM
M024552	Hartley Post Office BoM Met Station	Meteorological Station	Closed	Daily Read 10.1 Rainfall SKM Disag + Infill 10.51 Rainfall	BoM	BoM	BoM
AW426636	Bird in Hand Sewage Treatment Works at Outlet	Effluent Water System	To monitor effluent discharge into Dawesley Creek from Bird In Hand Sewage Treatment Works for a period of 2 wet seasons. Site discontinued and recording equipment removed. Closed.	Recording: 100 Water Level	Closed	Closed	DWLBC
AW426658	Dawesley Creek at u/s Brukunga Mine	Natural Stream	AW426659 - Dawesley Creek at Brukunga Mine d/s AW426660 - Days Creek at Brukunga Mine, AW426661 - Lindsay Creek at Brukunga Mine, AW426662 - Jane Creek at Brukunga Mine.	Recording: 100 Water Level Composite Sample: 450.99 Water Temp. 800.99 TDS 801.99 TDS 806.99 pH 821.99 Conductivity 837.99 Sulphate 841.99 Cadmium 842.99 Chromium 843.99 Copper 844.99 Lead 846.99 Zinc 847.99 Iron 848.99 Nickel 849.99 Aluminium 851.99 Manganese	PIRSA	Water Data Services	DWLBC

Site Number	Site Name	Type	Purpose / Comments / Related Stations	Parameters	Funding Agency	Data Collection	Data Custodian
AW426543	Dawesley Creek at Brukunga	Natural Stream	AW426558 – 'Dawesley Creek at Dawesley' – which is a pollution and planning study of Angas/Bremer region. Abandoned	Old site at Brukunga Mine on Dawesley Creek. There was a proposal back in the late 70's to establish a site to measure flow to allow releases of highly acidic water from a tailings dam during the winter months. This site was abandoned	Unknown Abandoned	Unknown	Unknown
AW426660	Days Creek at Brukunga Mine	Natural Stream	AW426659 - Dawesley Creek at Brukunga Mine d/s, AW426658 - Dawesley Creek at Brukunga Mine u/s, AW426661 - Lindsay Creek at Brukunga Mine, AW426662 - Jane Creek at Brukunga Mine.	Recording: 100 Water Level	PIRSA	Water Data Services	DWLBC
AW426661	Lindsay Creek at Brukunga Mine	Natural Stream	AW426659 - Dawesley Creek at Brukunga Mine d/s, AW426658 - Dawesley Creek at Brukunga Mine u/s, AW426660 - Days Creek at Brukunga Mine, AW426662 - Jane Creek at Brukunga Mine. Closed	Recording: 100 Water Level	PIRSA	Water Data Services	DWLBC
AW426662	Jane Creek at Brukunga Mine	Natural Stream	AW426659 - Dawesley Creek at Brukunga Mine d/s, AW426658 - Dawesley Creek at Brukunga Mine u/s, AW426660 - Days Creek at Brukunga Mine, AW426661 - Lindsay Creek at Brukunga Mine. Closed	Recording: 100 Water Level	PIRSA	Water Data Services	DWLBC
AW426659	Dawesley Creek at d/s Brukunga Mine	Natural Stream	AW426658 - Dawesley Creek at Brukunga Mine u/s, AW426660 - Days Creek at Brukunga Mine, AW426661 - Lindsay Creek at Brukunga Mine, AW426662 - Jane Creek at Brukunga Mine.	Recording: 100 Water Level Composite Sample: 800.99 TDS 801.99 TDS 806.99 pH 821.99 Conductivity 837.99 Sulphate 841.99 Cadmium 842.99 Chromium 843.99 Copper 844.99 Lead	PIRSA	Water Data Services	DWLBC

Site Number	Site Name	Type	Purpose / Comments / Related Stations	Parameters	Funding Agency	Data Collection	Data Custodian
				846.99 Zinc 847.99 Iron 848.99 Nickel 849.99 Aluminium 851.99 Manganese			
AW426665	Brukunga Mine Pluvio at Depot	Meteorological Station	Closed	Recording: 10 Rainfall	PIRSA	Water Data Services	DWLBC
A4261018	Western Flat Creek at Mount Barker	Natural Stream	-	Recording: 100 Water Level 450 Water Temp. 816 Conductivity	DWLBC	DWLBC	DWLBC
AW426638	Mount Barker Creek Catchment Pluvio at Effluent Lagoons	Meteorological Station	Automatic recording pluviometer to facilitate event modelling of catchment. AW426557	Recording: 10 Rainfall Daily Read 10.1 Rainfall	DWLBC	Water Data Services	DWLBC
AW426557	Mount Barker Creek at d/s Mount Barker	Natural Stream	Pollution and planning study of Angas/Bremer basin. AW426679-Mt Barker Creek at u/s Bremer River Confluence, AW426688-Bremer River at u/s Mt Barker Confluence. Also Pluvio AW426638-Mt Barker Pluvio.	Recording: 100 Water Level Ad Hoc Field Reading 100.9 Water Level 140.9 Stream Discharge 141.9 Stream Discharge 450.9 Water Temp. 800.91 TDS 806.9 pH 807.9 DO 821.9 Conductivity	DWLBC	DWLBC	DWLBC
AW426558	Dawesley Creek at Dawesley	Natural Stream	Pollution and planning study of Angas/Bremer region. AW426658, AW426659, AW426660, AW426661, AW426662, ie: all Brukunga mine stations.	Recording: 100 Water Level 151 Stream Discharge 806 pH Ad Hoc Field Reading 100.9 Water Level	DWLBC	Water Data Services	DWLBC

Site Number	Site Name	Type	Purpose / Comments / Related Stations	Parameters	Funding Agency	Data Collection	Data Custodian
				140.9 Stream Discharge 141.9 Stream Discharge 450.9 Water Temp. 800.91 TDS 806.9 pH 807.9 DO 821.9 Conductivity			
A4261016	Bremer River at Millitary Road X-ing Calington	Natural Stream	No Purpose attributed. No Period of Record. No equipment specified.	A proposed site on the upper reaches of the Bremer River. No site reconnaissance or construction has commenced yet. Unknown	Unknown	Unknown	DWLBC
AW426907	Kanmantoo Pluvio at Kanmantoo	Meteorological Station	-	Rainfall	BoM	BoM	BoM
AW426906	Red Creek Pluvio at 10 km S-E Wistow	Meteorological Station	-	Rainfall	BoM	BoM	BoM
AW426688	Bremer River at u/s Mt Barker Confluence	Natural Stream	-	Recording: 100 Water Level 450 Water Temperature 816 Conductivity	DWLBC	Water Data Services	DWLBC
AW426679	Mount Barker Creek at u/s Bremer River Confluence	Natural Stream	-	Recording: 100 Water Level 450 Water Temperature 816 Conductivity	DWLBC	Water Data Services	DWLBC
AW426533	Bremer River at near Hartley	Natural Stream	AW426679 - Mt Barker Creek at u/s Bremer River Confluence, AW426688 - Bremer River at u/s Mt Barker Confluence.	Recording: 100 Water Level 450 Water Temp. 802 Suspended Solids 820 Conductivity Ad Hoc Field	DWLBC	Water Data Services	DWLBC

Site Number	Site Name	Type	Purpose / Comments / Related Stations	Parameters	Funding Agency	Data Collection	Data Custodian
				Reading 100.9 Water Level 140.9 Stream Discharge 450.9 Water Temp. 800.91 TDS 806.9 pH 807.9 DO 821.9 Conductivity			
AW426559	Bremer River at Stanton Ford	Natural Stream	Dept of Mines project in recharge studies. Site discontinued. Staff Gauge. No Period of Record. Closed	Unknown	Closed	Closed	DWLBC
AW426560	Bremer River at d/s Bletchly	Natural Stream	Dept of Mines project in recharge studies. Site discontinued. Staff Gauge. No Period of Record. Closed	Unknown	Closed	Closed	DWLBC
AW426561	Bremer River at Peech Balla	Natural Stream	Dept of Mines project in recharge studies. Site discontinued. Staff Gauge. No Period of Record. Closed	Unknown	Closed	Closed	DWLBC
AW426696	Bremer River at Langhorne Creek	Natural Stream	Salinity monitoring site. Data logger and EC sensor installed. Closed	Recording: 450 Water Temperature 821 Conductivity	Closed	Closed	DWLBC
AW426562	Bremer River at Langhorne Creek Road Bridge	Natural Stream	Dept of Mines project in recharge studies. Site discontinued. Staff Gauge. No Period of Record. Closed	Unknown	Closed	Closed	DWLBC
AW426563	Bremer River at Lake Plains Road Ford	Natural Stream	Dept of Mines project in recharge studies. Site discontinued. Staff Gauge. No Period of Record. Closed	Unknown	Closed	Closed	DWLBC
A4261071	Bremer River at Bletchley Road	Natural Stream		Recording: 100 Water Level 450 Water Temp. 816 Conductivity	RMCWMC	Hydro Tasmania	DWLBC
A4261072	Bremer River at Ballandown Road	Natural Stream		Recording: 100 Water Level 450 Water Temp. 816 Conductivity	RMCWMC	Hydro Tasmania	DWLBC

Site Number	Site Name	Type	Purpose / Comments / Related Stations	Parameters	Funding Agency	Data Collection	Data Custodian
A4261070	Bremer River at Woodstock Road	Natural Stream		Recording: 100 Water Level 450 Water Temp. 816 Conductivity	RMCWMC	Hydro Tasmania	DWLBC
Ferries-McDonald							
M024507	Murray Bridge (Loomooloo) BoM Met Station	Meteorological Station	Daily Read	Daily Read 10.1 Rainfall SKM Disag + Infill 10.51 Rainfall	BoM	BoM	BoM
M024505	Brinkley East BoM Met Station	Meteorological Station	Daily Read Closed	Daily Read 10.1 Rainfall SKM Disag + Infill 10.51 Rainfall	BoM	BoM	BoM
M024572	Wellington (Brinkley South) BoM Met Station	Meteorological Station	Daily Read	Daily Read 10.1 Rainfall SKM Disag + Infill 10.51 Rainfall	BoM	BoM	BoM
M024538	Wellington East BoM Met Station	Meteorological Station	Daily Read Closed	Daily Read 10.1 Rainfall SKM Disag + Infill 10.51 Rainfall	BoM	BoM	BoM
M024561	NALPA	Meteorological Station	Closed	Unknown	Closed	Closed	DWLBC
M024514	Lake Plains (Metala) BoM Met Station	Meteorological Station	Closed	Daily Read 10.1 Rainfall SKM Disag + Infill 10.51 Rainfall	BoM	BoM	BoM
AW426574	Lake Alexandrina at near Mulgundawa Recorder	Natural Lake	Calculate daily average lake level.	Recording: 102 Lake Water Level 450 Water Temp. 816 Conductivity	MDBC	DWLBC	DWLBC
A4261032	Lake Alexandrina at near Mulgundawa Daily Read Location	Natural Lake	Continuous recorded data for this location held in site AW426574.	Daily Read: 102.1 Lake Water Level 821.1 Conductivity	DWLBC	SA Water	DWLBC

Site Number	Site Name	Type	Purpose / Comments / Related Stations	Parameters	Funding Agency	Data Collection	Data Custodian
Angas River							
M023728	Macclesfield BoM Met Station	Meteorological Station		Daily Read 10.1 Rainfall SKM Disag + Infill 10.51 Rainfall	BoM	BoM	BoM
M023805	Strathalbyn (Pattangga) BoM Met Station	Meteorological Station	Closed	Daily Read 10.1 Rainfall SKM Disag + Infill 10.51 Rainfall	BoM	BoM	BoM
M023747	Strathalbyn BoM Met Station	Meteorological Station		Daily Read 10.1 Rainfall SKM Disag + Infill 10.51 Rainfall	BoM	BoM	BoM
M024580	Strathalbyn Racecourse BoM Met Station	Meteorological Station	Continuous rainfall (Pluvio). Daily Read	Daily Read 10.1 Rainfall SKM Disag + Infill 10.51 Rainfall	BoM	BoM	BoM
AW426503	Angas River at Angas Weir	Natural Stream	AW426629 – 'Angas River at Angas Plains' which is now closed	Recording: 100 Water Level Ad Hoc Field Reading 100.9 Water Level 140.9 Stream Discharge 141.9 Stream Discharge 450.9 Water Temp. 800.91 TDS 806.9 pH 807.9 DO 821.9 Conductivity	DWLBC	Water Data Services	DWLBC
AW426564	Angas River at d/s Strathalbyn	Natural Stream	Dept of Mines project. Site discontinued. Staff Gauge. Lab results. Closed	Ad Hoc Lab Results: 800.91 TDS 821.91 Conductivity	Closed	Closed	DWLBC
AW426565	Angas River at Belvidere	Natural Stream	Dept of Mines project in recharge studies. Site discontinued. Staff Gauge. No Period of Record. Closed	Unknown	Closed	Closed	DWLBC

Site Number	Site Name	Type	Purpose / Comments / Related Stations	Parameters	Funding Agency	Data Collection	Data Custodian
AW426629	Angas River at Angas Plains	Natural Stream	Station closed due to severe erosion problems under weir. Instruments installed - existing weir and float well. Closed	Recording: 100 Water Level 450 Water Temperature 816 Conductivity	DWLBC	Closed	DWLBC
AW426567	Angas River at Richmore Park	Natural Stream	Dept of Mines project in recharge studies. Site discontinued. Staff Gauge. No Period of Record. Closed	Unknown	Closed	Closed	DWLBC
A4261073	Angas River at Ballandown Road	Natural Stream		Recording: 100 Water Level 450 Water Temperature 816 Conductivity	RMCWMC	Hydro Tasmania	DWLBC
A4261074	Angas River at Cheriton Road	Natural Stream		Recording: 100 Water Level 450 Water Temperature 816 Conductivity	RMCWMC	Hydro Tasmania	DWLBC
Angas Plains							
AW426566	Angas River at Innisfail	Natural Stream	Dept of Mines project in recharge studies. Site discontinued. Staff Gauge. No Period of Record. Closed	Unknown	Closed	Closed	DWLBC
M024516	Langhorne Creek 2 BoM Met Station	Meteorological Station	Closed	Daily Read 10.1 Rainfall SKM Disag + Infill 10.51 Rainfall	BoM	BoM	BoM
M024515	Langhorne Creek BoM Met Station	Meteorological Station		Daily Read 10.1 Rainfall SKM Disag + Infill 10.51 Rainfall	BoM	BoM	BoM
M023795	Woodburn BoM Met Station	Meteorological Station	Closed	Daily Read 10.1 Rainfall SKM Disag + Infill 10.51 Rainfall	BoM	BoM	BoM

Site Number	Site Name	Type	Purpose / Comments / Related Stations	Parameters	Funding Agency	Data Collection	Data Custodian
Sandergrove Plains							
M024576	Milang (Navarino) BoM Met Station	Meteorological Station		Daily Read 10.1 Rainfall SKM Disag + Infill 10.51 Rainfall	BoM	BoM	BoM
M023781	Watalunga Estate BoM Met Station	Meteorological Station	Closed	Daily Read 10.1 Rainfall SKM Disag + Infill 10.51 Rainfall	BoM	BoM	BoM
M024519	Milang Post Office BoM Met Station	Meteorological Station		Daily Read 10.1 Rainfall SKM Disag + Infill 10.51 Rainfall	BoM	BoM	BoM
M024545	Milang Dept of Agric. BoM Met Station	Meteorological Station	Closed	Daily Read 10.1 Rainfall SKM Disag + Infill 10.51 Rainfall	BoM	BoM	BoM
M024550	Clayton (Point Sturt) BoM Met Station	Meteorological Station		Daily Read 10.1 Rainfall	BoM	BoM	BoM
AW426695	Milang Meteorological Station at Milang E&WS Depot	Meteorological Station	Closed	Recording: 500 Wind Direction 515 Wind Velocity 520 Wind Run Daily Read: 10.1 Rainfall 500.1 Wind Direction 516.1 Wind Velocity 700.1 Evaporation	Closed	Closed	DWLBC
M024558	Milang E&WS BoM Met Station	Meteorological Station	Closed	Daily Read 10.1 Rainfall SKM Disag + Infill 10.51 Rainfall	BoM	BoM	BoM

Site Number	Site Name	Type	Purpose / Comments / Related Stations	Parameters	Funding Agency	Data Collection	Data Custodian
A4261004	Lake Alexandrina at Milang Jetty Daily Read Location	Natural Lake	M024558, AW426695. Continuously recorded water level data held in site AW426524.	Daily Read: 102.1 Lake Water Level 821.1 Conductivity	MDBC	SA Water	DWLBC
AW426524	Lake Alexandrina at Milang Jetty Recorder	Natural Lake	Lake Alexandrina water level measurements. Daily read data held in site A4261004. AW426574, AW426575, AW426583, AW426527, AW426525	Recording: 102 Lake Water Level 450 Water Temp 816 Conductivity Ad Hoc Field Reading: 450.9 Water Temp. 821.9 Conductivity	MDBC	DWLBC	DWLBC
A4261033	Lake Alexandrina at Clayton Jetty	Natural Lake		Daily Read: 821.1 Conductivity	SA Water	SA Water	SA Water
Finnis River							
A4261050	Finnis River Inlet at near Finniss	Natural Lake		Daily Read: 821.1 Conductivity	MDBC	SA Water	DWLBC
AW426639	Finnis River Catchment Pluvio at Kyeema	Meteorological Station	Automatic recording pluviometer to facilitate event modelling of Finnis catchment. AW426504.	Recording: 10 Rainfall	DWLBC	Water Data Services	DWLBC
AW426504	Finnis River at 4 km East of Yundi	Natural Stream	Catchment Yield NLWRA: January 1978 - April 1989 gauged daily flow May 1989 - June 1992 monthly data estimated by cross basin correlation July 1992 - September 1992 gauged daily flow October 1992 - October 1994 monthly data estimated by cross basin correlation November 1994 - August 1996 gauged daily flow September 1992 - December 1997 monthly data estimated by cross basin correlation	Recording: 100 Water Level Ad Hoc Field Reading: 100.9 Water Level 140.9 Stream Discharge 141.9 Stream Discharge 450.9 Water Temp. 800.91 TDS 806.9 pH 807.9 DO 821.9 Conductivity 198.72/3 Catchment Yield	DWLBC	Water Data Services	DWLBC

Site Number	Site Name	Type	Purpose / Comments / Related Stations	Parameters	Funding Agency	Data Collection	Data Custodian
M023730	Meadows BoM Met Station	Meteorological Station		Daily Read 10.1 Rainfall SKM Disag + Infill 10.51 Rainfall	BoM	BoM	BoM
M023819	Meadows (Harewood) BoM Met Station	Meteorological Station	Closed	Daily Read 10.1 Rainfall SKM Disag + Infill 10.51 Rainfall	BoM	BoM	BoM
M023818	Kuitpo Forest HQ BoM Met Station	Meteorological Station		Daily Read 10.1 Rainfall SKM Disag + Infill 10.51 Rainfall	BoM	BoM	BoM
M023799	Meadows (Oakland Hills) BoM Met Station	Meteorological Station		Daily Read 10.1 Rainfall SKM Disag + Infill 10.51 Rainfall	BoM	BoM	BoM
M023789	Bull Creek 2 BoM Met Station	Meteorological Station	Closed	Daily Read 10.1 Rainfall SKM Disag + Infill 10.51 Rainfall	BoM	BoM	BoM
M023772	Bull Creek (Marble House) BoM Met Station	Meteorological Station	Closed	Daily Read 10.1 Rainfall SKM Disag + Infill 10.51 Rainfall	BoM	BoM	BoM
M023808	Yundi BoM Met Station	Meteorological Station		Daily Read 10.1 Rainfall SKM Disag + Infill 10.51 Rainfall	BoM	BoM	BoM
M023701	Ashbourne BoM Met Station	Meteorological Station		Daily Read 10.1 Rainfall SKM Disag + Infill 10.51 Rainfall	BoM	BoM	BoM
M023714	Finnis BoM Met Station	Meteorological Station	Closed	Daily Read 10.1 Rainfall SKM Disag + Infill 10.51 Rainfall	BoM	BoM	BoM

Site Number	Site Name	Type	Purpose / Comments / Related Stations	Parameters	Funding Agency	Data Collection	Data Custodian
M023845	Finnis (Viewbank) BoM Met Station	Meteorological Station		Daily Read 10.1 Rainfall SKM Disag + Infill 10.51 Rainfall	BoM	BoM	BoM
A4261076	Finnis River at Braeside	Natural Stream		Recording: 100 Water Level 450 Water Temp. 816 Conductivity	RMCWMB	Hydro Tasmania	DLWBC
A4261075	Finnis River at Ford Road	Natural Stream		Recording: 100 Water Level 450 Water Temp. 816 Conductivity	RMCWMB	Hydro Tasmania	DLWBC
Tookayerta Creek							
AW426534	Nangkita Creek at Nangkita	Natural Stream	Dept of Mines project in recharge studies. Site discontinued. Staff Gauge. Closed	Ad Hoc Field Reading 100.9 Water Level 450.9 Water Temp. 800.91 TDS 806.91 pH 821.9 Conductivity	Closed	Closed	DWLBC
A4261020	Tookayerta Creek at d/s Nangkita Creek	Natural Stream	New Site. No Period of Record, Record of Instrumentation, Purpose.	New site on Tookayerta Creek measuring water velocity through a culvert under the road. DWLBC testing new flow sensors	RMCWMB	DWLBC	DWLBC
M023735	Mount Compass BoM Met Station	Meteorological Station		Daily Read 10.1 Rainfall SKM Disag + Infill 10.51 Rainfall	BoM	BoM	BoM
A4261077	Deep Creek at Fiegert Road	Natural Stream		Recording: 100 Water Level 450 Water Temp. 816 Conductivity	RMCWMB	Hydro Tasmania	DLWBC

Site Number	Site Name	Type	Purpose / Comments / Related Stations	Parameters	Funding Agency	Data Collection	Data Custodian
Currency Creek							
AW426647	Currency Creek Catchment Pluvio at Dalenka Downs	Meteorological Station	AW426530 - Currency Creek near Higgins. Rimco event recorder and pluviometer installed. Closed	Recording: 10 Rainfall	Closed	Closed	DWLBC
AW426530	Currency Creek at near Higgins	Natural Stream	A-Type recorder removed. Site discontinued. Closed	Recording: 100 Water Level Ad Hoc Field Reading: 100.9 Water Level 140.9 Stream Discharge 141.9 Stream Discharge 450.9 Water Temp. 800.91 TDS 806.9 pH 807.9 DO 821.9 Conductivity	Closed	Closed	DWLBC
			Catchment Yield NLWRA: January 1978 - April 1989 Gauged daily flow May 1989 - June 1992 Monthly Data estimated by cross basin correlation July 1992 - September 1992 Gauged daily flow October 1992 - October 1994 Monthly Data estimated by cross basin correlation November 1994 - August 1996 Gauged daily flow September 1992 - December 1997 Monthly Data estimated by cross basin correlation Closed	198.72/3 Catchment Yield			
M023777	Mount Jagged BoM Met Station	Meteorological Station	Closed	Daily Read 10.1 Rainfall SKM Disag + Infill 10.51 Rainfall	BoM	BoM	BoM
M023832	Currency Creek (Kiloran) BoM Met Station	Meteorological Station	Closed	Daily Read 10.1 Rainfall SKM Disag + Infill 10.51 Rainfall	BoM	BoM	BoM

Site Number	Site Name	Type	Purpose / Comments / Related Stations	Parameters	Funding Agency	Data Collection	Data Custodian
M023838	Mount Compass (Marshall Brae) BoM Met Station	Meteorological Station	Closed	Daily Read 10.1 Rainfall SKM Disag + Infill 10.51 Rainfall	BoM	BoM	BoM
M023776	Merrilea BoM Met Station	Meteorological Station	Closed	Daily Read 10.1 Rainfall SKM Disag + Infill 10.51 Rainfall	BoM	BoM	BoM
M023841	Currency Creek BoM Met Station	Meteorological Station	Closed	Daily Read 10.1 Rainfall SKM Disag + Infill 10.51 Rainfall	BoM	BoM	BoM
M023834	Victor Harbor (Berrima) BoM Met Station	Meteorological Station		Daily Read 10.1 Rainfall SKM Disag + Infill 10.51 Rainfall	BoM	BoM	BoM
A4261078	Currency Creek at Currency Creek	Natura Stream		Recording: 100 Water Level 450 Water Temp. 816 Conductivity	RMCWMB	Hydro Tasmania	DWLBC
Catchments for which no ongoing surface water monitoring is currently being carried out:							
Mypolonga Flat							
M024522	Mypolonga BoM Met Station	Meteorological Station	Closed	Daily Read 10.1 Rainfall SKM Disag + Infill 10.51 Rainfall	BoM	BoM	BoM
Preamimma Creek							
AW426545	Preamimma Creek at u/s Monarto	Natural Stream	Severe flood event occurred. Inspection of weir at visit on 13 01 93 found the weir to be severely damaged. A-Type recorder removed. Site discontinued. AW426546 Closed	Recording: 10 Rainfall 100 Water Level Ad Hoc Field Reading 100.9 Water Level 450.9 Water Temp.	Closed	Closed	DWLBC

Site Number	Site Name	Type	Purpose / Comments / Related Stations	Parameters	Funding Agency	Data Collection	Data Custodian
				800.91 TDS 806.9 pH 807.9 DO 821.9 Conductivity			
AW426546	Preamimma Creek at d/s Monarto	Natural Stream	A-Type recorder removed. Site discontinued. Staff gauge left on site. AW426545. Closed	Recording: 100 Water Level Ad Hoc Field Reading 100.9 Water Level 450.9 Water Temp. 800.91 TDS 806.9 pH 807.9 DO 821.9 Conductivity	Closed	Closed	DWLBC
M024566	Monarto (Hillview) BoM Met Station	Meteorological Station	Closed	Daily Read 10.1 Rainfall SKM Disag + Infill 10.51 Rainfall	BoM	BoM	BoM
M024567	Monarto (Rockleigh Downs) BoM Met Station	Meteorological Station	Closed	Daily Read 10.1 Rainfall SKM Disag + Infill 10.51 Rainfall	BoM	BoM	BoM

1. Recording relates to parameters continuously monitored in the field;
2. Ad Hoc Field Reading relates to parameters monitored in conjunction with ad hoc water quality sampling;
3. SKM Disag + Infill is a process of infilling of missing data.

E. LIST OF SURFACE WATER / FLOW MONITORING SITES

(Current and Historic)

Site Number	Site Name	Commenced	Ceased	Level Continuous Recording	Stream Flow From Ratings	Easting	Northing
Marne River							
A4261012	Marne River at Main Road Bridge	05.10.01	-	Yes	No	365182.0	6158875.0
A4261011	Marne River at d/s Black Hill Springs	03.10.01	-	Yes	No	359745.0	6158773.0
A4261010	Marne River at Gum Park	03.10.01	-	Yes	No	355478.0	6162171.0
A4261009	Marne River at Kings Park	05.10.01	-	Yes	No	352779.0	6164923.0
A4261008	Marne River at Kongolia Bridge	09.10.01	-	Yes	No	350239.0	6164300.0
A4261007	Marne River at u/s Redbanks Road Ford x-ing	09.10.01	-	Yes	No	344830.0	6162245.0
AW426605	Marne River at Marne Gorge	19.07.01	-	Yes	Yes (Latest Gauging 24/06/05)	337995.0	6161666.0
AW426529	Marne River at u/s Cambrai	06.12.72	-	Yes	Yes (Latest Gauging 20/09/00)	338222.0	6161578.0
A4261030	Marne River at 1 km d/s Jutland Road Crossing	04.09.02	-	Yes	No	331857.0	6162397.0
A4261013	Marne River at Jutland Road Crossing	16.01.02	-	Yes	No	331749.0	6162221.0
A4261014	North Rhine River near Kappalunta	11.12.01	-	Yes	No	332812.0	6165408.0
Saunders Creek							
A4261028	Saunders Creek at Saunders Gorge	27.05.02	-	Yes	No	336141.0	6154447.0
A4261029	Saunders Creek at Lenger Reserve	28.05.02	-	Yes	No	351013.0	6145680.0
Preamimma Creek							
AW426545	Preamimma Creek at u/s Monarto	22.05.75	19.08.93	Yes	No (Latest Gauging 24/10/75)	330422.0	330422.0
AW426546	Preamimma Creek at d/s Monarto	03.01.75	27.05.92	Yes	Yes (Latest Gauging 06/10/80)	336322.0	6119578.0

Site Number	Site Name	Commenced	Ceased	Level Continuous Recording	Stream Flow From Ratings	Easting	Northing
Reedy Creek							
A4261069	Reedy Creek at South of Palmer	13.08.2004		Yes	No (Latest Gauging 10/06/75)	333649.0	6134644.0
A4261026	Reedy Creek	18.3.2003	Unknown	Yes	No	340445.0	6131469.0
Rocky Gully Creek							
AW426544	Dry Creek at Monarto	10.06.75	26.02.86	Yes	Yes (Latest Gauging 10/06/75)	327322.0	6115278.0
AW426549	Rocky Gully Creek at Monarto	29.04.75	26.02.86	Yes	Yes (Latest Gauging 28/07/77)	339222.0	6113778.0
Bremer River							
AW426636	Bird in Hand Sewage Treatment Works at Outlet	27.03.91	21.01.93	Yes	Yes (Latest Gauging 24/02/92)	310722.0	6129678.0
AW426658	Dawesley Creek at u/s Brukunga Mine	20.07.93	-	Yes	Yes (Latest Gauging 21.08.03)	312226.0	6125037.0
AW426660	Days Creek at Brukunga Mine	05.08.93	-	Yes	Yes (No Gauging Done)	311722.0	6124478.0
AW426661	Lindsay Creek at Brukunga Mine	18.08.93	22.08.03	Yes	Yes (Latest Gauging 30/09/02)	311687.0	6124443.0
AW426662	Jane Creek at Brukunga Mine	06.08.93	22.08.03	Yes	Yes (Latest Gauging 30/09/02)	311582.0	6124208.0
AW426659	Dawesley Creek at d/s Brukunga Mine	29.07.93	-	Yes	Yes (Latest Gauging 30/09/02)	311722.0	6123178.0
A4261018	Western Flat Creek at Mt Barker	30.06.03		Yes	No (Latest Gauging 21/06/05) (still to derive a rating relationship for the concrete weir)	303868.0	6116227.0
AW426557	Mount Barker Creek at d/s Mt Barker	24.04.79	-	Yes	Yes (Latest Gauging 04/08/04)	310222.0	6115478.0
AW426558	Dawesley Creek at Dawesley	01.06.78	-	Yes	Yes (Latest Gauging 22/09/03)	313040.0	6120556.0
AW426688	Bremer River at u/s Mt Barker Confluence	15.10.97	-	Yes	No	320374.0	6110330.0
AW426679	Mount Barker Creek at u/s Bremer River Confluence	11.06.97	-	Yes	No (Latest Gauging 22/02/00)	319922.0	6109878.0
AW426533	Bremer River at near Hartley	11.05.73	-	Yes	Yes (Latest Gauging 31/10/03)	318522.0	6101978.0
A4261071	Bremer River at Bletchley Road	10.08.04	-	Yes	No	317686.0	6097406.0
A4261072	Bremer River at Ballandown Road	06.08.04	-	Yes	No	322927.0	6084483.0
A4261070	Bremer River at Woodstock Road	10.08.04	-	Yes	No	322536.0	6086981.0

Site Number	Site Name	Commenced	Ceased	Level Continuous Recording	Stream Flow From Ratings	Easting	Northing
Angas River							
AW426503	Angas River at Angas Weir	29.05.64	-	Yes	Yes (Latest Gauging 07/10/03)	304939.0	6099634.0
AW426629	Angas River at Angas Plains	07.06.91	02.12.02	Yes	Yes (Latest Gauging 18/09/02)	317921.0	6088778.0
A4261073	Angas River at Ballandown Road	06.08.04	-	Yes	No	318450.0	6084627.0
A4261074	Angas River at Cheriton Road	11.08.04	-	Yes	No	315429.0	6091255.0
Finnis River							
AW426504	Finnis River at 4 km East of Yundi	08.06.65	-	Yes	Yes (Latest Gauging 24/09/02)	288521.0	6088578.0
A4261076	Finnis River at Braeside	11.08.04	-	Yes	No	298011.0	6085834.0
A4261075	Finnis River at Ford Road	11.08.04	-	Yes	No	297629.0	6089866.0
Tookayerta Creek							
A4261020	Tookayerta Creek at d/s Nangkita Creek	06.06.03	-	Yes	A new site on Tookayerta Creek where water velocity is being measured as it passes through a culvert under the road. DWLBC are testing new flow sensors here.	295847.0	6080943.0
Deep Creek							
A4261077	Deep Creek at Fiegert Road	19.08.04	-	Yes	No	301318.0	6073492.0
Currency Creek							
AW426530	Currency Creek at near Higgins	06.06.72	23.08.93	Yes	Yes (Latest Gauging 24/06/87)	290521.0	6075278.0
A4261078	Currency Creek at Currency Creek	12.08.04	-	Yes	No	296751.0	6074239.0

F. LIST OF ONGOING SURFACE WATER SALINITY MONITORING SITES

(Current and Historic)

Site Number	Site Name	Commenced	Ceased	Salinity	Levels and Salinity	Easting	Northing
Marne River							
A4261012	Marne River at Main Road Bridge	05.10.01	-	Yes	Yes	365182.0	6158875.0
A4261011	Marne River at d/s Black Hill Springs	03.10.01	-	Yes	Yes	359745.0	6158773.0
A4261010	Marne River at Gum Park	03.10.01	-	Yes	Yes	355478.0	6162171.0
A4261009	Marne River at Kings Park	05.10.01	-	Yes	Yes	352779.0	6164923.0
A4261008	Marne River at Kongolia Bridge	09.10.01	-	Yes	Yes	350239.0	6164300.0
A4261007	Marne River at u/s Redbanks Road Ford x-ing	09.10.01	-	Yes	Yes	344830.0	6162245.0
AW426605	Marne River at Marne Gorge	19.07.01	-	Yes	Yes	337995.0	6161666.0
A4261014	North Rhine River near Kappalunta	11.12.01	-	Yes	Yes	332812.0	6165408.0
A4261013	Marne River at Jutland Road Crossing	16.01.02	-	Yes	Yes	331749.0	6162221.0
Saunders Creek							
A4261029	Saunders Creek at Lenger Reserve	28.05.02	-	Yes	Yes	351013.0	6145680.0
A4261028	Saunders Creek at Saunders Gorge	27.05.02	-	Yes	Yes	336141.0	6154447.0
Reedy Creek							
A4261069	Reedy Creek at South of Palmer	13.08.04	-	Yes	Yes	333649.0	6134644.0
A4261026	Reedy Creek	08.02.03	Unknown	Yes	Yes	340445.0	6131469.0
Bremer River							
AW426658	Dawesley Creek at u/s Brukunga Mine	20.07.93	-	Yes	Yes	312226.0	6125037.0
AW426659	Dawesley Creek at d/s Brukunga Mine	29.07.93	-	Yes	Yes	311722.0	6123178.0
A4261018	Western Flat Creek at Mount Barker	30.06.03	-	Yes	Yes	303868.0	6116227.0
AW426688	Bremer River at u/s Mount Barker Confluence	15.10.97	-	Yes	Yes	320374.0	6110330.0
AW426679	Mount Barker Creek at u/s Bremer River Confluence	11.06.97	-	Yes	No	319922.0	6109878.0

Site Number	Site Name	Commenced	Ceased	Salinity	Levels and Salinity	Easting	Northing
AW426533	Bremer River at near Hartley	11.05.73	-	Yes	Yes	318522.0	6101978.0
AW426696	Bremer River at Langhorne Creek	04.07.96	07.04.99	Yes	No	321071.0	6093005.0
A4261071	Bremer River at Bletchley Road	10.08.04	-	Yes	Yes	317686.0	6097406.0
A4261072	Bremer River at Ballandown Road	06.08.04	-	Yes	Yes	322927.0	6084483.0
A4261070	Bremer River at Woodstock Road	10.08.04	-	Yes	Yes	322536.0	6086981.0
Angas River							
AW426629	Angas River at Angas Plains	07.06.91	02.12.02	Yes	Yes	317921.0	6088778.0
A4261073	Angas River at Ballandown Road	06.08.04	-	Yes	Yes	318450.0	6084627.0
A4261074	Angas River at Cheriton Road	11.08.04	-	Yes	Yes	315429.0	6091255.0
Finnis River							
A4261076	Finnis River at Braeside	11.08.04	-	Yes	Yes	298011.0	6085834.0
A4261075	Finnis River at Ford Road	11.08.04	-	Yes	Yes	297629.0	6089866.0
Deep Creek							
A4261077	Deep Creek at Fiegert Road	19.08.04	-	Yes	Yes	301318.0	6073492.0
Currency Creek							
A4261078	Currency Creek at Currency Creek	12.08.04	-	Yes	Yes	296751.0	6074239.0

G. RIVER MURRAY SURFACE WATER MONITORING

Site Number	Site Name	Easting	Northing	Parameters	Commenced	Funding Agency	Data Collection
A4261001	MURRAY RIVER at Calculated Flow to SA	496651.0	6239993.0	Discharge	01/01/1870	MDBC	SA Water
A4261022	MURRAY RIVER at U/S Old Customs House (637.1 km)	496404.0	6240079.3	Salinity	08/08/2002	MDBC	DWLBC
AW426510	MURRAY RIVER at Lock 6 Upstream (619.8 km)	489522.0	6238278.0	Levels, Salinity	01/01/1930	MDBC	SA Water
AW426511	MURRAY RIVER at Lock 6 Downstream (619.8 km)	489522.0	6238278.0	Levels, Discharge	01/01/1927	MDBC	SA Water
AW426705	MURRAY RIVER at U/S Chowilla Creek (612.3 km)	487415.0	6235645.0	Salinity	15/02/2001	DWLBC	DWLBC
AW426704	MURRAY RIVER at D/S Chowilla Creek (609.0 km)	485648.0	6235167.0	Salinity	15/02/2001	DWLBC	DWLBC
AW426632	MURRAY RIVER at Templeton (602.9 km)	483962.0	6231888.0	Levels, Salinity	Closed	Closed	Closed
AW426703	MURRAY RIVER at U/S Renmark (570.6 km)	479663.0	6220718.0	Salinity	15/02/2001	DWLBC	DWLBC
AW426900	MURRAY RIVER at Renmark Town Gauge (567.4 km)	477322.0	6219378.0	Unknown	01/01/1891	MDBC	Unknown
AW426628	MURRAY RIVER at Renmark Domestic Pump Station (567.9 km)	477232.0	6219378.0	Levels, Salinity	01/01/1974	MDBC	SA Water
AW426513	MURRAY RIVER at Lock 5 Downstream (562.4 km)	478522.0	6216878.0	Rainfall, Levels, Discharge, Evap	01/01/1924	MDBC	SA Water
AW426512	MURRAY RIVER at Lock 5 Upstream (562.4 km)	478522.0	6216878.0	Levels, Salinity	01/01/1927	MDBC	SA Water
A4261023	MURRAY RIVER at Upstream Pike River Outlet	473902.7	6209804.5	Salinity	21/08/2002	MDBC	DWLBC
AW426663	MURRAY RIVER at Lyrup Pumping Station (537.7 km)	467792.0	6209618.0	Levels, Salinity	Closed	Closed	Closed

Site Number	Site Name	Easting	Northing	Parameters	Commenced	Funding Agency	Data Collection
AW426643	MURRAY RIVER at Habel Landing (485.6 km)	457132.0	6187268.0	Salinity	09/05/1991	MDBC	DWLBC
A4261024	MURRAY RIVER at Upstream Katarapko Creek Outlet	454974.0	6187879.6	Salinity	22/08/2002	MDBC	DWLBC
AW426555	MURRAY RIVER at Loxton Domestic Pump Stn (490.0 km)	460317.0	6188027.0	Unknown	01/01/1976	MDBC	SA Water
AW426550	MURRAY RIVER at Loxton Irrigation Pump Stn. (493.9 km)	462422.0	6191478.0	Levels, Discharge, Flow Vel, EC	01/01/1951	MDBC	DWLBC
AW426642	MURRAY RIVER at U/S Rilli Island (500.5 km)	461982.0	6194328.0	Salinity	09/05/1991	MDBC	DWLBC
AW426515	MURRAY RIVER at Lock 4 Downstream (516.2 km)	461122.0	6199778.0	Levels, Discharge, Salinity	01/01/1927	MDBC	SA Water
AW426514	MURRAY RIVER at Lock 4 Upstream (516.2 km)	461122.0	6199778.0	Levels, Salinity	01/01/1929	MDBC	SA Water
AW426537	MURRAY RIVER at Berri Irrigation Pump Stn. (525.7 km)	463222.0	6205778.0	Levels, Salinity, Turbidity	01/01/1931	MDBC	SA Water
A4261025	MURRAY RIVER at Upstream Moorook	443053.3	6202562.7	Salinity	22/08/2002	MDBC	DWLBC
AW426624	MURRAY RIVER at Loveday Pump Station (446.9 km)	444642.0	6208488.0	Levels, Salinity	01/01/1974	MDBC	SA Water
AW426538	MURRAY RIVER at Cobdogla Irrigation Pump Stn. (443.3 km)	444722.0	6210278.0	Unknown	01/01/1931	MDBC	SA Water
AW426516	MURRAY RIVER at Lock 3 Upstream (431.4 km)	440822.0	6216678.0	Levels, Salinity	01/01/1925	MDBC	SA Water
AW426517	MURRAY RIVER at Lock 3 Downstream (431.4 km)	440822.0	6216678.0	Levels, Discharge, Battery V, EC	01/01/1925	MDBC	DWLBC
AW426652	MURRAY RIVER at U/S Overland Corner (426.5 km)	439422.0	6219378.0	Salinity	14/04/1992	MDBC	DWLBC
AW426528	MURRAY RIVER at Overland Corner (417.5 km)	433222.0	6217778.0	Levels, Discharge	01/01/1956	MDBC	DWLBC

Site Number	Site Name	Easting	Northing	Parameters	Commenced	Funding Agency	Data Collection
AW426573	MURRAY RIVER at Woolpunda Pump Station (411.5 km)	427822.0	6217978.0	Water Level, Flow Vel, Salinity	19/12/1985	MDBC	DWLBC
AW426593	MURRAY RIVER at Holder (392.0 km)	411542.0	6218468.0	Salinity	14/09/1988	MDBC	DWLBC
AW426539	MURRAY RIVER at Waikerie Irrigation Pump Stn. (383.0 km)	406622.0	6217778.0	Levels, Salinity	01/01/1931	MDBC	SA Water
AW426594	MURRAY RIVER at U/S Sunlands Pump Station (373.6 km)	399872.0	6220778.0	Levels, Salinity	18/11/1988	MDBC	DWLBC
AW426518	MURRAY RIVER at Lock 2 Upstream (362.1 km)	401422.0	6228778.0	Levels, Salinity	01/01/1928	MDBC	SA Water
AW426519	MURRAY RIVER at Lock 2 Downstream (362.1 km)	401422.0	6228778.0	Levels, Discharge, Salinity	01/01/1924	MDBC	DWLBC
AW426702	MURRAY RIVER at D/S Hogwash Bend (347.5 km)	392872.0	6230328.0	Salinity	09/10/1997	DWLBC	DWLBC

H. CATCHMENT-SCALE SURFACE WATER QUANITITY MONITORING SUGGESTIONS

The suggested monitoring methodology for the parameters listed in the table below is explained in Section 5.6.1.3.

	Catchment	Parameter	Priority	Monitoring Location	Objective /Comments
High-Yield Catchments	**Marne River**	Rainfall Distribution	MEDIUM	In the Upper Reaches of the Marne River (Western Side)	To represent the high rainfall area of the catchment; To obtain more accurate rainfall-Runoff relation for the high-yielding and high use area of the catchment.
		Streamflow: Sub-Catchment Yield	MEDIUM	North Rhine Tributary	To determine sub-catchment yield for better "Water Allocation" purpose.
		Streamflow: Catchment Outflow	HIGH	Outlet of catchment	Refer Table Footer[1]
	Reedy Creek	Rainfall Distribution	HIGH	In the high rainfall upper reaches	To represent the high rainfall area of the catchment; To obtain more accurate rainfall-Runoff relation for the high-yielding and high use area of the catchment.
		Streamflow: Catchment Yield	HIGH	Downstream of confluence of major tributaries	To determine catchment yield; For "Water Allocation" purpose.
		Streamflow: Catchment Outflow	HIGH	Outlet of catchment	Refer Table Footer[1]
	Bremer River	*Streamflow:* Sub-Catchment Yield	MEDIUM	Rodwell Creek	To determine sub-catchment yield for better "Water Allocation" purpose.
		Streamflow: Catchment Outflow	HIGH	Outlet of catchment	Refer Table Footer[1]
	Angas River	*Streamflow:* Sub-Catchment Yield	MEDIUM	Middle Creek, Dawson Creek, Burnside Creek	To determine sub-catchment yields for better "Water Allocation" purpose.
		Streamflow: Catchment Outflow	HIGH	Outlet of catchment	Refer Table Footer[1]

[1] (a) Determine the catchment's total yields; (b) Quantity and frequency of catchment flows into the River Murray/Lake Alexandrina; (c) Estimate stream losses/gains in the "Plains Zone" of the catchment; (d) Better understand surface water – groundwater interactions in the "Plains Zone".

	Catchment	Parameter	Priority	Monitoring Location	Objective /Comments
High-Yield Catchments	**Finnis River**	*Streamflow:* Sub-Catchment Yield	MEDIUM	Bull Creek, Wattle Flat Creek	To determine sub-catchment yields for better "Water Allocation" purpose.
		Streamflow: Catchment Outflow	HIGH	Outlet of catchment	Refer Table Footer[1]
	Tookayerta	Rainfall Distribution	LOW	In upper reaches of Cleland Gully sub-catchment	To obtain more accurate rainfall-Runoff relation for the sub-catchment. Existing rainfall station in the Nangkita Creek sub-catchment.
		Streamflow: Catchment Yield	HIGH	Downstream of confluence of Nangkita Creek and Cleland Gully	To determine catchment yield and flow characteristics. No current streamflow monitoring in the catchment
		Streamflow: Catchment Outflow	HIGH	Outlet of catchment	Refer Table Footer[1]
	Currency Creek	Rainfall Distribution	LOW	In upper reaches of northern tributary	To obtain more accurate rainfall-Runoff relation for the sub-catchment.
		Streamflow: Catchment Yield	HIGH	Downstream of confluence of the two main streams	To determine catchment yield and flow characteristics. No current streamflow monitoring in the catchment.
		Streamflow: Catchment Outflow	HIGH	Outlet of catchment	Refer Table Footer[1]
Medium-Yield Catchments	**Saunders Creek**	*Rainfall Distribution*	High	In the high rainfall upper reaches	To represent the high rainfall area of the catchment; To obtain more accurate rainfall-Runoff relation for the high-yielding and high use area of the catchment.
		Streamflow: Sub-Catchment Yield	HIGH	Downstream of confluence of the two main streams	To determine catchment yield and flow characteristics. No current streamflow monitoring in the catchment.
		Streamflow: Catchment Outflow	MEDIUM	Outlet of catchment	Refer Table Footer[2]

	Catchment	Parameter	Priority	Monitoring Location	Objective /Comments
Medium-Yield Catchments	**Millendella, Preamimma, Deep Creek**	*Rainfall:* Primary Station	MEDIUM	In the high rainfall upper reaches	Currently there is no rainfall monitoring in these catchments.
		Streamflow: Sub-Catchment Yield	HIGH	Downstream of confluence of the two main streams	To determine catchment yield and flow characteristics. No current streamflow monitoring in the catchment.
		Streamflow: Catchment Outflow	MEDIUM	Outlet of catchment	Refer Table Footer[2]
	Salt Creek, Rocky Gully, Sandergrove	*Streamflow:* Sub-Catchment Yield	HIGH	Downstream of confluence of the two main streams	To determine catchment yield and flow characteristics. No current streamflow monitoring in the catchment.
		Streamflow: Catchment Outflow	MEDIUM	Outlet of catchment	Refer Table Footer[2]
		Streamflow: Catchment Outflow	HIGH	Outlet of catchment	Refer Table Footer[2]
Low-Yield Catchments	**Kakoonie**	*Rainfall:* Primary Station	MEDIUM		Currently there is no rainfall monitoring in the "Plains Zone".
	Long Gully, Bees Knees	*Streamflow:* Catchment Outflow	LOW	Outlet of catchment	Refer Table Footer[2]

[2] (a) Determine the catchment's total yields; (b) Quantity and frequency of catchment flows into the River Murray/Lake Alexandrina; (c) Estimate stream losses/gains in the "Plains Zone" of the catchment; (d) Better understand surface water – groundwater interactions in the "Plains Zone".

UNITS OF MEASUREMENT

Units of measurement commonly used (SI and non-SI Australian legal)

Name of unit	Symbol	Definition in terms of other metric units	Quantity
day	d	24 h	time interval
gigalitre	GL	10^6 m^3	volume
gram	g	10^{-3} kg	mass
hectare	ha	10^4 m^2	area
hour	h	60 min	time interval
kilogram	kg	base unit	mass
kilolitre	kL	1 m^3	volume
kilometre	km	10^3 m	length
litre	L	10^{-3} m^3	volume
megalitre	ML	10^3 m^3	volume
metre	m	base unit	length
microgram	µg	10^{-6} g	mass
microlitre	µL	10^{-9} m^3	volume
milligram	mg	10^{-3} g	mass
millilitre	mL	10^{-6} m^3	volume
millimetre	mm	10^{-3} m	length
minute	min	60 s	time interval
second	s	base unit	time interval
tonne	t	1000 kg	mass
year	y	365 or 366 days	time interval

δD	hydrogen isotope composition	$\delta^{18}O$	oxygen isotope composition
EC	electrical conductivity (µS/cm)	^{14}C	carbon-14 isotope (percent modern carbon)
pH	acidity	CFC	chlorofluorocarbon (parts per trillion volume)
ppm	parts per million	ppb	parts per billion
TDS	total dissolved solids (mg/L)	TKN	Total Kjeldahl Nitrogen
TN	Total Nitrogen	TP	Total Phosphorus
u/s	upstream	d/s	downstream

GLOSSARY

Ambient water quality monitoring - the overall or background water quality, integrating all factors that may affect a water body. The ambient water quality of a water body provides an indication of ecosystem health and long-term sustainability of environmental values. Monitoring ambient water quality enables long-term trends and pressures to be identified and the impacts of management strategies to be evaluated.

ANZECC - Australia New Zealand Environmental Consultative Council.

ARMCANZ - Agriculture and Resource Management Council of Australia and New Zealand.

Aquatic community - An association of interacting populations of aquatic organisms in a given water body or habitat.

Aquatic ecosystem - The stream channel, lake or estuary bed, water, and/or biotic communities and the habitat features that occur therein.

Aquatic habitat - Environments characterised by the presence of standing or flowing water.

Aquiclude - In hydrologic terms, a formation which contains water but cannot transmit it rapidly enough to furnish a significant supply to a well or spring.

Aquifer - A body of rock that is sufficiently permeable to conduct groundwater and to yield economically significant quantities of water to wells and springs.

AusRivAS - Australian River Assessment System. A national river and stream health assessment program run by the Australian Government.

AWQC - Australian Water Quality Centre.

AWQMP - Ambient Water Quality Monitoring Program. Run by the South Australian Environment Protection Authority (EPA) since 1996.

Bioassessment - An evaluation of the biological condition of a water body by using biological surveys and other direct measurements of a resident biota in surface water.

Biological integrity - Functionally defined as the condition of the aquatic community that inhabits unimpaired water bodies of a specified habitat as measured by community structure and function.

Biomonitoring - The measurement of biological parameters in repetition to assess the current status and changes in time of the parameters measured.

BoM - Bureau of Metrology, South Australia. Also referred to in this document as 'the Bureau'.

Catchment - The land area that drains into a stream, river, lake, estuary, or coastal zone.

Compliance monitoring - A type of monitoring done to ensure the meeting of immediate statutory requirements, the control of long-term water quality, the quality of receiving waters as determined by testing effluents, or the maintenance of standards during and after construction of a project.

Contaminant - A material added by humans or natural activities that may, in sufficient concentrations, render the environment unacceptable for biota. The mere presence of these materials is not necessarily harmful.

CWMB - Catchment Water Management Board

Data comparability - The characteristics that allow information from many sources to be of definable or equivalent quality, so that this information can be used to address program objectives not necessarily related to those for which the data were collected. These characteristics need to be defined but would likely include detection limit precision, accuracy, bias, and so forth (ITFM/Data Methods Collection Task Group).

DES - Drillhole Enquiry System. A database of groundwater wells in South Australia. Administered by the Department of Water, Land and Biodiversity Conservation of the South Australian Government.

DEH - Department for Environment and Heritage, South Australia.

DHS - Department of Human Services, South Australia.

Diversity - The distribution and abundance of different kinds of plant and animal species and communities in a specified area.

Dryland salinity - The process whereby salts stored below the surface of the ground are brought close to the surface by the rising water table. The accumulation of salt degrades the upper soil profile, with impacts on agriculture, infrastructure and the environment.

d/s - downstream

DO - Dissolved Oxygen.

DOC - Dissolved Organic Carbon.

DWLBC - Department of Water, Land, and Biodiversity Conservation, South Australia.

EC - Electrical conductivity.

Ecological indicators - Plant or animal species, communities, or special habitats with a narrow range of ecological tolerance. For example, in forest areas, such indicators may be selected for emphasis and monitored during forest plan implementation because their presence and abundance serve as a barometer of ecological conditions within a management unit.

Ecosystem - A system that is made up of a community of animals, plants, and bacteria and its interrelated physical and chemical environment.

EDMS - Environmental Database Management System, administered by the Environment Protection Authority, South Australia.

Effectiveness monitoring - Documents how well the management practices meet intended objectives for the riparian area. Monitoring evaluates the cause and effect relations between management activities and conditions of the riparian dependent resources. Terrestrial and instream methods constitute monitoring that evaluates and documents the total effectiveness of site-specific actions.

Emerging environmental problems - Problems that may be new and/or are becoming known because of better monitoring and use of indicators.

EMLR - Eastern Mount Lofty Ranges.

Environmental water requirement - The water regimes needed to sustain the ecological values of water dependent ecosystems, including their process and biological diversity.

EPA - Environment Protection Authority, South Australia.

Estuarine habitat - Tidal habitats and adjacent tidal wetlands that are usually semi-enclosed by land but have open, partly obstructed, or sporadic access to the open ocean and in which ocean water is at least occasionally diluted by freshwater runoff from the land.

EWR - Environmental Water Requirement

Fixed-station monitoring - The repeated long-term sampling or measurement of parameters at representative points for the purpose of determining environmental quality characteristics and trends.

GIS - Geographic Information System. A computerised system for combining, displaying, and analysing geographic data. GIS produces maps for environmental planning and management by integrating physical and biological information (soils, vegetation, hydrology, living resources, etc.,) and cultural information (population, political boundaries, roads, bank and shoreline development, etc.).

Groundwater - Water occurring naturally below ground level or water pumped, diverted and released into a well for storage underground.

GW – Groundwater.

Habitat - (1) A place where the physical and biological elements of ecosystems provide a suitable environment, and the food, cover, and space resources needed for plant and animal existence. (2) The physical/chemical theatre in which the ecological play takes place; it is a template for the biota, their interactions, and their evolution.

Hydrogeology - The study of groundwater, which includes its occurrence, recharge and discharge processes, and the properties of the aquifers.

HYDSTRA – A time series data management system that stores continuously recorded water related data such as water level, salinity and temperature. It provides a powerful data analysis, modelling and simulation system, and contains details of site locations, setup and other supporting information.

Impact - A change in the chemical, physical, or biological quality or condition of a water body caused by external sources.

Impairment - A detrimental effect on the biological integrity of a water body caused by impact that prevents attainment of the designated use.

Implementation monitoring - Documents whether or not management practices were applied as designed. Project and contract administration is a part of implementation monitoring.

Indigenous species - A species that originally inhabited a particular geographic area.

LAP – Local Action Planning Group

Metadata - Information that describes the content, quality, condition, and other characteristics of data (Federal Geographic Data Committee).

Method comparability - The characteristics that allow data produced by multiple methods to meet or exceed the data quality objectives of primary or secondary data users. These characteristics need to be defined but would likely include data quality objectives, bias, precision, information on data comparability, etc.

Monitoring - (1) The repeated measurement of parameters to assess the current status and changes over time of the parameters measured. (2) Periodic or continuous surveillance or testing to determine the level of compliance with statutory requirements and/or pollutant levels in various media or in humans, animals, and other living things.

NATA - National Association of Testing Authorities.

Native species - Any animal and plant species originally in Australia.

NHT - National Heritage Trust.

NLWRA - National Land and Water Resource Audit.

Nonpoint-source pollution - A contributory factor to water pollution that cannot be traced to a specific location. For example, pollution that results from water runoff from urban areas, construction sites, agricultural and silvicultural operations, etc.

Obswell - Observation Well Network.

P - Phosphorous.

Perennial streams - Permanently inundated surface stream courses. Surface water flows throughout the year except in years of infrequent drought.

PIRSA - Department of Primary Industries and Resources, South Australia.

Pluviometer - An automated rain gauge consisting of an instrument to measure the quantity of precipitation over a set period of time.

Point-source pollution - Pollution discharged through a pipe or some other discrete source from municipal water treatment plants, factories, confined animal feedlots, or combined sewers.

Population - (1) For the purposes of natural resource planning, the set of individuals of the same species that occurs within the natural resource of interest. (2) An aggregate of interbreeding individuals of a biological species within a specified location.

Prescribed water resource - A water resource declared by the Governor of South Australia to be prescribed under the *Water Resource Act 1997*. Includes underground water to which access is obtained by prescribed wells. Prescription of a water resource requires that future management of the resource be regulated by a licensing system.

Prescribed well - A well declared to be a prescribed well under the *Water Resource Act 1997*. See also Prescribed water resource.

PWA - Prescribed Wells Area.

RCT - Resource Condition Targets

Reticulated water - Water supplied through a piped distribution system.

Riparian - Of, pertaining to, or situated or dwelling on the bank of a river or other water body.

Riparian areas - Geographically delineable areas with distinctive resource values and characteristics that compose the aquatic and riparian ecosystems.

Riparian dependent resources - Resources that owe their existence to a riparian area.

Riparian ecosystems - A transition between the aquatic ecosystem and the adjacent terrestrial ecosystem; these are identified by soil characteristics or distinctive vegetation communities that require free or unbound water.

Riparian habitat - The transition zone between aquatic and upland habitat. These habitats are related to and influenced by surface or subsurface waters, especially the margins of streams, lakes, ponds, wetlands, seeps, and ditches.

Riverine habitat - All wetlands and deep-water habitats within a channel, with two exceptions - wetlands dominated by trees, shrubs, persistent emergent mosses or lichens, and habitats with water that contains ocean-derived salt in excess of 0.5 parts per thousand.

RMCWMB - River Murray Catchment Water Management Board.

SA Geodata - A collection of linked, publicly accessible databases storing geological and hydrogeological data. Custodianship of data related to minerals and petroleum is vested in PIRSA. Custodianship of groundwater related data is vested in DWLBC.

SARDI - South Australian Research and Development Institute.

SASQAP - South Australian Shellfish Quality Assurance Program.

SA Water - South Australian Water Corporation.

SOP - Standard operating procedure.

SRA - Sustainable Rivers Audit. Carried out by the Murray-Darling Basin Commission.

Sub-catchment - The area of land determined by topographical features within which rainfall will contribute to runoff at a particular point.

Surface water - Water flowing over land (except in a watercourse), (1) after having fallen as rain or hail or having precipitated in any other manner; or (2) after rising to the surface naturally from underground; or (3) water of the kind that has been collected in a dam or reservoir.

Surface Water Archive - An Internet based database linked to HYDSTRA operated by DWLBC. It contains rainfall, water level, streamflow, and salinity data collected from a network of surface water monitoring sites located throughout South Australia.

SW – Surface water.

SWMCC - State Water Monitoring Coordination Committee.

TDS - Total Dissolved Solids. A measure of water salinity (in mg/L).

Tertiary aquifer - A term used to describe a water-bearing rock formation deposited in the Tertiary Geological period (from 1-70 millions years ago).

Threatened species - Any species that is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.

TKN - Total Kjeldahl Nitrogen.

TN - Total Nitrogen.

Toxic - Relating to harmful effects to biota caused by a substance or contaminant.

TP - Total Phosphorus.

u/s - upstream

USGS - United States Geological Survey.

WAP – Water Allocation Plan.

Water allocation - in respect of water licensing, is the maximum quantity of water that a licensee is entitled to take and use pursuant to an authorisation under section 11 of the *Water Resource Act 1997*.

Water Allocation Plan (WAP) - A plan prepared by a Catchment Water Management Board or water resource planning committee and adopted by the Minister in accordance with Division 3, Part 7 of the *Water Resource Act 1997*.

Water dependent ecosystems - Those parts of the environment, the species composition and natural ecological processes, which are determined by the permanent or temporary presence of flowing or standing water, above or below ground. The in-stream area of rivers, riparian vegetation, springs; wetlands, floodplains, estuaries and lakes are all water dependent ecosystems.

Water quality criteria - comprised of both numerical criteria and narrative criteria. Numerical criteria are scientifically-derived ambient concentrations developed by the Environment Protection Agency (Australian Federal Government) or the States for various pollutants of concern, so that human health and aquatic life can be protected. Narrative criteria are statements that describe the desired water quality goal.

Water quality data - Chemical, biological, and physical measurements or observations of the characteristics of surface and ground waters, atmospheric deposition, potable water, treated effluents, and waste water and of the immediate environment in which the water exists.

Water quality information - Derived through analysis, interpretation, and presentation of water quality and ancillary data.

Water quality monitoring - An integrated activity for evaluating the physical, chemical, and biological character of water in relation to human health, ecological conditions, and designated water uses.

Water quality standard - A law or regulation that consists of the beneficial designated use or uses of a water body, the numerical and narrative water quality criteria that are necessary to protect the use or uses of that particular water body, and an anti-degradation statement.

Water resource monitoring - An integrated activity for evaluating the physical, chemical, and biological character of water resources, including: (1) surface waters, groundwaters, estuaries, and near coastal waters; and (2) associated aquatic communities and physical habitats, which include wetlands.

Water resource quality - (1) The condition of water or some water-related resource as measured by biological surveys, habitat-quality assessments, chemical-specific analyses of pollutants in water bodies, and toxicity tests. (2) The condition of water or some water-related resource as measured by habitat quality, energy dynamics, chemical quality, hydrological regime, and biotic factors.

Wetlands - Habitat that is transitional between terrestrial and aquatic where the water table is usually at or near the land surface, or land that is covered by shallow water. Wetlands have one or more of the following characteristics: at least periodically, the land supports predominantly hydrophytic plants; the substrate is predominantly undrained hydric soil; the substrate is nonsoil and is saturated with water or covered by shallow water at sometime during the yearly growing season.

WDE - Water Dependent Ecosystem.

REFERENCES

Baldwin DS, Nielsen DL, Bowen PM, and Williams J, 2005, *Recommended methods for monitoring floodplains and wetlands,* MDBC Publication No 72/04, Murray-Darling Basin Commission, Canberra.

Barnett SR and Zulfic D, 2002, *Mount Lofty Ranges Groundwater Assessment Southern Fleurieu Catchments* Department for Water Resources, South Australia.

Barnett S, Yan W and Zulfic D, 2001, *Marne River Catchment Groundwater Assessment,* Report DWLBC 2001/009, Department for Water Resources, South Australia.

Barnett SR. and Zulfic D, 1999, *Mount Lofty Ranges Groundwater Assessment Tookayerta Catchment,* Department of Primary Industries and Resources South Australia.

Boulton AJ, Humphreys WF, and Eberhard SM, 2003, *Imperilled subsurface waters in Australia: Biodiversity, threatening processes and conservation,* Aquatic Ecosystem Health and Management 6, p. 41-54.

Brydges T, 2004, 'Basic concepts and applications of environmental monitoring' in Wiersma GB (ed), *Environmental Monitoring*, Cooperative Research Centre Press, p. 83-110.

Chessman BC, 1986, 'Dietary studies of aquatic insects from two Victorian rivers' in *Australian Journal of Marine and Freshwater Research*, 37, p. 129-46.

Chessman BC, 1995, 'Rapid assessment of rivers using macroinvertebrates: A procedure based on habitat-specific sampling, family level identification and a biotic index, in *Australian Journal of Ecology*, 20, p. 122-129.

Conallin A and Hammer M, 2003, *Fish surveys of selected streams in the Eastern Mount Lofty Ranges,* MDFRC Report No. 7/2003. Mildura, The Murray-Darling Freshwater Research Centre, South Australia, p. 59.

DEH, 2003, *Annual report 2002/03* Department for Environment and Heritage, South Australia.

DEH, 2005, *River health in the Eastern Mount Lofty Ranges* URL accessed March 2005: http://www.environment.sa.gov.au/reporting/inland/rivers_streams/healthassess.html#eastern_lofty. Department for Environment and Heritage, South Australia.

DWLBC, 2003, *Annual Report 2002-03* Department Water, Land and Biodiversity Conservation, South Australia.

DWLBC, 2005, *State Natural Resources Management plan 2005-2010 - draft State Natural Resources Management plan - consultation documents.* Department of Water, Land and Biodiversity Conservation, South Australia.

DWLBC, 2005, *Towards South Australia's Natural Resources Management plan 2005-2010 - draft State Natural Resources Management plan - consultation documents.* Department of Water, Land and Biodiversity Conservation, South Australia.

DWR, 2000, *State Water Plan 2000,* Department for Water Resources, South Australia.

Downes BJ, Barmuta LA, Fairweather PG, Faith DP, Keough MJ, Lake PS, Mapstone BD and Quinn GP, 2002, *Monitoring ecological impacts: concepts and practice in flowing water,* Cambridge University Press, New York.

EPA, 2003, *EPA Annual Report 2002-2003,* unpublished report. Environment Protection Authority, South Australia.

EPA, 2005, *EPA water quality monitoring programs, a review,* unpublished report, Environmental Protection Authority, South Australia.

Finlayson CM and Mitchell DS, 1999, 'Australian Wetlands: The monitoring challenge' in *Wetlands Ecology and Management* 7, p. 105-112.

Gilbert J and Deharveng L, 2002, 'Subterranean ecosystems: A truncated functional biodiversity' in *BioScience* 52, p. 473-481.

Gordon N, McMahon T and Finalyson B, 2000, *Stream Hydrology: An Introduction for Ecologists,* John Wiley and Sons, Chichester.

Greenwood AG, 2001, *Surface Water Monitoring Review, Volume 1: The Mount Lofty Ranges* Internal Report, Department of Water Resources, South Australia.

Hammer M. 2001, *Molecular systematics and conservation biology of the southern pygmy perch Nannoperca australis (Günther, 1861) (Teleostei: Percichthyidae) in south-eastern Australia,* Department of Environmental Biology, Adelaide University, South Australia.

Hammer M, 2002, *Environmental water requirements for freshwater fishes of the Marne River Catchment, South Australia* Report produced for the River Murray Catchment Water Management Board.

Hammer M, 2004a, *Recovery progress for the southern pygmy perch in the Mount Lofty Ranges: 2001-2003,* Native Fish Australia (SA) Inc.

Hammer M, 2004b, *Eastern Mount Lofty Fish Inventory: distribution and conservation of freshwater fishes of tributaries to the Lower River Murray, South Australia*, Native Fish Australia (SA) Inc and River Murray Catchment Water Management Board, 104.

Harding CL, 2005, *Wetland Inventory for the Fleurieu Peninsula, South Australia*, Department for Environment and Heritage, South Australia.

Harris JH, 1995, 'The use of fish in ecological assessments' in *Australian Journal of Ecology*, 20, p. 65-80.

Hicks BB and Brydges TG, 1994, 'A strategy for integrated monitoring' in *Environmental Management*, 18(1), p. 1-12.

Humphreys WF, 2002, *Groundwater ecosystems in Australia: an emerging understanding*. Proc International Association of Hydrogeologists Conf, pp. 1-14.

Kneebone J, 2000, *State Water Monitoring Review: Monitoring Partnerships Paper,* Environmental Protection Agency, South Australia.

Lake PS, 1982, 'Ecology of macroinvertebrates of Australian upland streams - review of current knowledge', in *Bulletin of the Australian Limnological Society*, 8, p. 1-16.

Liddicoat C and Dooley T, 2004 *Salinity Benchmarking and Monitoring Strategy, Goolwa to Wellington LAP Area,* Rural Solutions SA.

Liddicoat C. and Dooley T, 2005 *Salinity Benchmarking and Monitoring: Strategy, Eastern Hills and Murray Plains LAP Area,* Rural Solutions SA.

Lopez C, and Dates G, 1998, 'The efforts of community volunteers in assessing watershed ecosystem health' in Rapport D, Costanza R, Epstein PR, Gaudet C and Levins R (eds), *Ecosystem Health*, Blackwell Science, Malden USA, pp. 103-128.

MacDonald LH, Smart AW, and Wissmar RC, 1991. *Monitoring Guidelines to Evaluate Effects of Forestry Activities on Stream in the Pacific Northwest and Alaska*. EPA-910/9-001, U.S. Environmental Protection Agency, Seattle Washington

Marchant R, 1986, 'Some quantitative aspects of the life history of aquatic insects in temperate Australian rivers' in de Decker P, Williams WD and Junk D (eds), *Limnology in Australia*, Dordrecht, CSIRO, Melbourne, p. 151-8.

Marmonier P, Vervier P, Gilbert J and Dole-Olivier M-J, 1993, 'Biodiversity in ground waters' in *Trends in Ecology and Evolution* 8, p. 392-395.

MDBC, 2004, *Fish Theme Pilot Audit Technical Report – Sustainable Rivers Audit,* Murray-Darling Basin Commission Publication 06/04, Canberra, Australia.

NLWRA (2003) *National land and water resources audit strategic plan 2003–2007.* National Land and Water Resources Audit, Canberra, Australia.

Pearson RG, Benson LJ, and Smith REW, 1986, 'Diversity and abundance of the fauna in Yuccabine Creek, a tropical; rain-forest stream' in de Decker P, Williams W, and Junk D (eds), *Limnology in Australia*, Dordrecht, CSIRO, Melbourne, p. 329-42.

Reid MA, Tibby JC, Penny D, and Gell PA, 1995, 'The use of diatoms to assess past and present water quality' in *Australian Journal of Ecology*, 20, p. 57-64.

RMCWMB, 2002, *Annual Report 2002* River Murray Catchment Water Management Board, South Australia.

RMCWMB, 2003 *Catchment Water Management Plan for the River Murray in South Australia,* Online URL: www.rivermurray.sa.gov.au, Accessed November 2005, River Murray Catchment Water Management Board, South Australia.

Savadamuthu, K, 2003, *Surface Water Assessment of the Upper Finnis Catchment,* Department of Water, Land and Biodiversity Conservation, South Australia.

Sinclair Knight Merz, 2002, *Integrated Water Monitoring Review of the Northern Adelaide and Barossa Catchment Area.*

Wen L, 2005 *Review of and Recommendations for Water Monitoring in Eyre Peninsula NRM Region,* Report DWLBC 2005/38, Department of Water, Land and Biodiversity Conservation, South Australia.

Williams WD, 1980, *Australian Freshwater Life. The Invertebrates of Australian Inland Waters,* McMillan, Melbourne.

Zulfic D and Barnett SR, 2002, *Saunders Creek Catchment Groundwater Assessment,* Department Water, Land and Biodiversity Conservation, South Australia.

Zulfic D and Barnett SR, 2003, *Eastern Mount Lofty Ranges Groundwater Assessment,* Department Water, Land and Biodiversity Conservation, South Australia.