DWLBC REPORT

Review of South Australian State Agency Water Monitoring Activities in the Patawalonga Catchment

2006/13

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

Review of South Australian State Agency Water Monitoring Activities in the Patawalonga Catchment

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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
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DEPARTMENT OF WATER, LAND AND BIODIVERSITY CONSERVATION

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PREFACE

This report, written during 2005, provides a useful record of water monitoring activities in the Torrens Catchment at the time of writing.

Implementation of the South Australian *Natural Resources Management Act 2004* and 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

The review of water monitoring activities in the Patawalonga Catchment is based on a desktop evaluation, and seeks to provide the starting point for discussions on the development of an integrated Natural Resources Management (NRM) monitoring framework and strategy.

The review covers information on the six themes of water resources 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, a more unified approach is a key goal of the South Australian Government's Natural Resources Management Plan 2006 (NRM Plan), which 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 Patawalonga Catchment is currently fragmented both within and between government agencies and community based organisations. There is limited communication or exchange of data between the main monitoring networks.

Monitoring of a variety of aspects of water resources, including surface and groundwater quantity and quality, aquatic ecosystems, and marine and estuarine waters, all occur in the Patawalonga Catchment, but to varying spatial and temporal scales, and with varying frequencies.

An opportunity exists for state and regional agency agreement to ensure that water monitoring programs:

- fulfill the basic requirements of the National Monitoring and Evaluation Framework and National Water Initiative (NWI)
- meet the needs of the National Land and Water Resource Audit and for Natural Heritage Trust (NHT) funded programs
- comply with the State Monitoring and Evaluation Framework for NRM
- satisfy the requirements for regional resource condition assessment and management
- satisfy the requirements of the state Environment Protection Act 1993.

This report is 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) which 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 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 Patawalonga Catchment

These suggestions provide a guide to agencies developing monitoring programs in the future (further details are provided in the body of the 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 category	Gaps	Suggestions for monitoring	Refer	Stakeholder(s)
Basin Outflow Station	Gulf St Vincent	Monitor quantities of surface water leaving the Patawalonga Catchment.	Sect 5.1.1	DWLBC, CWMB
Streamflow — Heathfield WWTP	Upper Sturt River sub-catchment	Monitor in relation to the impact on flow regime of the Heathfield WWTP whereby artificial baseflows have been created from wastewater being directed into the river.	Sect 5.2.2 Sect 5.2.3 Sect 5.6.2	

Surface Water Quality Monitoring

Monitoring category	Gaps	Suggestions for monitoring	Refer	Stakeholder(s)
Ambient	Workanda Creek, Shepherds Hill and Chambers Creek sub-catchments	Establish ambient water quality monitoring sites.	Sect 5.6.3	CWMB, EPA
WWTP	Glenelg WWTP	Monitor wastewater from the WWTP for water quality and quantity.	Sect 5.6.3	

Groundwater Quantity and Quality Monitoring

Monitoring category	Gaps	Suggestions for monitoring	Refer	Stakeholder(s)
Quantity and quality	Urban section	Expansion of Obswell network.	Sect 6	DWLBC, CWMB

Aquatic Ecosystems

Monitoring category	Gaps	Suggestions for monitoring	Refer	Stakeholder(s)
Integrated monitoring program	WMLR region	Develop calibrated catchment model.	Sect 7.4.1	DWLBC, DEH, EPA, CWMB

Monitoring category	Gaps	Suggestions for monitoring	Refer	Stakeholder(s)
Stygofauna	No data	Basic research.	Sect 7.3.4	DWLBC, EPA
Significant aquatic ecosystems	Not identified	Identification of priority aquatic ecosystems for ambient monitoring is needed.	Sect 7.4.1.3	DWLBC, EPA, CWMB
Riparian vegetation	Riparian vegetation is degraded	Monitor restoration of riparian vegetation.	Sect 7.4.1.4	DWLBC, CWMB
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.	Sect 7.3.2	DWLBC, CWMB
Ephemeral streams	Understanding of impact of altered flow regime	Research the impacts of altered flow regime on ephemeral streams.	Sect 7.3.3	DWLBC, CWMB

Catchment Characteristics

Monitoring category	Gaps	Suggestions for monitoring	Refer	Stakeholder(s)
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.	Sect 8	CWMB, PIRSA
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.	Sect 8	CWMB, PIRSA, DWLBC, EPA
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.	Sect 8	CWMB, DWLBC

Data and Information Management

Monitoring category	Gaps	Suggestions for monitoring	Refer	Stakeholder(s)
All monitoring	Data quality, storage and accessibility	Review monitoring data across all monitoring themes for all agencies.	Sect 9	All stakeholders

Roles and Responsibilities

Monitoring category	Gaps	Suggestions for monitoring	Refer	Stakeholder(s)
Integration between agencies	Coordination between state agencies and CWMBs to clarify state-scale and catchment-scale responsibilities	Agencies and CWMBs coordinate with regard to reviewing, rationalising or expanding monitoring programs, to avoid duplications or gaps, e.g. macro-invertebrate and groundwater.	General	All stakeholders

1. INTRODUCTION

1.1 BACKGROUND

As part of achieving the object of the *Water Resources Act 1997* (now superseded by the *Natural Resources Management Act 2004)*, the State Water Monitoring Coordinating 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 development of recommendations for future water monitoring that will meet the state's core business needs and legislative responsibilities. Recommendations 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 WMLR, 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. It is advisable that monitoring these systems be reviewed in a separate document.

1.2 AIM

The aim of this project is to provide key stakeholders with suggestions they can use in the development of water monitoring strategies. These 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
- identify barriers to coordination of monitoring programs
- 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
- make general suggestions for a future water monitoring strategy.

In identifying monitoring gaps, comparisons have been made between existing on-going monitoring and ideal models for monitoring, which can be found in the appendices. Surface water monitoring has been dealt with on a site-by-site basis. Due to their large numbers, groundwater monitoring sites have been dealt with by reference to networks.

1.5 CONSULTATION

Under the auspices of SWMCC, a range of agencies have had opportunities to provide input to the monitoring review process. People within state agencies have been broadly consulted, and the key officers involved are listed in the Acknowledgements Section.

1.6 STUDY AREA

Potable water to metropolitan Adelaide is sourced from the River Murray and from run-off in the Mount Lofty Ranges. Water quality and availability of this water supply must be maintained at suitable levels for drinking and other domestic uses. The quality and volume of surface and groundwater resources for primary production also need to be maintained at levels that can sustain this important part of the economy. In addition, it is imperative that surface and groundwater levels and quality, in both rural and urban areas, are able to sustain aquatic ecosystems.

Rural and urban land management practices, including native vegetation clearance, irrigation activities, agricultural chemicals, groundwater extraction, surface water storages, domestic wastewater disposal, urban stormwater flows and industrial activities have significantly impacted upon the quantity and quality of surface and groundwater resources in the WMLR region. These land management practices present a risk to the sustainable use of water resources in the future.

Pressures from SA Water infrastructure, including the operation of large, major water supply dams and weirs, as well as the use of aqueducts to transfer water, have had a significant impact on flow regimes of natural watercourses. These impacts occur downstream of such infrastructure.

Farm dam development alters the hydrology of a catchment by capturing water that would otherwise flow into streams, reservoirs and recharge aquifers. The current level of farm dam development and potential for further development in some WMLR areas poses a risk to surface water, groundwater and aquatic ecosystem 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 discharges to streams (particularly during summer), which may have significant impacts on aquatic ecosystems.

Because the hydrological processes of fractured rock aquifers are not well understood, water balance estimates and resulting estimates of sustainable groundwater use should be approached with caution. A better understanding of recharge and flow in these aquifers is needed to ascertain the effects of any increase in extraction rates of groundwater from them.

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 *Escherichia (E.) Coli*, *Cryptosporidium* and *Giardia* from animal waste and septic tank effluent systems; nutrients including phosphorus, nitrogen and carbon from fertilisers; animal waste, sewage and industry effluent; and pesticides from forestry, agriculture and horticulture.

Sediments can adsorb nutrients, pesticides and micro-organisms, and transport them into waterways. Sediment is easily removed from drinking water at water treatment plants but the greater the sediment load the greater is the cost of its removal.

1.7 STAKEHOLDERS

Key stakeholders for monitoring in the Patawalonga Catchment include (refer to Section 3 for further information):

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

2. CATCHMENT DESCRIPTION

2.1 GROUNDWATER RESOURCES

The Patawalonga Catchment overlies Tertiary sediments beneath the Adelaide metropolitan area and the Noarlunga Embayment, with Adelaidean-age fractured rocks consisting of slate, dolomite, sandstone and quartzite underlying the Hills Catchment.

2.1.1 HILLS CATCHMENTS

Groundwater is stored in, and moves through, joints and fractures in the rocks underlying these catchments in what are called fractured rock aquifers. Recharge to these aquifers occurs directly from that portion of rainfall which percolates down through the soil profile (most of the rainfall runs off straight to the streams or is used by plants). Groundwater moves from the higher points in the landscape to the lowest where discharge occurs to the streams. Consequently, the streams act as drains for the fractured rock aquifer systems. This discharge constitutes the baseflow of the streams which dominates flow for most of the year, particularly over the summer and between rainfall events.

The Adelaidean sediments underlie most of the catchment, and are dominated by the Burra Group which consists of siltstone, shale, slate, dolomite, sandstone and quartzite. These are considered good aquifers because of their relatively high yields and low salinity.

2.1.2 METROPOLITAN CATCHMENT

Unconsolidated sediments of the St Vincent Basin underlie the Metropolitan Catchment. They consist of interbedded beds of sand and clay up to 80 m thick which in turn are underlain by a shelly limestone and sand of Tertiary age, averaging 150 m in thickness. These sediments overlie basement rocks that are exposed in the Hills Zone. Because of the urbanised nature of this zone with the predominance of impermeable surfaces (roofs, sealed roads, etc.), and the clayey nature of the soils, direct recharge from rainfall to the shallow watertable aquifer is limited.

Recharge to the shallow aquifer does occur from creeks that are unlined and some reaches of the Patawalonga River through permeable alluvial sediments. The deeper Tertiary aquifers however, are recharged only by groundwater flow from the fractured rock aquifers along the Hills Face Zone.

Groundwater flows through pore spaces in the sand and limestone beds towards the sea, where it eventually discharges. Development of the groundwater resources has occurred mainly from the deep Tertiary aquifer to the west of the city in the Thebarton area.

2.1.3 NOARLUNGA EMBAYMENT

The Tertiary sands are thin and often very fine grained, making well completions difficult. In areas where sands are coarse, moderate irrigation supplies can be obtained, although the most reliable supplies are obtained from the fractured bedrock underlying the Tertiary sands. Salinities are lowest near the eastern margin near Happy Valley Reservoir. This area has suffered encroachment by urban expansion and a subsequent reduction in demand for irrigation.

2.2 AQUATIC ECOSYSTEMS

The WMLR has a diverse range of aquatic ecosystems. The region's ephemeral and permanent streams contain a diversity of habitats such as pools, riffles and the riparian zone, and floodplains and gorges. The major freshwater courses of the WMLR are the Gawler, Little Para, Torrens, Sturt and Onkaparinga Rivers and their associated tributary streams. 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 would also support subterranean groundwater ecosystems, although little is known about these systems. These water-dependent ecosystems support a range of flora and fauna including instream, riparian and floodplain vegetation; phyto- and zoo-plankton communities; macro-invertebrates; fish; birds and mammals.

3. ROLES AND RESPONSIBILITIES OF STAKEHOLDERS

3.1 ROLES OF MAJOR STAKEHOLDERS

3.1.1 DEPARTMENT OF WATER, LAND AND BIODIVERSITY CONSERVATION (DWLBC)

DWLBC is the lead state government agency in the management and administration of the state's water resources, including licensing, allocation, monitoring and policy advice. It has a significant focus on securing the supply of good quality water for South Australia from the Murray–Darling Basin system. Additionally, DWLBC works to ensure the high-quality management of groundwater and other water resources throughout the state (Department for Water Resources 2000; DWLBC 2004).

Knowledge and Information Division, DWLBC

The key focus for the division is to provide knowledge and information about the state, condition, use and management of natural resources. This is achieved through partnerships across government; with natural resources managers, industry and the community, and through excellence in science, professional advice and information management services.

The functions of the division are to:

- establish knowledge and management, including the development of information management systems to support integrated Natural Resource Management (NRM)
- ensure that scientific information is available for decision making within government, industry and the community
- monitor, assess and advise on the status and condition of natural resources and levels of sustainable resource allocation
- support research and development organisations' innovations in NRM technologies, practices and methodologies.

3.1.2 ENVIRONMENT PROTECTION AUTHORITY (EPA)

The EPA is South Australia's primary environmental regulator. It has responsibility for the protection of air and water quality, and the control of pollution, waste and noise, to ensure the protection and enhancement of the environment (EPA 2003).

The EPA is required to meet legislative monitoring and reporting requirements under the *Environment Protection Act 1993* and the *Water Resources Act 1997* (now repealed by the *NRM Act 2004*). The Environment Protection Agency assists the Authority in undertaking these tasks.

The Environment Protection Act requires the Authority to institute or supervise environmental monitoring and evaluation programs relevant to the protection, restoration or enhancement of the environment. Additionally, the Authority is required to prepare and publish the State of the Environment Report (SoE), which must:

- include an assessment of the condition of the major environmental resources of South Australia
- identify significant trends in environmental quality based on an analysis of indicators of environmental quality
- identify significant issues and make recommendations that should be drawn to the attention of the Minister.

In addition to SoE reporting requirements, the Environment Protection Act requires the Authority 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.

The Authority also has reporting responsibilities to provide input into State Water Plan amendments under the Water Resources Act (now repealed by the *NRM Act 2004*).

To satisfy legislative requirements, the EPA's monitoring program needs to:

- be representative of the major environmental resources
- have adequate coverage to identify geographical trends and/or variation
- use indicators that are able to reflect significant trends that are likely to be a response to pressures and/or management strategies
- use indicators that are suitable for multiple reporting requirements (SoE and State Water Plan)
- use monitoring frequency that is optimal for the identification of trends in a cost-effective manner.

3.1.3 DEPARTMENT FOR ENVIRONMENT AND HERITAGE (DEH)

DEH is involved in research, planning and delivery of biodiversity conservation programs and the provision of scientific support and monitoring for biodiversity management, including wetlands (DEH 2004).

DEH manages its business through the following programs:

- Attaining Sustainability — by promoting sustainable and eco-efficient human endeavour with minimal impact on essential life systems
- Nature Conservation — whereby management, science and education contribute to conserving the state's biodiversity
- Public Land Management — through the conservation, maintenance and stewardship of the state's public lands
- Coast and Marine Conservation — by conserving, managing and protecting the state's coast and marine environments
- Heritage Conservation — through understanding, conserving and protecting the state's rich heritage

- Environmental Information — through the provision of information to support the state's environmental needs.

3.1.4 SOUTH AUSTRALIAN WATER CORPORATION (SA WATER)

SA Water is responsible for ensuring that potable water supplied to customers is safe to drink. There are agreed levels of service between SA Water and the Department of Human Services (DHS), and regular (monthly) reporting on compliance with these levels, and with the requirements of the Australian Drinking Water Guidelines, is required. This arrangement involves a preventative, multiple-barrier approach to water quality management and requires management of the water system from source to tap.

SA Water's mission is to provide innovative water and wastewater solutions that:

- safeguard public health
- sustain water resources and the environment for the future
- deliver increasing value for its customers, the government and the community (SA Water 2003).

Its primary functions are to provide services:

- for the supply of water by means of reticulated systems
- for the storage, treatment and supply of bulk water
- for the removal and treatment of wastewater by means of sewerage systems (SA Water 2003).

SA Water has the following further function in relation to water monitoring:

- to carry out research and works to improve water quality and wastewater disposal and treatment methods (SA Water 2003).

In satisfying these requirements, SA Water extensively monitors water quality at inlets to water supply reservoirs and water intakes, in the reservoirs, at treatment plants and in the distribution system. Water quality monitoring parameters are chemical, physical, biological (algal) and microbiological. Monitoring is mainly carried out by the collection of 'grab samples'. SA Water carries out load-based monitoring of reservoirs at some sites. All water quality data collected by SA Water are maintained on a central database managed by the Australian Water Quality Centre (AWQC).

SA Water also has an interest in the quantity of water flowing into reservoirs and volumes transferred between storages. An informal arrangement exists with DWLBC to store this information on the HYDSTRA database or as spreadsheets. SA Water is currently developing a system on which to store water transfer data, and is reviewing its water quantity monitoring and data requirements (Kneebone 2000).

3.1.5 PATAWALONGA CATCHMENT WATER MANAGEMENT BOARD (PCWMB)

Goals of the PCWMB (refer to App. D for Actions and Strategies)

Goal 1 Water quality — to improve and maintain water quality in the catchment to a level suitable for the safe use by the community (including for recreation) and to sustain ecosystems and reduce impacts on the receiving aquatic environments.

Goal 2 Riverine ecology and environment — to protect and restore aquatic ecosystems.

Goal 3 Water resources — the water resources of the catchment are available and used to maintain ecosystems and for equitable and economic community use.

Goal 4 Flooding — to coordinate floodplain management at the catchment scale.

Goal 5 Community involvement and education — to inform and involve the community and encourage it to take responsibility for catchment management.

Goal 6 Monitoring and evaluation — to establish and implement monitoring and evaluation systems that enable the board to assess the effectiveness of its programs and the health of the catchment.

Goal 7 Integration — to deliver the board's programs in an integrated manner in partnership with all other stakeholders, taking into account environmental, economic and social considerations (triple bottom line).

3.1.6 BUREAU OF METEOROLOGY (BOM)

BoM is a major water resource data collection agency for South Australia. It is responsible (since 1988) for providing a flood warning service for non-flash flooding (i.e. rivers that take more than six hours to flood).

Flash flooding (i.e. floods that develop in less than six hours) is probably more critical for Adelaide and surrounding areas. BoM provides hydrological advice and critical support to local councils for flash floods as well as assistance in setting up monitoring equipment for rainfall and water levels, but is not responsible for forecasting or issuing flood warnings for this type of flooding.

Local councils have contributed towards the cost of setting up a network of rainfall and water-level monitoring stations, as well as flood ALERT computer base stations for monitoring flash flooding. These systems are primarily monitoring systems and are not able to provide generalised warnings to the public. BoM maintains the monitoring equipment and computers, and recovers associated costs from councils. All data collected by the ALERT monitoring stations are quality controlled and stored in the DWLBC HYDSTRA database.

BoM also has a significant role in providing rainfall and general climate data for water resource purposes, and maintains sites that collect daily rainfall data, automatic weather stations that collect rainfall data both daily and in ‘time series’ form, and pluviometer sites that collect the full time series record down to 10-second increments.

Data from the pluviometer sites are edited and archived in the DWLBC HYDSTRA database. Data from the sites that collect daily rainfall and the automatic weather stations is held in the National Climate Centre in Melbourne, and can be accessed from the BoM office in Adelaide.

3.2 RESPONSIBILITIES OF MAJOR STAKEHOLDERS

The current responsibilities of principle agencies for water monitoring are shown in Table 1 (adapted from Wen 2005; App. C). It also provides reference to other principle agencies carrying out related monitoring that can be used in determining information-sharing opportunities.

Table 1. Current responsibilities of principle agencies for water monitoring.

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

4.1.2 WATER QUALITY

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

4.1.3 SURFACE WATER

Many Federal, state, and local agencies in South Australia analyse stream-flow data, the uses of which 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 are used to:

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

Groundwater data are 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) considered it 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:

- **monitoring for SoE reporting** — aims to provide instantaneous reporting of current conditions
- **regulatory and/or 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 the 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 five broad categories (adapted and modified from Brydges 2004):

- **simple monitoring** — records the values of a single variable (e.g. rainfall)
- **multivariate monitoring** — records multiple variables (e.g. 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 WMLR 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 and quality control, laboratory analysis, data handling, data analysis), data utilisation, communication and coordination. Saunders (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 or not activities were carried out as planned
- **effectiveness monitoring** — used to evaluate the effectiveness of specified activities
- **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 if specified water quality criteria are being met.

4.3 MONITORING METHODS EMPLOYED

4.3.1 SURFACE WATER QUANTITY

DWBLC is the state agency primarily responsible for collecting, analysing and sharing data on surface water quantity (availability and use) and, in particular, is the main collector of stream flow data, which measures the volume of water flowing through a stream using stream gauges. DWLBC collects data through its state stream-gauge network, which continuously measures the level and flow of rivers and streams at 80 stations state wide. These data are 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 ~200 hydrometric stations across the state. Data collected by other agencies, such as SA Water, are stored in the HYDSTRA data management and reporting system, maintained by the Hydrographic Unit of DWLBC.

The stream-gauging stations include a range of in-stream 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, DWLBC has classified the stream-gauging stations into six types (App. B), each type having an assigned priority level, unique purposes and minimum parameter requirements.

4.3.2 SURFACE WATER QUALITY

EPA is responsible for assessing the condition of surface waters on a state-wide basis in accordance with the Environment Protection Act (SA). The EPA conducts ambient water quality monitoring programs including the rivers and streams program, marine and estuarine 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, NH_3, TKN and total P). Biological parameters include an estimate of algal biomass (chlorophyll *a*), microbiological parameters (*E. coli* and enterococci) and macro-invertebrates. 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 macro-invertebrate sampling is consistent with AusRivAS (Australian River Assessment System) 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 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 — 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 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, it is advisable to carefully select and incorporate existing wells 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 must be submitted as a condition of the permit. These data are then recorded on the SAGeodata database. Where the bore 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 onto the database vary. 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 SAGeodata 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 are 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 WMLR 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 macro-invertebrates 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 is a rapid prediction system used to assess the biological health of Australian rivers. It 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 bio- and physical assessment methods in its 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 macro-invertebrate 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: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 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 is gleaned on the distribution and abundance of frogs in South Australia.

5. SURFACE WATER MONITORING

5.1 BASE STATIONS

The role of a base station is to monitor outflow from the major yielding section(s) of a catchment and should be operated indefinitely, monitoring rainfall, water level or stream flow and salinity. It is considered to be a high priority form of monitoring.

5.1.1 BASIN OUTFLOW STATIONS

A high percentage of the water that enters Gulf St Vincent comes from highly urbanised sub-catchments that are drained by a number of urban drainage systems that discharge directly into the gulf. The impact of these discharges is not well understood and it is therefore important that comprehensive monitoring of surface water levels and quality be carried out. The minimum monitoring parameters for basin outflow stations is levels and salinity, and preferably also physical and chemical parameters for a more comprehensive assessment of water quality entering the sea.

5.2 CURRENT SURFACE WATER QUANTITY MONITORING

5.2.1 SURFACE WATER MONITORING STATIONS

Table 2 lists the 13 surface water monitoring sites currently operating in the Patawalonga Catchment (refer also to App. E). Many of these are operated by the Adelaide and Mount Lofty Ranges NRM Board (previously by the Patawalonga Catchment Water Management Board).

A recent update of the database has included a further six gauges on Keswick Creek and two on Brown Hill Creek. Some of these have up to 10 years of continuous water level records but the rating curves, which are required to translate the water level recordings into flow estimates, are either missing or have been classified of a lower or uncertain quality (Quality Code 150). These data were not used in the study.

In general, the accuracy of the flow measurements is believed to be satisfactory at low flow but less certain at high flow.

5.2.2 HEATHFIELD WASTEWATER TREATMENT PLANT

Heathfield WWTP discharges its wastewater into an upper reach of the Sturt River. It was commissioned in 1981 to serve a population of 6000 with an estimated wastewater discharge of 1.05 ML/d. Discharged flow is measured at gauging station AW504931 immediately downstream of the discharge point.

Table 2. Gauging stations with flow data in the DWLBC HYDSTRA database

Station	Name	Catchment area (km^2)	Start	End	Control	Remarks
Sturt River sub-catchment						
AW504518	STURT RIVER @ u/s Minno Ck Junction	19.3	7.10.1976	Current	Low profile concrete V crump weir	Closed from 1983, reopened 2001
AW504519	MINNO CREEK @ u/s Sturt River Junction	18.3	8.12.1977	Current	Low profile V crump weir	
AW504521	CHAMBERS CK @ Coromandel Valley	10.0	3.11.1976	26.6.1989	Standard concrete V crump weir	Closed since June 1989
AW504530	STURT RIVER at u/s flood control dam	60.2	24.7.1979	27.6.1989	Concrete V notch crump weir	Closed since June 1989
AW504576	STURT RIVER @ d/s Sturt Rd Mitchell Park	73.3	1.9.1994	Current	Open channel	
AW504582	ADELAIDE TCE PIPE @ d/s West Street	0.9	7.7.1996	Current		
AW504549	STURT RIVER @ d/s Anzac Highway	115.0	24.7.1990	Current	Concrete trapezoidal channel	
Brown Hill Creek and Keswick Creek sub-catchments						
AW504901	BROWN HILL CREEK @ Scotch College	17.5	16.2.1990	Current	Low profile flat V weir	
AW504580	BROWN HILL CREEK @ u/s Keswick Creek	31.5	12.5.1996	Current		
AW504581	MORPHETT ROAD PIPE @ transfer station	1.25	13.6.1996	current		
AW504575	BROWN HILL CREEK @ Adelaide Airport (closed)	62.4	31.8.1994	10.1.1997	Open channel	Closed since January 1997
AW504583	BROWN HILL CREEK @ Adelaide Airport (Morphett Road)	65.8	29.11.1993	current	Broad-crested rectangular drop weir	
Local Patawalonga catchment						
AW504561	FREDERICK STREET DRAIN @ Glenelg	0.42	30.6.1992	24.5.2004	Free flowing reinforced concrete pipe	Closed since 2004

Records of wastewater discharge were only available from January 1991 onwards, at first in monthly time steps but in daily time steps from March 1997 onwards. A repeat of the discharges of 1991–95 has been used to synthesise the missing data from 1981–90.

5.2.3 TRANSMISSION LOSSES OF SURFACE WATER FLOW

The correlation between flows measured at the WWTP discharge site (AW504931) and downstream, just above the junction with Minno Creek (AW504518), indicates transmission losses of the order of at least 1.5 ML/d in the intervening channel.

Estimation of the transmission loss in winter in rural catchments is difficult due to the high and variable flows; in summer, when the flows are more stable, estimation is more likely to be accurate. By comparing summer baseflows at AW504518 before and after the commissioning of the WWTP, it appears that ~85% of discharged flows may be lost (either by infiltration or diversion to irrigation).

Using the same investigation technique on flows measured on Brown Hill Creek at Scotch College and downstream, just above the junction with Keswick Creek, it appears that losses of up to 5 ML/d may be taking place. This would account for the very low runoff coefficient calculated for the lower site.

It is expected that losses will also be taking place on Sturt River where it emerges from the escarpment.

The areas where the Park Lands and Glen Osmond creeks emerge from the escarpment do not seem to align with a groundwater plume with such low total dissolved solids values as those mapped for Sturt River and Brown Hill Creek. Thus, large losses (if any) may be concentrated in certain locations only.

5.3 CURRENT SURFACE WATER QUALITY MONITORING

There is an obvious lack of water quality monitoring in the Patawalonga Catchment. This needs to be addressed by lead agencies in accordance with their business plans and data needs.

5.4 GAPS AND OVERLAPS IN MONITORING

The EPA is monitoring surface water quality around the Barcoo Outlet but there does not appear to be any water quantity monitoring. It is suggested that the PCWMB or DWLBC monitors quantities of surface water leaving the Patawalonga Catchment. This is considered to be a high priority monitoring category to be done as required for statutory reporting purposes. Figure 1 shows the current surface water quantity and quality monitoring sites in the catchment.

5.4.1 RAINFALL DATA FOR HYDROLOGICAL MODELLING

Currently there are no rainfall gauging stations in Workanda Creek and Shepherds Hill.

5.4.2 STREAM FLOW

There is no stream-flow monitoring in Upper Sturt River, Workanda Creek, Chambers Creek, Brown Hill Creek and Shepherds Hill.

Patawalonga Catchment Surfacewater monitoring - Quantity & Quality

Drainage
Subcatchments
CWMB
Waste Water Treatment Plant

Monitoring Sites by Funding Agencies

- BOM
- DWLBC
- PCWMB
- TSA
- EPA
- Ambient Monitoring
- CLOSED

N

0 2 4 8 km

Produced : Resource Assessment Division
Department of Water, Land and Biodiversity Conservation
Projection: GDA_1994_MGA_Zone_54 Transverse_Mercator
Datum: Geocentric Datum of Australia 1994
Date: April 2003

The Department of Water, Land and Biodiversity Conservation

Government of South Australia

5.4.3 WATER QUALITY

There is no water quality monitoring in Workanda Creek, Shepherds Hill and Chambers Creek.

5.5 FUTURE DIRECTIONS FOR SURFACE WATER MONITORING

5.5.1 RAINFALL DATA FOR HYDROLOGICAL MODELLING

With regard to hydrological modelling of the sub-catchments that are not being monitored for rainfall, it is important that nearby sub-catchments being monitored for rainfall are representative of them in terms of topography, soil, geology, aspect, vegetation cover and land use. Where this is not possible, representative sites should be used from elsewhere.

5.5.2 STREAMFLOW

It is suggested that streamflow monitoring be carried out in the Upper Sturt River sub-catchment in relation to the impact on flow regime from the Heathfield WWTP whereby artificial baseflows have been created from wastewater being directed into the river. For the remaining sub-catchments, where it is impractical to establish streamflow gauging stations, it is suggested that representative sites be identified to ensure that water balances can be calculated for these sub-catchments. Representative sites need to have the same kind of topography, geology, aspect, soil, vegetation cover and land use as the subject sub-catchments. DWLBC should be responsible for investigating representative sites either within the Patawalonga Catchment or within another catchment that has suitable sites.

The current streamflow gauging network cannot efficiently determine the causes of the transmission losses being observed in the flow data. The scoping of what needs to be assessed, and how it may be achieved through potential new monitoring sites, needs to occur.

5.5.3 WATER QUALITY

It is suggested that PCWMB carry out ambient water monitoring for the Workanda Creek, Shepherds Hill and Chambers Creek sub-catchments on an on-going basis. Wastewater from the Glenelg WWTP needs to be monitored for water quality and quantity.

6. GROUNDWATER MONITORING

DWLBC undertakes the majority of groundwater monitoring for levels and salinity.

6.1 CURRENT GROUNDWATER QUANTITY MONITORING

Groundwater levels are read on a six-monthly basis in 48 observation wells, mainly in the metropolitan area. Groundwater use in this urban section of the Patawalonga Catchment is high and is not currently monitored. Current groundwater quantity and quality monitoring sites in the catchment are shown in Figures 2 and 3, respectively.

6.2 CURRENT GROUNDWATER QUALITY MONITORING

Salinity measurements from 57 observation wells are taken less frequently. DWLBC also carries out sampling for chemical analysis in the metropolitan areas every seven to eight years.

6.3 GAPS AND OVERLAPS IN MONITORING

PCWMB considers it important to monitor major ions, nutrients and metals in the fractured rock aquifers beneath urban areas.

6.4 FUTURE DIRECTIONS FOR GROUNDWATER MONITORING

PCWMB also considers it important that expansion of the observation wells network in the rural section be undertaken for both water levels and water quality. Groundwater use in the rural section catchment should also be investigated.

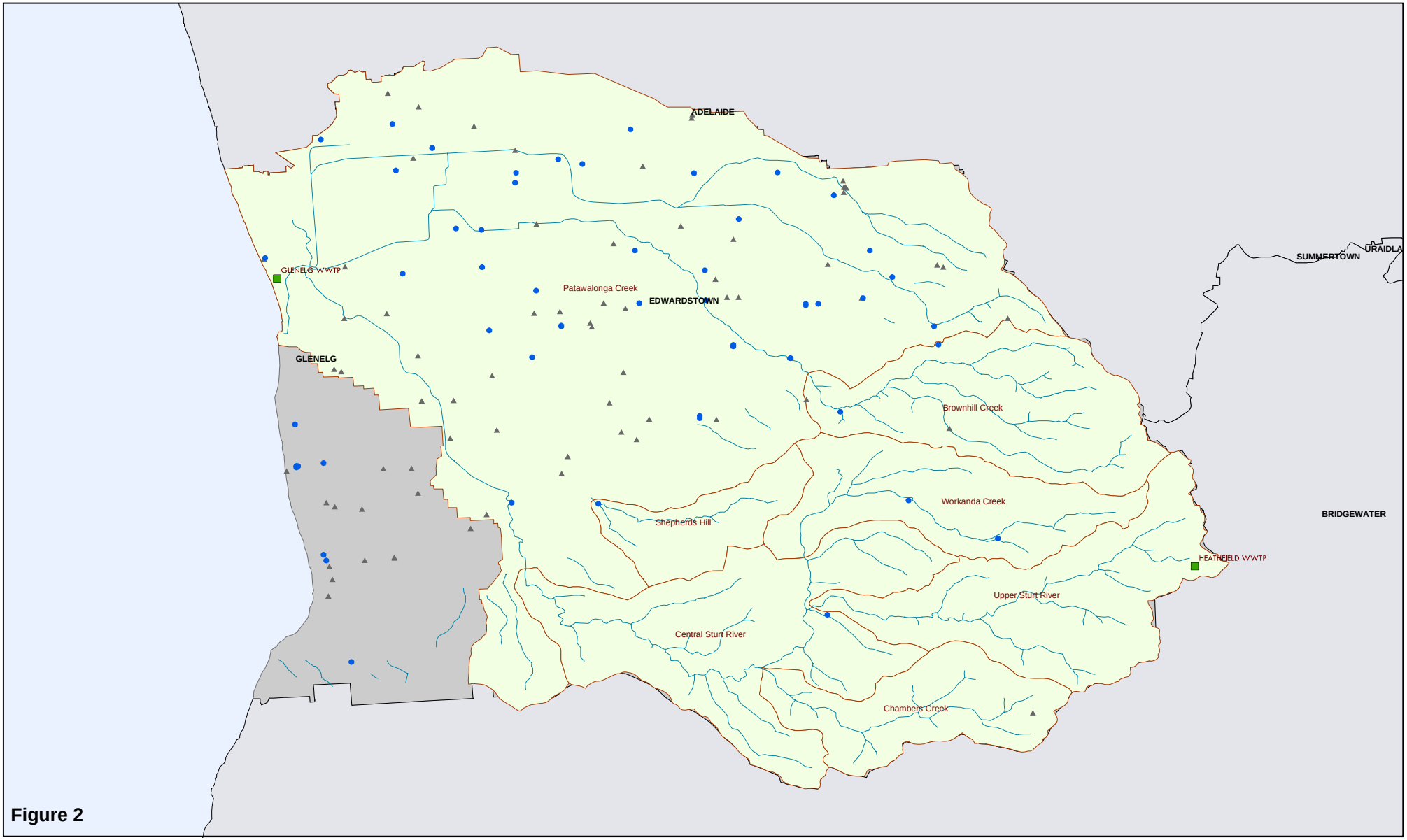

Figure 2

Patawalonga Catchment Groundwater monitoring - Quantity

Drainage
Subcatchments
CWMB
Waste Water Treatment Plant

ASR Sites
Metro. Adelaide - Current
Metro. Adelaide - Historical

N

0 2 4 8 km

Produced : Resource Assessment Division
Department of Water, Land and Biodiversity Conservation
Projection: GDA_1994_MGA_Zone_54 Transverse_Mercator
Datum: Geocentric Datum of Australia 1994
Date: April 2003

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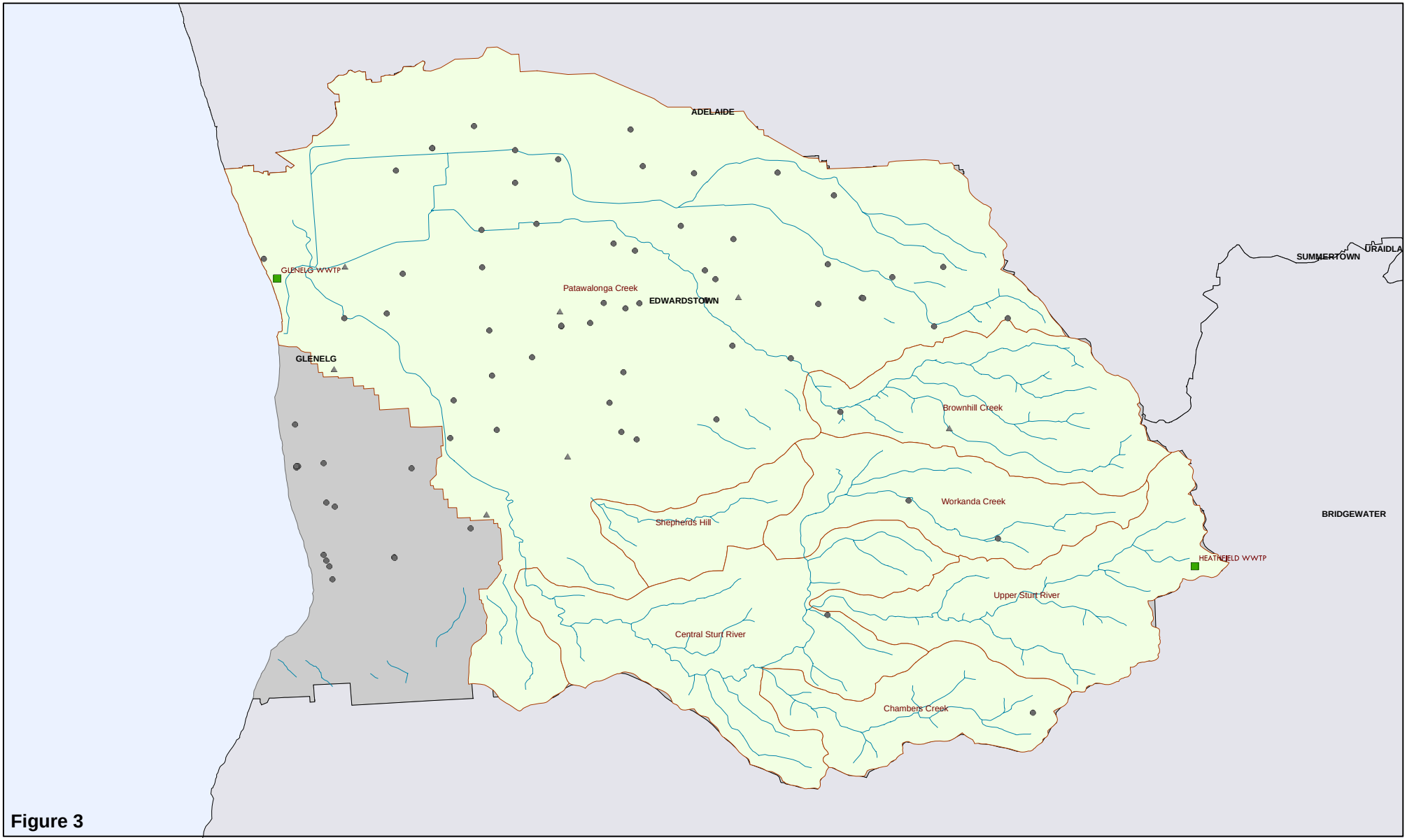

Figure 3

Patawalonga Catchment Groundwater monitoring - Quality

Drainage
Subcatchments
CWMB
Waste Water Treatment Plant
ASR Sites
Metro. Adelaide - Current
Metro. Adelaide - Historical

N

0 2 4 8 km

Produced : Resource Assessment Division
Department of Water, Land and Biodiversity Conservation
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Government of South Australia

7. AQUATIC ECOSYSTEMS

7.1 OVERVIEW OF AQUATIC ECOSYSTEMS

Aquatic ecosystems support a diverse range of native flora and fauna, including numerous threatened species, and comprise complex interactions between plants, animals and the physical, chemical and climatic characteristics of the environment in which they occur. The health of these 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 WMLR.

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, including: 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 MACRO-INVERTEBRATES

Macro-invertebrates 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). Macro-invertebrates 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 macro-invertebrates is often indicative of a healthy aquatic ecosystem. An ecosystem under stress will be home to a greater number of more stress tolerant (i.e. pollution) macro-invertebrate species, whereas a healthy ecosystem will have a more even spread 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

Numerous fish surveys have been undertaken throughout the WMLR. These surveys have been commissioned by the CWMBs and they are the custodians of this information.

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 macro-invertebrates found in a particular river or stream, and comparing results to those obtained from a similar type of river or stream that has not been disturbed or affected by human activities. Macro-invertebrate 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. A subset of sites sampled for the AusRivAS program forms the basis of the EPA's ambient and macro-invertebrate monitoring program (see Macro-invertebrate Monitoring section below).

Results of the AusRivAS sampling are available at http://www.environment.sa.gov.au/reporting/inland/rivers_streams/healthassess.html#eastern_lofty. AusRivAS used multivariate monitoring to provide SoE reporting whilst also providing reference sites.

7.2.3 MACRO-INVERTEBRATE MONITORING

The CWMBs of the WMLR undertake macro-invertebrate monitoring across the WMLR. The OCWMB conducted a review of macro-invertebrate survey data between 2001 and 2003.

7.2.4 AERIAL VIDEOGRAPHY

Aerial videography involves capturing geo-stabilised and geo-referenced video data of a watercourse 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 WMLR. 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 DWLBC and the CWMBs of the WMLR.

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 considerable gaps are present because of the little monitoring that has taken place. Baseline data were limited to macro-invertebrates, fish, diatoms and data obtained from aerial videography.

7.3.1 ENVIRONMENTAL WATER REQUIREMENTS (EWR)

EWR have been determined by the CWMB for a subset of rivers within the WMLR and delivery of environmental water provisions are currently being negotiated for three catchments (Onkaparinga, Torrens and South Para). A draft report by DWLBC (Pikusa and Bald 2005) states DWLBC's position on EWR in the WMLR and sets the foundation for negotiating environmental water provisions. Monitoring programs to assess the effectiveness of these provisions are currently being developed by DWLBC, the CWMBs and SA Water.

7.3.2 GROUNDWATER-DEPENDENT ECOSYSTEMS

Groundwater-dependent ecosystems are known to be important components of the region's aquatic ecosystems. Whilst the location of some are known, there is a lack of data on the distribution and abundance of the region's groundwater-dependent ecosystems. There is also 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

Many of the streams in the WMLR 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'. Stygofauna 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 WMLR were 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 suggest specific programs in this area other than to highlight this need. However, such monitoring may fit within the proposed monitoring framework presented below.

7.4.1 A CALIBRATED CATCHMENT

In order to adequately manage the aquatic ecosystems of the WMLR, aquatic ecosystem monitoring could form part of what Brydges (2004) refers to as a 'calibrated watershed' integrated monitoring program. In such a program, 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 could 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 could 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 are 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.

7.4.1.1 Significant Aquatic Ecosystems

Identification of priority aquatic ecosystems for ambient monitoring should be carried out across the catchment.

7.4.1.2 Riparian Vegetation

Most of the native riparian vegetation in the WMLR 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. CATCHMENT CHARACTERISTICS

A number of factors influence the way water and sediment move within a catchment from upland areas into the main channel and then 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 (2005), it is generally accepted that catchment characteristics affect both surface and groundwater quality, but there is no consistent definition and the list of catchment features can vary from study to study. Table 3 offers a number of characteristic definitions, their purpose and their source.

Table 3. 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 and 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 run-off 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
Vegetation cover	Native and introduced vegetation types to aid in identifying location of habitats.	Aerial photography, reports from 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
Land use	Influences water quantity and quality.	DWLBC, PIRSA
Demographics	Influences projected land use.	Planning SA

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. Maintenance of all on-going quantity and quality monitoring by DWLBC, BoM, SA Water and EPA on one database, or at least provision of a portal that links all databases, would provide ease of access and enhance the usefulness of the information.

Ideally, water quantity and quality monitoring carried out by other agencies (e.g. ambient and macro-invertebrate 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 CWMBs, BoM and SA Water. In many cases, stations that are not funded or managed by DWLBC do not have information about gaugings in HYDSTRA.

9.2.2 FREQUENCY OF DATA COLLECTION FOR STREAM FLOW

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 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 on request, but direct access to data would expedite the process. It is recognised that some data may be commercially confidential and therefore not readily accessible.

9.5 GROUNDWATER DATABASES

Extraction rates of private bores need to be monitored and the data and associated information entered onto the SAGeodata and Obswell databases managed by DWLBC. In addition, water-use information generally should be entered onto Obswell. This database would also provide an indication of which aquifer is being monitored by relevant bores.

Making EPA's groundwater quality monitoring data available to other stakeholders, and possible integration with DWLBC's groundwater monitoring database, is desirable.

9.6 LAND-USE DATASET

It is suggested that a standard land-use dataset, 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 that require access to information about monitoring or resource assessment, part or all of which they do not carry out themselves, are listed in Table 4.

Table 4. 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	Development planning
	Transport SA	Design of Infrastructure
	Forestry SA	To assist in analysing water quality monitoring data
	SA Water	Potential impacts on potable water supplies
Water use	SA Water	Potential impacts on potable water supplies

What	Who	Why
Surface water quality		
Water quality data collection and assessment	Forestry SA	To monitor impacts of their industry
	Transport SA	Run-off from road surfaces
	Planning SA	Development planning
	Local government	Wastewater and stormwater
	DWLBC	Impacts on ecosystems, water allocation planning, and use and sustainable water management generally
Ambient water quality	DHS	To fulfil 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		
Groundwater quantity assessments	SA Water	Particularly allocation systems that may impact on the availability of water supplies for potable use
	EPA	Relates to groundwater and surface water quality
	Forestry SA	With regard to development of groundwater resources
Groundwater quality		
Ambient	DHS	Drinking water supplies
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
Estuarine monitoring information	DWLBC	In relation to pollutants and flow regime of the catchments
	CWMBs	In relation to pollutants and flow regime of the catchments

What	Who	Why
Marine environments		
Water quality	DWLBC	For reporting purposes
	CWMBs	Impacts of surface water and groundwater quality
	DEH	Coasts and marine responsibilities
	SA Water	Impacts of discharges
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: and
- 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."

Relevant Core Indicators for Monitoring Performance of Policy Outcomes: (Also refer to *Report on the Implementation of the State Water Plan,* SA Govt. (for reporting against these indicators).

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

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

(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 (*Chapter 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; and

(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 (*Chapter 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; and

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

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

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

(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; and

(d) promote the integrated management of natural resources; and

(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 Resource 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 (*Chapter 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; and

(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; and

(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; and

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

B. MONITORING STATION CATEGORIES — SURFACE WATER MONITORING

(Modified from Greenwood 2001)

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 or streamflow; salinity (EC and temperature). Possibly rainfall or other climatic parameters as required.	On-going (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.	Represent-ative station.	Streamflow from areas with particular hydrological characteristics arising from distinct features, e.g. vegetation types or land-use practices.	Water level or streamflow; salinity (EC and temperature).	Medium term (10 years).	Continuous.	As per project priorities, but high to medium in supporting ambient programs.
		Environ-mental 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 to 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 or 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 and outflow.	Relates to streamflow entering or released from heavily developed or regulated river systems and infrastructure, e.g. in and out of Prescribed Areas and upstream and downstream of reservoirs.	Water Level or streamflow; salinity (EC and temperature). May be subject to other parameters specified in the management plan.	For duration of the development or as per the relevant management requirements (years to decades?).	Continuous.	High, subject to resource management requirements.
		Basin outflow station	Streamflow leaving the catchment, e.g. flows into the ocean, inland lakes or interstate. Could arguably be classified as project type information to augment a conventional network.	Water Level or 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[1]	Collaborative agency[2]	Interested agency[3]
Water availability	Rainfall.	Analyse rainfall patterns. Climate change management. Forecast flood and drought. Calibrate computer models.	BoM	DWLBC, NRMB, SA Water	EPA, PIRSA, DEH
	Rainfall intensity.	Catchment hydrological model. Surface–groundwater relationship. Climate change management.	DWLBC	BoM, NRMB, SA Water	EPA, PIRSA, DEH
	Catchment stream flow.	Water allocation. Flood frequency analysis. Environment flow. Aquatic ecosystem health assessment. Water quality assessment.	DWLBC	EPA, NRMB, SA Water	BoM, PIRSA, DEH
	Sub-catchment stream flow.	Environment flow. Aquatic ecosystem health assessment. Water quality assessment.	NRMB	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	NRMB, 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.	NRMB	DWLBC, local councils, SA Water, EPA	DEH, BoM

Classification	Parameter	Purposes	Lead agency[1]	Collaborative agency[2]	Interested agency[3]
	Effluent.	Additional water supplies. Receiving waterbody ecosystem health assessment. Water quality assessment.	SA Water	EPA, NRMB, Local Councils, DWLBC	DEH
	Soil moisture.	Catchment hydrological model.	PIRSA	DWLBC, NRMB	EPA, DEH
	Groundwater level.	Water allocation. Environment flow. Groundwater dependent ecosystem health assessment. Water quality assessment. Dryland salinity management. Surface–groundwater relationships.	DWLBC	EPA, NRMB, PIRSA, SA Water	DEH
	Climate change.	All aspects of natural resource management.	BoM	PIRSA, DWLBC, DEH, EPA, NRMB, SA Water	
Water withdrawal	Extraction.	Water allocation. Environmental flow. Catchment water budget.	DWLBC	SA Water, NRMB	EPA, DEH
	Water use.	Water allocation. Environmental flow. Efficient use of water resources. Catchment water budget.	NRMB	DWLBC, SA Water	EPA, DEH
	Farm dam.	Catchment hydrological model. Environmental flow.	DWLBC	NRMB, PIRSA, EPA	SA Water, DEH
Return flow	Irrigation drainage.	Catchment hydrological model. Environmental flow. Salinity management.	PIRSA	DWLBC, NRMB, SA water, EPA	DEH

Classification	Parameter	Purposes	Lead agency[1]	Collaborative agency[2]	Interested agency[3]
	Deep drainage.	Dryland salinity management.	PIRSA	DWLBC, NRMB	EPA
		Groundwater quality assessment.			
Water quality	Pesticides, organics, metals, nutrients, DO, pH, turbidity, temperature, structure of aquatic communities, habitat, macro-invertebrates, indictor bacteria, others.	Classify water quality.	EPA	DWLBC, NRMB, SA Water	DEH, PIRSA
		Trend analysis.			
		Pollution incident report.			
		Assessment of water quality standards.			
		Identify emerging problems.			
	Salinity (surface and groundwater).	Water quality assessment. Evaluation of salt interception schemes.	DWLBC	EPA, NRMB, PIRSA, SA Water	DEH
		Dryland salinity management.			
	Water regime.	Environmental value assessment.	DWLBC	EPA, NRMB, DEH	PIRSA
Aquatic ecosystems (inland)	Water quality.	Ecosystem health assessment.			
	Biological integrity.	Environmental flow.			
		Surface–groundwater interaction.			
Aquatic ecosystems (marine)	Water quality.	Ecosystem health assessment.	DEH	DWLBC, EPA, NRMB	
	Biological integrity.	Environmental value assessment.			PIRSA
		Aquaculture based monitoring.	PIRSA		DWLBC, EPA

1. Lead agency: under legislative mandate, and is responsible for:
   Developing monitoring strategy, plan, and protocols;
   Data custodian, and supervising data quality assurance; and
   Supporting monitoring undertaken by other parties.
2. Collaborative agency: need information for business operation, contribute to monitoring through joint funding, advise and consultation, etc.
3. Interested agency: in the best interests of the business that monitoring is undertaken.

D. EXCERPT FROM PCWMP CATCHMENT MANAGEMENT STRATEGY

(From PCWMPs list of actions as part of its Catchment Management Strategy, seen relevant to this review)

GOAL 1.		**To improve and maintain water quality in the catchment to a level suitable for the safe use by the community (including for recreation) and to sustain ecosystems and reduce impacts on the receiving aquatic environments.**		
Strategy 1.3		Develop and maintain constructed wetlands. Constructed wetlands have the potential to make small but significant reductions in nutrient loads to Gulf St Vincent. Wetlands have multiple benefits including the implementation of ASR schemes, improved amenity, flow attenuation and enhanced values.		
Actions		**Description**	**Outcomes**	**Partners**
Action	1.3.1	Complete the Morphettville Racecourse Wetland and ASR project.	Completion of the Morphettville Wetland will deliver improved water quality and stormwater reuse by ASR at the racecourse.	PCWMB (lead agency), local government.
Action	1.3.2	Progress the Oaklands Park Wetland.	Completion of the Oaklands Park Wetland will deliver improved water quality and potential ASR Scheme.	PCWMB (lead agency), local government.
Action	1.3.4	Monitor constructed wetlands performance.	The performance of the wetlands developed by the board needs to be periodically monitored for water quality and sediment.	PCWMB (lead agency), local government.
Strategy 1.4		Eliminate or reduce wastewater discharges to watercourses and receiving waters. EPA-licensed discharges from the Heathfield WWTP and Glenelg WWTP are significant loads to the Sturt River and Gulf St Vincent, respectively. These two discharges, together with lesser discharges from problem septic systems (e.g. Fourth Road Belair), must be addressed.		
Actions		**Description**	**Outcomes**	**Partners**
Action	1.4.1	Promote the upgrade of effluent discharge from the Heathfield WWTP.	Major reduction in nutrients in upper reaches of Sturt River system and the subsequent benefit of improved water quality downstream.	SA Water (lead agency), EPA.
Action	1.4.2	Promote the upgrade of effluent discharge from the Glenelg WWTP.	Major reduction in nutrients to Gulf St Vincent during critical summer period.	SA Water (lead agency), EPA.

GOAL 2.	**To Protect and Restore Aquatic Ecosystems.**			
Strategy 2.1		Define water for environmental requirements and review resource use and availability implications. There is use of water from the catchment, with farm dams and groundwater withdrawal competing with the environment. There is a need for greater understanding of the water-dependent ecosystems and their need for water.		
Actions		**Description**	**Outcomes**	**Partners**
Action	2.1.1	Undertake detailed investigations and surveys for the catchments Water for the Environment requirements.	Specific survey work in the catchment will include the impact of farm dams, diversions and location and requirements of aquatic ecosystems. The ecological implications of the timing of flows and the impacts of anthropogenic activities will be included.	PCWMB (lead agency), DWLBC, SA Water, DEH, EPA.

GOAL 3.	**The water resources of the catchment are available to be used to maintain ecosystems and for equitable and economic community use.**			
Strategy 3.2		Develop and implement risk management plans for the catchment groundwater and surface water resources. Although the catchment's water resources do not require prescription at this stage, there is a need to undertake more detailed monitoring and assessments. The groundwater resources could provide Adelaide with a back-up resource and the surface water resources need to be protected through the provisions relating to Water Affecting Activities in Section 9 of the *Water Resources Act 1997.*		
Actions		**Description**	**Outcomes**	**Partners**
Action	3.2.1	Develop a Risk Management Plan for groundwater in the urban area.	Proper management of the significant resource available in the Tertiary aquifers is essential, since it represents a backup resource for Adelaide. At this stage little information is readily available on extraction from Adelaide Plains groundwater aquifers. Monitoring of larger users is needed.	PCWMB (lead agency), DWLBC, industry, SA Water.
Action	3.2.2	Develop a Risk Management Plan for groundwater and surface water in the rural area	Investigate the need for greater control of surface water and groundwater in the rural part of the watershed. Assessments will be undertaken of usage levels on a sub-catchment level for farm dams and groundwater withdrawals. Provision for water for the environment will be incorporated into these assessments.	PCWMB (lead agency), DWLBC. Industry.

GOAL 4.		**To coordinate floodplain management at the catchment scale**		
Strategy 4.1		Coordinate integrated stormwater and flood plain management. The new era of urban stormwater management now integrates water quality and quantity together. Multi-objective aims of enhancing local amenity, improving water quality and reusing stormwater combined with the fundamental flood protection objectives. There still needs to be some leadership taken for floodplain management issues that cross council boundaries and the board will take a coordinating role.		
Actions		**Description**	**Outcomes**	**Partners**
Action	4.1.1	Coordinate flood mapping and mitigation studies required in the catchment.	The board will coordinate cross-council flood mapping and the identification of mitigation options to assess the requirements for protection against flooding of Brown Hill and Keswick Creeks.	PCWMB (lead agency), councils, DWLBC.
Action	4.1.5	Assist with the resolution of the flood problem of the Mile End–Cowandilla–Patawalonga Creek system.	The establishment of flood storages and/or capacity in the City of West Torrens/Patawalonga Creek area to resolve outlet capacity issues is needed, the board will help the City of West Torrens to facilitate a resolution to these problems.	PCWMB, City of West Torrens.

GOAL 5.		**To inform and involve the community and encourage it to take responsibility for catchment management**		
Strategy 5.2		Support groups and schools in community education and involvement programs. The Our Patch and Waterwatch programs have been very successful in providing support to community groups and schools to undertake on-ground works and outdoor education activities. Continue to support these and other action-orientated community efforts including community service clean-ups.		
Actions		**Description**	**Outcomes**	**Partners**
Action	5.2.2	Continue to support continuation and expansion of the Patawalonga and Torrens Waterwatch Program.	Waterwatch will continue to be supported in the catchment. Already involving groups, including many schools, the program has developed very valuable services such as a web site, community water quality reports and a variety of on-ground activities.	PCWMB, EPA, Waterwatch.

GOAL 6.		**To establish and implement monitoring and evaluation systems which enable the board to assess the effectiveness of its programs and the health of the catchment**		
Strategy 6.1		Link with other existing and proposed data collected in the catchment. The range of activities and issues in the catchment make the data collection needs complex. Opportunities need to be taken to coordinate requirements with other agencies and catchment water management boards.		
Actions		**Description**	**Outcomes**	**Partners**
Action	6.1.1	Investigate water-related data collection by SA Water, EPA, councils and other agencies, and resolve a monitoring plan in conjunction with the State Water Monitoring Committee.	Further work is needed to establish appropriate linkages with existing data collection systems and identify the gaps. Water use and groundwater monitoring are two areas for consideration.	PCWMB (lead agency), other agencies.
Strategy 6.2		Provide a performance indicator/evaluation database for the board's program. A combination of water quality, biological monitoring, industry, community activity audits and market research will form the basis for performance measurement. Further indicators on outputs and targets will also be developed.		
Actions		**Description**	**Outcomes**	**Partners**
Action	6.2.1	Expand the current water quality/quantity/biological health monitoring program.	Continue with the Board's existing monitoring network and exploit opportunities to expand the program through other agency programs	PCWMB (lead agency), SA Water, EPA, DEH.

GOAL 7.		**To deliver the board's programs in an integrated manner in partnership with all other stakeholders taking into account environmental, economic and social considerations (triple bottom line).**		
Strategy 7.1		Support an Integrated Natural Resources Management (INRM) approach across the catchment. The board needs to work closely with a number of organisations and agencies to achieve its goals and fulfil its responsibilities under the Water Resources Act.		
Actions		**Description**	**Outcomes**	**Partners**
Action	7.1.4	Support the coordination of research and development opportunities.	In collaboration with partner organisations, invest in research and development programs that support the board's investigation and data requirements.	PCWMB (lead agency), partner organisations.

E. PATAWALONGA CATCHMENT CURRENT AND HISTORIC ON-GOING SURFACE WATER MONITORING

Site number	Site name	Type	Purpose, comments	Parameters	Funding agency	Data collection	Data custodian
Patawalonga Creek							
AW504586	Glen Osmond Creek @ Park Avenue	Natural stream		Recording: Water level Turbidity	TSA	Water Data Services	DWLBC
AW504922	Glen Osmond Creek @ Ridge Park	Natural stream		Recording: Rainfall Water level	BoM	BoM	BoM
M023005	Adelaide (Glen Osmond)	Meteorological station		Daily read: Rainfall	BoM	BoM	BoM
M023031	Adelaide (Waite Institute)	Meteorological station		Daily read: Rainfall	BoM	BoM	BoM
AW504906	Glenside Pluvio @ Glenside	Meteorological station		Recording: Rainfall	BoM	BoM	BoM
M023014	Adelaide (Glenside)	Meteorological station	Closed	Daily read: Rainfall	BoM	BoM	BoM
AW504923	Parklands Creek @ Roberts Street (Unley)	Channel, drain, aquaduct		Recording: Water level	BoM	BoM	BoM
M023053	Unley (Reed)	Meteorological station	Closed	Daily read: Rainfall	BoM	BoM	BoM
M023075	Adelaide (Clapham)	Meteorological station		Daily read: Rainfall	BoM	BoM	BoM
M023890	Belair (St Johns)	Meteorological station		Daily read: Rainfall	BoM	BoM	BoM
M023703	Belair (Kalyra)	Meteorological station	Closed	Daily read: Rainfall	BoM	BoM	BoM

Site number	Site name	Type	Purpose, comments	Parameters	Funding agency	Data collection	Data custodian
M023770	Belair Public School	Meteorological station	Closed	Daily read: Rainfall	BoM	BoM	BoM
M023704	Belair (State Flora Nursery)	Meteorological station		Daily read: Rainfall	BoM	BoM	BoM
M023706	Blackwood Post Office	Meteorological station	Closed	Daily read: Rainfall	BoM	BoM	BoM
M023839	Blackwood (Wittunga)	Meteorological station		Daily read: Rainfall	BoM	BoM	BoM
M023711	Coromandel Valley (Branden)	Meteorological station	Closed	Daily read: Rainfall	BoM	BoM	BoM
M023846	Belair ETSA	Meteorological station		Daily read: Rainfall	BoM	BoM	BoM
M023114	Beaumont Caithness Ave	Meteorological station		Daily read: Rainfall	BoM	BoM	BoM
AW504921	Glen Osmond Creek @ Charles Street	Natural stream		Recording: Rainfall Water level	BoM	BoM	BoM
AW504927	Keswick Creek @ Keswick Barracks	Channel, drain, aquaduct		Recording: Rainfall Water level	BoM	BoM	BoM
M023115	Adelaide (Keswick)	Meteorological station		Daily read: Rainfall	BoM	BoM	BoM
AW504926	Brown Hill Creek @ Cross Road (Hawthorn)	Natural stream		Recording: Rainfall Water level	BoM	BoM	BoM
AW504589	Urrbrae Wetlands @ Lake	Urban drainage, stormwater		Recording: Rainfall Water level Evaporation	PCWMB	Unknown	DWLBC
AW504588	Urrbrae Wetlands @ Inflow	Urban drainage, stormwater		Unknown	PCWMB	Unknown	DWLBC

Site number	Site name	Type	Purpose, comments	Parameters	Funding agency	Data collection	Data custodian
AW504590	Urrbrae Wetlands @ Outflow	Urban drainage, stormwater		Unknown	PCWMB	Unknown	DWLBC
AW504901	Brown Hill Creek @ Scotch College	Natural stream		Recording: Rainfall Water level Composite sampling: TDS Suspended Solids Turbidity Conductivity Phosphorus Nitrogen Calcium Magnesium Potassium Sodium Bicarbonate Chloride Sulphate Cadmium Chromium Copper Lead Zinc	PCWMB	Water Data Services	DWLBC
M023105	Brown Hill Creek Scotch College	Meteorological station		Daily read: Rainfall SKM disag + infill: Rainfall	BoM	BoM	BoM
M023010	Mitcham Post Office	Meteorological station	Closed	Daily read: Rainfall SKM disag + infill: Rainfall	BoM	BoM	BoM
AW504576	Sturt River @ d/s Sturt Rd	Urban drainage,		Recording:	PCWMB	Water Data	DWLBC

Site number	Site name	Type	Purpose, comments	Parameters	Funding agency	Data collection	Data custodian
	Mitchell Park	stormwater		Water level Composite sampling: TDS Suspended Solids Turbidity Colour Conductivity Phosphorus Nitrogen Calcium Magnesium Potassium Sodium Bicarbonate Carbonate Chloride Sulphate Cadmium Chromium Copper Lead Zinc		Services	
M023779	Sturt BoM met station	Meteorological station	Closed	Daily read: Rainfall	BoM	BoM	BoM
AW504582	Adelaide Tce Pipe @ d/s West Street	Urban drainage, stormwater		Recording: Water level Composite sampling: TDS Suspended Solids Turbidity Colour Conductivity Phosphorus	PCWMB	Water Data Services	DWLBC

Site number	Site name	Type	Purpose, comments	Parameters	Funding agency	Data collection	Data custodian
				Nitrogen Calcium Magnesium Potassium Sodium Bicarbonate Chloride Sulphate Cadmium Chromium Copper Lead Zinc Ethyl Benzine O-Xylene Toluene Benzene Hydrocarbons			
AW504580	Brown Hill Creek @ u/s Keswick Creek	Urban drainage, stormwater		Recording: Water level Composite sampling: TDS Suspended Solids Turbidity Colour Conductivity Phosphorus Nitrogen Calcium Magnesium Potassium Sodium Bicarbonate	PCWMB	Water Data Services	DWLBC

Site number	Site name	Type	Purpose, comments	Parameters	Funding agency	Data collection	Data custodian
				Chloride Sulphate Cadmium Chromium Copper Lead Zinc			
M023034	Adelaide Airport	Meteorological station		Daily read: Rainfall SKM disag + infill: Rainfall	BoM	BoM	BoM
M023046	Adelaide Airport Old Site	Meteorological station		Daily read: Rainfall	BoM	BoM	BoM
AW504575	Brown Hill Creek @ Adelaide Airport	Urban drainage, stormwater	Closed	Recording: Water level Stream discharge Ad hoc field reading: TDS Conductivity	Closed	Closed	DWLBC
AW504583	Brown Hill Creek @ Adelaide Airport (Morphett Road)	Urban drainage, stormwater		Recording: Rainfall Water level Composite sampling: TDS Suspended Solids Turbidity Colour Conductivity Phosphorus Nitrogen Calcium Magnesium Potassium	PCWMB	Water Data Services	DWLBC

Site number	Site name	Type	Purpose, comments	Parameters	Funding agency	Data collection	Data custodian
				Sodium Bicarbonate Chloride Sulphate Cadmium Chromium Copper Lead Zinc			
3540	Brown Hill / Keswick Creek at Adelaide Airport	Urban drainage	Located downstream of the confluence of the Brown Hill and Keswick Creeks.	Ambient and Macro	PCWMB	AWQC	PCWMB
AW504581	Morphett Road Pipe Transfer Station	Urban drainage, stormwater		Recording: Water level Water temperature pH Conductivity Composite sampling: TDS Suspended Solids Turbidity Colour Conductivity Phosphorus Nitrogen Calcium Magnesium Potassium Sodium Bicarbonate Chloride Sulphate Cadmium	PCWMB	Water Data Services	DWLBC

Site number	Site name	Type	Purpose, comments	Parameters	Funding agency	Data collection	Data custodian
				Chromium Copper Lead Zinc Ethyl Benzine O-Xylene Toluene Benzene Hydrocarbons			
AW504549	Sturt River @ d/s Anzac Highway	Urban drainage, stormwater		Recording: Water level Ad hoc field reading: Stream discharge Water temperature TDS pH DO Conductivity Composite sampling: TDS Suspended Solids Turbidity Colour Conductivity Phosphorus Nitrogen Calcium Magnesium Potassium Sodium Bicarbonate Carbonate Chloride	PCWMB	Water Data Services	DWLBC

Site number	Site name	Type	Purpose, comments	Parameters	Funding agency	Data collection	Data custodian
				Sulphate Cadmium Chromium Copper Lead Zinc			
M023098	Adelaide (Morphettville Racecourse)			Daily read: Rainfall	BoM	BoM	BoM
AW504522	Sturt River @ Anzac Highway Culvert	Channel, drain, aqueduct	Closed	Ad hoc field reading: Water temperature TDS pH DO Conductivity	Closed	Closed	DWLBC
M023006	Lockleys (Kooyonga Golf Club)	Meteorological station	Closed	Daily read: Rainfall SKM disag + infill: Rainfall	BoM	BoM	BoM
3400	Parklands Creek near Greenhill Road	Natural stream	A reach just upstream of the culvert under Greenhill Road. Two straight tributary drains from the sports grounds to the North enter the main creek at this site.	Ambient and Macro.	PCWMB	AWQC	PCWMB
M023000	Adelaide West Terrace	Meteorological station	Closed	Daily read: Rainfall SKM disag + infill: Rainfall	BoM	BoM	BoM
AW504555	Willoughby Park Pluvio @ Sturt River	Meteorological station	Closed	Recording: Rainfall	Closed	Closed	DWLBC

Site number	Site name	Type	Purpose, comments	Parameters	Funding agency	Data collection	Data custodian
AW504556	Morphett Arms Hotel Pluvio @ Glengowrie	Meteorological station	Closed	Recording: Rainfall	Closed	Closed	DWLBC
AW504561	Frederick Street Drain @ Glenelg (Glenelg urban runoff into sea)	Urban drainage, stormwater		Recording: Rainfall Water level Flow velocity Water temperature Turbidity Conductivity Ad hoc field reading: TDS pH Conductivity	DWLBC	Water Data Services	DWLBC
M023093	Adelaide (Clarence Gardens Bowling Club) BoM Met Stn	Meteorological station		Daily read: Rainfall SKM disag + infill: Rainfall	BoM	BoM	BoM
M023059	Torrens Park (Mitcham) BoM Met Stn	Meteorological station	Closed	Daily read: Rainfall SKM disag + infill: Rainfall	BoM	BoM	BoM
AW504554	Maxwell Terrace @ Glenelg Tramway	Urban drainage, stormwater	Closed	Recording: Rainfall Water level Flow velocity Ad hoc field reading: TDS pH Conductivity	Closed	Closed	DWLBC
AW504557	Women's Bowling Club Pluvio	Meteorological station	Closed	Recording: Rainfall	Closed	Closed	DWLBC

Site number	Site name	Type	Purpose, comments	Parameters	Funding agency	Data collection	Data custodian
AW504565	Glenelg Catchment Pluvio @ Coles Carpark	Meteorological station	Closed	Recording: Rainfall	Closed	Closed	DWLBC
AW504562	Torrens Square Drain @ Glenelg	Urban drainage, stormwater	Closed	Recording: Water Level Flow Velocity Ad hoc field reading: TDS pH Conductivity	Closed	Closed	DWLBC
AW504551	Edward Street Drain @ Patritti Winery	Meteorological station	Closed	Recording: Rainfall	Closed	Closed	DWLBC
2151	Gulf St Vincent off Brighton Jetty	Marine		Unknown	EPA	EPA	EPA
2150	Gulf St Vincent off Glenelg Jetty	Marine		Unknown	EPA	EPA	EPA
16356	Patawalonga Lake Site 1	Lake		Unknown	EPA	EPA	EPA
16359	Patawalonga Lake Site 2			Unknown	EPA	EPA	EPA
AW504592	Patawalonga Lake @ King Street Bridge	Estuary, tidal stream		Recording: Water temperature Conductivity	PCWMB	Water Data Services	DWLBC
16361	Holdfast Bay Site 1			Unknown	EPA	EPA	EPA
?	Patawalonga Lake Site 4			Unknown	EPA	EPA	EPA
16360	Patawalonga Lake Site 3			Unknown	EPA	EPA	EPA
16362	Holdfast Bay Site 2			Unknown	EPA	EPA	EPA
16363	Holdfast Bay Site 3			Unknown	EPA	EPA	EPA
16364	Holdfast Bay Site 4			Unknown	EPA	EPA	EPA
Brown Hill Creek							
AW504929	Belair Pluvio @ Belair ETSA	Meteorological station		Recording: Rainfall	BoM	BoM	BoM
AW504931	Crafers West Pluvio @ Heathfield Dump	Meteorological station		Recording: Rainfall	BoM	BoM	BoM
M023873	Crafers West BoM Met Station	Meteorological station		Daily Read: Rainfall	BoM	BoM	BoM

Site number	Site name	Type	Purpose, comments	Parameters	Funding agency	Data collection	Data custodian
M023835	Crafers BoM Met Station	Meteorological station	Closed	Daily read: Rainfall SKM disag + infill: Rainfall	BoM	BoM	BoM
M023848	Crafers Highways Dept BoM Met Station	Meteorological station	Closed	Daily read: Rainfall SKM disag + infill: Rainfall	BoM	BoM	BoM
AW504587	Brown Hill Creek (Northern Branch) @ Eagle Quarry	Natural stream	Closed	Recording: Water level Turbidity Daily read: Rainfall Ad hoc field reading: TDS pH Conductivity	Closed	Closed	DWLBC
AW504932	Eagle-on-the-Hill Pluvio @ Eagle-on-the-Hill	Meteorological station		Daily read: Rainfall	BoM	BoM	BoM
M023874	Mount Lofty (Eagle on the Hill)	Meteorological station		Daily read: Rainfall	BoM	BoM	BoM
Workanda Creek							
M023846	Belair ETSA BoM Met Station	Meteorological station		Daily Read: Rainfall SKM disag + infill: Rainfall	BoM	BoM	BoM
M023704	Belair (State Flora Nursery) BoM Met Station	Meteorological station		Daily read: Rainfall SKM disag + infill: Rainfall	BoM	BoM	BoM

Site number	Site name	Type	Purpose, comments	Parameters	Funding agency	Data collection	Data custodian
Upper Sturt River							
3350	Heathfield Creek @ d/s of WWTP	Natural stream	A reach just upstream of the Sturt River by Sturt Grove. The Heathfield WWTP, 1.2 km upstream, discharges a year round flow of nutrient-enriched waters.	Ambient and macro-invertebrate	PCWMB	AWQC	PCWMB
AW504933	Olave Pluvio @ Olave Hill	Meteorological station		Recording: Rainfall	BoM	BoM	BoM
AW504928	Ackland Hill Pluvio @ Ackland Hill Road	Meteorological station		Recording: Rainfall	BoM	BoM	BoM
3351	Sturt River at Sturt Valley Road, Upper Sturt	Natural stream	This reach is immediately upstream of the road. Flow occurs all year round (PCWMB 2000).	Ambient	PCWMB	AWQC	PCWMB
3354	Sturt River at Pole Road	Natural stream	This reach consists of a riffle, pool, riffle system under mature ash trees (PCWMB 2000).	Ambient and macro-invertebrate	PCWMB	AWQC	PCWMB
3352	Sturt River at Sturt Road	Natural stream	This is the last natural section of the river just upstream of the concrete channel at Mitchell Park.	Ambient and macro-invertebrate	PCWMB	AWQC	PCWMB
Chambers Creek							
AW504918	Chambers Creek @ Weymouth Oval (Coromandel Valley)	Natural stream		Recording: Rainfall Water level	BoM	BoM	BoM
AW504550	Chambers Creek Catchment @ Ackland Hill	Meteorological station	Closed	Recording: Rainfall	Closed	Closed	DWLBC

Site number	Site name	Type	Purpose, comments	Parameters	Funding agency	Data collection	Data custodian
AW504521	Chambers Creek @ Coromandel Valley	Natural stream	Closed	Recording: Water Level Ad hoc field reading: Water level Stream discharge Water temperature TDS pH DO Conductivity	Closed	Closed	DWLBC
Central Sturt River							
AW504530	Sturt River @ u/s Flood Control Dam	Natural stream	Closed	Recording: Water level Reservoir water level Ad hoc field reading: Water level Stream discharge Water temperature TDS pH DO Conductivity	Closed	Closed	DWLBC
AW504519	Minno Creek @ u/s Sturt River Junction	Natural stream	Closed	Recording: Water level Ad hoc field reading: Water level Stream discharge Water temperature TDS pH DO Conductivity	BoM	BoM	BoM

Site number	Site name	Type	Purpose, comments	Parameters	Funding agency	Data collection	Data custodian
AW504518	Sturt River @ u/s Minno Creek Junction	Natural stream		Recording: Rainfall Water level Ad hoc field reading: Water level Stream discharge Water temperature TDS pH DO Conductivity Composite sampling: TDS Suspended Solids Turbidity Colour Conductivity Phosphorus Nitrogen Calcium Magnesium Potassium Sodium Bicarbonate Carbonate Chloride Sulphate Cadmium Chromium Copper Lead Zinc	PCWMB	Water Data Services	DWLBC

Site number	Site name	Type	Purpose, comments	Parameters	Funding agency	Data collection	Data custodian
3320	Minno Creek U/S Sturt River				PCWMB	AWQC	PCWMB
M023711	Coromandel Valley (Branden) BoM Met Station	Meteorological station	Closed	Daily read: Rainfall SKM disag + infill: Rainfall	BoM	BoM	BoM
Shepherds Hill							
M023839	Blackwood (Wittunga) BoM Met Station	Meteorological station		Daily read: Rainfall SKM disag + infill: Rainfall	BoM	BoM	BoM
M023706	Blackwood Post Office BoM Met Station	Meteorological station	Closed	Daily read: Rainfall SKM disag + infill: Rainfall	BoM	BoM	BoM

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

GLOSSARY

Ambient water monitoring — All forms of monitoring conducted beyond the immediate influence of a discharge pipe or injection well, and may include sampling of sediments and living resources.

ANZECC — Australia New Zealand Environmental Consultative Council.

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.

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.

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, Australia.

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.

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, run by DWLBC.

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 watertable. The accumulation of salt degrades the upper soil profile, with impacts on agriculture, infrastructure and the environment.

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.

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.

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 run-off from the land.

FC — Faecal Colliform.

FIB — Faecal Indicator Bacteria.

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.

FS — Faecal streptococci.

GIS — Geographic Information Systems. 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.

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.

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.

MDBC — Murray–Darling Basin Commission.

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.

NLWRA — National Land and Water Resource Audit.

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

OBSWELL — Observation Well Network.

P —- Phosphorus.

PCWMB — Patawalonga Catchment Water Management Board

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.

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.

Potable — Water that is fit to drink.

Prescribed water resource — A water resource declared by the Governor of South Australia to be prescribed under the Water Resource Act 1997. Includes undergroundwater 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.

SA Water — South Australian Water Corporation.

SOP — Standard operating procedure.

Sub-catchment — The area of land determined by topographical features within which rainfall will contribute to run-off 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.

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 (1–70 million 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.

USGS — United States Geological Survey.

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 (WDE) — Those parts of the environment, the species composition and natural ecological processes, that 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 EPA (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 groundwaters, 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 watertable 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.

WMLR — Western Mount Lofty Ranges.

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