DWLBC REPORT

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

2006/14

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

Review of South Australian State Agency Water Monitoring Activities in the Onkaparinga 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
CHIEF EXECUTIVE
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 Onkaparinga 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

Water resources in the Onkaparinga Catchment are managed to provide water for domestic, agricultural, horticultural and industrial use, while providing for the environmental requirements of water-dependent ecosystems. This review of water monitoring activities in the 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 Onkaparinga 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 Onkaparinga 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 Onkaparinga Catchment

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

Surface Water Quantity Monitoring

Monitoring category	Gaps	Suggestions for monitoring	Refer
Basin outflow stations	Noarlunga	Reinstrument and reopen 'Onkaparinga @ Noarlunga' (AW503522)	Sect. 5.2 and 5.6.1.4`
Meteorological	Mitchell Creek, Biggs Flat, Angel Gully, Clarendon Weir, Waterfall Gully, Maslins sub-catchments.	Consideration be given to a possible need for meteorological stations in any of these sub-catchments	Sect. 5.6.1.3
Evaporation	Most of the catchment	Considerable expansion of evaporation monitoring	Sect 5.6.1.3
System inflow–outflow	Inflows to reservoirs, controlled releases, spills, evaporation losses at some locations	Expand flow and evaporation monitoring within water supply distribution system	Table 7
Stream flow gaugings for ratings	Up-to-date flow gaugings to establish ratings for flow calculations from levels	Annual flow gaugings to be carried out to establish ratings for calculating flows that relate to current flow regimes	Sect 5.6.1.4
Stream flow	Mitchell Creek, Balhannah, Hahndorf, Biggs Flat, Angel Gully, Clarendon Weir, Onkaparinga Main Channel, Waterfall Creek, Christie Creek, Maslins, Willunga, Aldinga South and Sellicks sub-catchments	Consideration be given to a possible need for stream flow monitoring in these sub-catchments, particularly in the Willunga Sub-area	Sect 5.6.1.3
Farm dams	Accuracy of sources of water in dams	Carry out surveys to ascertain sources of water in dams whether surface water, groundwater or both, or from off-line diversions from another stream or catchment	Sect 5.3.7.2

Monitoring category	Gaps	Suggestions for monitoring	Refer
Irrigation water use outside McLaren Vale Prescribed Wells Areas	Accurate measurements of irrigation water use	More accurate measurements of irrigation water use, by investigating land management practices, rather than relying on estimations from land-use surveys	Sect 5.3.7.3
Hydrological modelling	Catchment characteristics coverage	Create hydrological models of all sub-catchments representative of the various catchment characteristics	Sect 5.3

Surface Water Quality Monitoring

Monitoring category	Gaps	Suggestions for monitoring	Refer
Continuous salinity	Monitoring across a wide range of flows at surface water levels and/or flow monitoring sites	Expand salinity monitoring to cover a wider range of stream flows. Look at feasibility of measuring continuous EC and temperature at all surface water levels and/or flow monitoring sites.	Sect. 5.5.2.1 and App G
Water quality generally	Water quality monitoring at newly established stream flow monitoring sites	Where stream flow monitoring is established (see 'Surface Water Quantity Monitoring' in this table), include water quality monitoring at the same location	Sect 5.5.2.1
System inflow–outflow	River Murray transfers, transfers between reservoirs, weir inflows and outflows	Expand water quality monitoring within water supply distribution system	Sect 5.6.2.3 and Table 7
Waste water treatment plants	Heathfield, Christies Beach, Aldinga	Expand water quality monitoring to include these WWTPs	Sect 5.6.2.1
	Pathogens and nutrients for WWTPs	Include monitoring for pathogens and nutrients in relation to impacts of WWTPs	Sect 5.6.2.1
Pollutant loads (composite)	Composite monitoring in conjunction with all flow monitoring	Consider expansion of network to coincide with sites that monitor water levels with a rating for flow	Sect 5.6.2.2
Ambient	Mitchell Creek, Balhannah, Angel Gully, Waterfall Creek	Consider the need to carry out ambient water quality monitoring in any of these sub-catchments	Sect 5.6.2.3

Groundwater Quantity Monitoring

Monitoring category	Gaps	Suggestions for monitoring	Refer
Levels	Upper Onkaparinga and Noarlunga Embayment sub-areas for levels	Expand monitoring for levels	Sect 6.5.1.1
Groundwater discharge and recharge	Recharge and discharge rates for information suitable for surface water modelling	Further refine understanding of groundwater recharge and discharge for the catchment	Sect 6.5.1.3

Groundwater Quality Monitoring

Monitoring category	Gaps	Suggestions for monitoring	Refer
Salinity	Upper Onkaparinga and Noarlunga Embayment Sub-areas for salinity	Expand monitoring for salinity	Sect 6.5.2.1
Fertilisers	Comprehensive monitoring for fertilisers	Expand groundwater monitoring to investigate presence of fertilisers in Charleston, Western Branch, Cock Creek, Cox Creek, Christie Creek sub-catchments	Sect 6.5.2.4
Diffuse pollution and results of shallow groundwater monitoring project	Consideration of all suggestions made by D. Clarke for inclusion in an on-going monitoring program	Include locations at which Faecal Indicator Bacteria (FIB) contamination is found, investigations of unknown sources of waste, unsewered areas, underground petrol storage tanks, areas with active mines, review of locations of sampling points	Sect 6.5.2.2

Aquatic Ecosystems

Monitoring category	Gaps	Suggestions for monitoring	Refer
Integrated monitoring program	WMLR region	Develop calibrated catchment model	Sect 7.4.1
Stygofauna	No data	Basic research	Sect 7.3.4
Significant aquatic ecosystems	Not identified	Identification of priority aquatic ecosystems for ambient monitoring	Sect 7.4.1.3
Riparian vegetation	Riparian vegetation is degraded	Monitor restoration of riparian vegetation	Sect 7.4.1.4
Groundwater dependent ecosystems	Data on distribution and abundance; and impact of altered flow regime	Survey the distribution and abundance of groundwater dependent ecosystems; research the impact of altered flow regime	Sect 7.3.2
Ephemeral streams	Understanding of impact of altered flow regime	Research the impacts of altered flow regime on ephemeral streams	Sect 7.3.3

Catchment Characteristics

Monitoring	Gaps	Suggestions for monitoring	Refer
Changes in land use	Up-to-date data and information	Collect up-to-date data and information about changes in land use for all catchments	Section 8
Land-use dataset	Land-use dataset specifically designed for water resources assessment	Develop a land-use dataset specifically designed for use by agencies involved in water resource monitoring and management	Section 8

Monitoring	Gaps	Suggestions for monitoring	Refer
Projected urban growth	Linking information about projected urban growth to current and future land use and practices	Research predicted urban growth and link to land-use practices with regard to future demands for water	Section 8

Data and Information Management

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

Roles and Responsibilities

Monitoring	Gaps	Suggestions for monitoring	Refer
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 recommend-dation

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 Onkaparinga Catchment include (refer to Section 3 for further detail):

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

2. CATCHMENT DESCRIPTION

2.1 PHYSICAL FEATURES

The Onkaparinga Catchment is the area of land contributing water to the Onkaparinga River up to the point where the river flows into Gulf St Vincent.

The Upper Onkaparinga Sub-area is above Mount Bold Reservoir and comprises the hills area of the OCWMB's area of responsibility. Sub-catchments occurring within this area are Charleston, Western Branch, Cock Creek, Inverbrackie Creek, Upper Onkaparinga, Cox Creek, Mitchell Creek, Balhannah, Aldgate Creek, Hahndorf, Biggs Flat, Echunga Creek and Onkaparinga Main Channel.

The Lower Onkaparinga Sub-area is below Mount Bold Reservoir and includes the lower reaches and mouth of the Onkaparinga River as well as a section of the coastline. Sub-catchments within this area are Angel Gully, Scott Creek, Onkaparinga Main Channel and Baker Gully.

The Noarlunga Embayment Sub-area is the most urbanised of the board's sub-areas, and includes the Happy Valley Reservoir and parts of both the City of Marion and City of Onkaparinga. Sub-catchments within this area are Field River, Christie Creek and Waterfall Gully.

The Willunga Basin includes most of the McLaren Vale Prescribed Wells Area. This sub-area contains a large section of the catchment board's coastal area and the catchments of four smaller waterways — Pedler, Maslin, Port Willunga and Sellicks Creeks. Sub-catchments within this area are Pedler Creek, Maslin, Willunga, Aldinga South and Sellicks (OCWMB 2000).

2.2 SURFACE WATER RESOURCES

2.2.1 ONKAPARINGA CATCHMENT

The Onkaparinga Catchment upstream of Clarendon Weir produces one of the largest surface water resources in the Mount Lofty Ranges. Of the five reservoir catchments[1] in the WMLR, the Onkaparinga is the single largest contributor of surface water to Adelaide's water supply, producing a median annual adjusted catchment yield[2] at Clarendon Weir of 72 GL (Teoh 2002). Most of this flow is diverted either by farm dams in the upstream catchment, or by reservoir and weir storages for water supply.

[1] South Para, Little Para, Torrens, Onkaparinga and Myponga catchments

[2] The adjusted catchment yield is the catchment run-off that would occur in the absence of all surface water diversions, with current land use. This definition is taken from the State Water Plan 2000 vol 1 p50.

The Onkaparinga River below the weir is generally a much drier catchment since the construction of the water supply system. Clarendon Weir spills only ~20% of the time (Teoh 2002). The only unregulated catchment in this section of the river is the Bakers Gully catchment, which generates an adjusted catchment yield of ~4.5 GL/y (Teoh 2002).

The Onkaparinga Gorge dominates the lower sections of the Onkaparinga River. This area is largely inaccessible, and the majority of its length is a national park. The levels of use are therefore comparatively low compared to the upper catchments.

The Upper Onkaparinga catchment is largely ephemeral, with many sub-catchments ceasing to flow for some of the summer period. The main channel of the Upper Onkaparinga is usually dry for some of the year, but from Hahndorf to Clarendon the river is an aqueduct for either River Murray water via the Murray Bridge–Onkaparinga Pipeline, or for bulk transfers from Mount Bold Reservoir to Clarendon Weir. These reaches of the river therefore tend to be permanently flowing during the summer months.

The sub-catchments of the Lower Onkaparinga (including Scott Creek and Bakers Gully) tend to be almost permanently flowing, with flow recorded for over 95% of the year (State Water Archive December 2005). These streams are accessing groundwater to maintain flows almost year round.

The Onkaparinga Gorge is hypothesised to have flowed year round. Due to Clarendon Weir blocking and diverting low flows from the Scott Creek, Angels Gully and Upper Onkaparinga catchments, many of these flows are now no longer available to the Gorge.

2.2.2 NOARLUNGA EMBAYMENT SUB-AREA

This area is dominated by the Field River and Christie Creek sub-catchments. These are coastal catchments, the downstream coastal areas of which have become urbanised, and with peri-urban headwaters.

The water resources of these areas have not been thoroughly assessed, although levels of extraction are not considered high. The principal issues of water resource management in these catchments relate to flood risk from the upper catchments to the urban areas, and water quality of discharges to Gulf St Vincent.

2.2.3 WILLUNGA BASIN

The surface water catchments of the Willunga Basin are characterised by headwaters in the steep, fractured rock headwaters of the Sellicks Hill Range, from which the water flows down and across the alluvial aquifers of the Willunga Basin towards Gulf St Vincent. Understanding the interactions between these surface water catchments and the groundwater resources of the Willunga Basin are important for the long- term sustainability of the McLaren Vale groundwater resources.

There have been some extractions from these catchments, sometimes for the purpose of aquifer storage and recovery. At present, the total amount of water extracted is not considered high, but future development needs to be carefully managed to mitigate adverse impacts to current users and the environment.

2.3 GROUNDWATER RESOURCES

The Onkaparinga Catchment forms the core of the central MLR and is underlain almost entirely by Adelaidean fractured rocks, with small occurrences of Barossa Complex gneiss and Kanmantoo Group schist. Quaternary alluvium overlies basement rocks in the main valley.

The western end of the catchment downstream of Old Noarlunga overlies Tertiary sediments of the Noarlunga Embayment. South of McLaren Vale, the Willunga Basin contains a considerable thickness of Tertiary marine sediments, namely sand, limestone and marl overlain by Quaternary alluvium.

2.3.1 HYDROGEOLOGY

There are two different types of aquifer systems in the Onkaparinga Catchment. Fractured rock aquifers occur in the hills where groundwater is stored and moves through joints and fractures in the basement rocks. Sedimentary aquifers occur in the Noarlunga and Willunga Basins, where groundwater flows through the pore spaces within the sediments.

The Adelaidean fractured rock aquifers (FRA) have not been subject to the heat and pressure of metamorphism; the joints and fractures are open and permeable. This results in high yields and generally good quality groundwater. Hydraulic properties in these are very complex and not well understood. Recharge to these aquifers occurs from rainfall in outcropping areas. It is considered that in the Upper Onkaparinga Sub-area, the FRA is approaching its estimated sustainable yield in Cock, Inverbrackie, Mitchell and Balhannah Creek sub-catchments (Zulfic et al. 2003). Downstream of Old Noarlunga, Tertiary sediments contain brackish to saline groundwater which is not considered a resource.

The Willunga Basin contains a complex multi-aquifer system consisting of sand, limestone and the underlying fractured rocks. Increasing withdrawals for the irrigation of vineyards and almonds led to falling groundwater levels and the formation of the McLaren Vale Prescribed Wells Area in 1991.

Quaternary aquifer — recharge to this aquifer occurs mainly from local rainfall and run-off provided by streams. The aquifer has little demand placed upon it for irrigation use because of its low yield.

Port Willunga Formation — recharge to the aquifer principally occurs across the unconfined portion, that being a narrow strip extending from the coast and slightly south of McLaren Vale township to McLaren Flat. The hydraulic properties of this aquifer are not well understood and its hydrogeology needs further investigation.

Maslin Sands aquifer — this aquifer, which overlies the fractured rock aquifer, is recharged from the northeast of the Prescribed Wells Area near Baker Gully, Blewitt Springs and north of McLaren Flat, where the aquifer crops out.

2.4 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, the riparian zone,

floodplains and gorges. The major freshwater streams of the WMLR are the Gawler, Little Para, Torrens, Sturt and Onkaparinga Rivers and their associated tributaries. 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 also supports subterranean groundwater ecosystems, although little is known about these. These water-dependent ecosystems support a range of flora and fauna including: instream, riparian and floodplain vegetation; phyto- and zooplankton communities; macro-invertebrates; fish; birds and mammals.

2.5 LAND USE

Major land-use areas are urban development along the fringe of Metropolitan Adelaide, intensive agriculture and horticulture in the Adelaide Hills and Willunga Embayment areas, and industrial activities in the Lonsdale area as well as some Adelaide Hills townships.

Vineyards are now estimated to be the largest water-using crop in the Onkaparinga Catchment. This is not a result of particularly high water application rates but because of an increase in the area dedicated to this industry over the last decade. Orchards, on the other hand, receive at least twice the volume of water application per hectare but cover only ~35% of the area covered by vines. Most of the vineyards are located in the lower catchment areas.

2.5.1 IMPACT OF LAND USE ON WATER RESOURCES

It is predicted that there will be a continuing increase in grapevine establishment along with the area dedicated to olive establishment. It also seems that there will be pressure to increase the number of small allotments for rural living as well as further encroachment of urbanised areas onto rural land (OCWMB 2000).

2.5.2 FUTURE TRENDS IN LAND USE

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

2.5.3 CHANGES IN LAND USE IN RELATION TO WATER MONITORING

Changes in land use can have a significant impact on natural resources. It is therefore important to consider current land-use activities in relation to monitoring needs, as well as an on-going assessment of land use to capture any changes and thus any need for changes in related monitoring activities (refer to Table 1 for major land-use activities). An inventory of land-use change is seen as imperative for the creation of an up-to-date water monitoring program as well as a means of gaining an historical perspective on the impacts of land-use change in relation to historical records of water quantity and quality data.

Table 1. Major land-use activities within sub-catchments of the Onkaparinga Catchment. Shading indicates occurrence (source: OCWMB 2000).

Upper Onkaparinga (above Mount Bold Reservoir)

Sub-catchments	General grazing	Dairy	Orchards	Vegetable production	Field crops	Vineyards	Native vegetation	Plantation forest	Horticulture	Industrial
Charleston	■	■	■	■						
Western Branch of Onkaparinga River	■	■	■			■	■			
Cock Creek			■			■	■	■		
Inverbrackie	■	■		■	■	■				
Mitchell Creek	■	■								
Upper Onkaparinga	■						■		■	
Balhannah	■								■	
Hahndorf	■								■	
Aldgate Creek				■			■			
Cox Creek			■	■		■	■	■		
Biggs Flat	■	■								
Echunga Creek	■	■					■	■		
Onkaparinga Main Channel (above and including Mount Bold Reservoir)	■						■	■		

Lower Onkaparinga sub-area

Sub-catchments	Cattle grazing	Dairy	Orchards	Vegetable production	Field Crops	Vineyards	Native vegetation	Plantation forest	Horticulture	Industrial
Scott Creek										
Angel Gully										
Baker Gully										
Onkaparinga River Channel (below Mount Bold Reservoir)										

Noarlunga Embayment sub-area

Sub-catchments	Cattle grazing	Dairy	Orchards	Vegetable production	Field crops	Vineyards	Native vegetation	Plantation forest	Horticulture	Industrial
Field River										
Christie Creek										

McLaren Vale and Willunga sub-area

Sub-catchments	Cattle grazing	Dairy	Orchards	Vegetable production	Field crops	Vineyards	Native vegetation	Plantation forest	Horticulture	Industrial
Pedler Creek										
Maslin										
Willunga										
Aldinga South										
Sellicks										

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 ONKAPARINGA CATCHMENT WATER MANAGEMENT BOARD (OCWMB)

Catchment water management boards are state government statutory authorities responsible to the Minister for Environment and Conservation. The OCWMB (2004) aims to meet five main goals, as outlined below:

Goal 1 Rehabilitate and manage watercourses by implementing and promoting best practice environmental management.

Goal 2 Maintain and enhance the quality of surface and groundwaters, including monitoring programs.

Goal 3 Use water sustainably and balance consumptive and environmental water use for current purposes and future needs, and reuse non-traditional water resources.

Goal 4 Develop an aware and committed community through an effective consultation and education program, promote environmental responsibility within the community, and involve the community in environmental issues.

Goal 5 Integrate resource management through coordinated policies and effective partnerships between stakeholders.

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

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

Water monitoring category	Responsible stakeholders[1]	Other agencies involved[2]
Surface water quantity		
Rainfall	BoM	DWLBC, SA Water, CWMB
Rainfall intensity	DWLBC	BoM, CWMB, SA Water
Catchment stream flow	DWLBC	EPA, CWMB, SA Water
Sub-catchment stream flow	CWMB	DWLBC, EPA, SA Water
Stormwater	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 ground water 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, NH3, 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 Waterwatch 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 is ideally operated indefinitely, monitoring rainfall, water level, stream flow and salinity. It is considered to be a high priority form of monitoring.

Currently, there are three base stations in the Onkaparinga Catchment — two are in the Onkaparinga Main Channel (Mount Bold Reservoir) sub-catchment:

- Onkaparinga @ upstream of Hahndorf Dissipator (A5031001) where water level, salinity and water quality are being recorded. In conjunction with site AW503504, it can be used to estimate total run-off from most of the Onkaparinga Catchment. At low flows, the record at this site is affected by outflows from the Hahndorf Waste Water Treatment Plant (WWTP). Flows at this outfall are also recorded at AW503537, so a corrected record can be created.
- Onkaparinga River @ Houlgraves Weir (AW503504) where rainfall, water level, inflow from the pipeline, water temperature and turbidity are being recorded, along with composite monitoring of salinity, phosphorus and nitrogen. The EPA is also monitoring water quality at this location (site no. 6392) through its ambient monitoring program. The site records flows for the catchment above Mount Bold Reservoir. Transfers of water from the River Murray via the Murray Bridge–Onkaparinga Pipeline affect the flow record; data relating to the transfer of water through this pipeline are required before determining run-off from the Upper Onkaparinga Catchment.

The third, Onkaparinga River @ Clarendon Weir (AW503500) in the Clarendon Weir sub-catchment, measures water level and quality. This weir is a broad-crested structure for water supply infrastructure. It is therefore highly sensitive at low flows, and is unlikely to record these accurately. It can be used to record medium-large flows (i.e. ~200 ML/d or greater) with reasonable accuracy. The majority of flows at this weir are diverted to Happy Valley Reservoir via a tunnel, flows through which are recorded at Horndale Flume (AW503519) on entry to Happy Valley Reservoir.

5.2 BASIN OUTFLOW STATIONS

Basin outflow stations are considered to be a high-priority monitoring category for measuring stream flow leaving the Onkaparinga Catchment, and are required for statutory reporting purposes. The minimum monitoring parameters for such stations are water level, stream flow, salinity and, preferably, physical and chemical parameters for a more comprehensive assessment of water quality entering the sea.

There is a closed DWLBC site at ‘Onkaparinga @ Noarlunga’ (AW503522) which served as the basin outflow station. The EPA is monitoring ambient physical and chemical parameters as well as macro-invertebrates at this site. There have been historical issues regarding accuracy of the site, as the flow control structure was unreliable.

DWLBC and OCWMB are co-funding a new site near AW503522 to monitor outflows to the Onkaparinga estuary, and also any environmental water provisions flowing down the Onkaparinga Gorge. Maintenance of the site will need to be negotiated between DWLBC and OCWMB.

OCWMB is monitoring outflows to the sea in the Field River and Willunga sub-catchments as part of its ambient and macro-invertebrate monitoring program.

5.3 SYSTEM INFLOW–OUTFLOW STATIONS

The Onkaparinga Catchment is heavily regulated for water supply purposes, and there are many bulk water transfers that need to be recorded to enable an accurate assessment of catchment run-off.

This category of monitoring relates to stream flow entering or released from regulated river systems and infrastructure, for example upstream and downstream of reservoirs and weirs. The minimum parameters to be measured are water level and stream flow for at least 10 years. The systemic model shown in Appendix C also suggests that water quality monitoring be carried out at these locations and in relation to WWTPs, as well as within reservoirs.

5.3.1 RIVER MURRAY TRANSFERS

The Hahndorf Dissipator accommodates the outfall of River Murray water transferred along the Murray Bridge–Onkaparinga Pipeline and into the Onkaparinga River before it flows down to the Mount Bold Reservoir. DWLBC site 'Onkaparinga @ U/S Hahndorf Dissipator' (A5031001) monitors water level and salinity upstream of the dissipator. There is a proposed SA Water site 'Murray Bridge–Onkaparinga Pipeline @ Outlet to Onkaparinga River' (A5031002).

5.3.2 RESERVOIRS AND WEIRS

Water quality monitoring within major reservoirs and weirs occurs regularly for drinking water supply protection and improvement.

Monitoring outflows from reservoirs and pipelines is considered a high priority to measure releases from regulated sections of the catchment. Monitoring is ideally carried out for a medium term of at least 10 years. Monitoring water quantity and quality below reservoirs in relation to assessment of environmental water provisions and the impact of water quality on ecosystems is desirable. Water flows and quality immediately upstream of reservoirs is a high priority to proactively assess water quality risks to the water supply.

5.3.3 MOUNT BOLD RESERVOIR

This is the largest water supply reservoir in the Onkaparinga Catchment and receives flow from the remainder of the Upper Onkaparinga Sub-area, as well as River Murray water transfers. It releases water downstream to the Clarendon Weir. DWLBC site 'Onkaparinga River @ Houlgrave' (AW503504) is monitoring water levels, inflow from the Murray Bridge–Onkaparinga Pipeline to the reservoir, as well as salinity, phosphorus, suspended solids and nitrogen content. The EPA also carries out ambient water quality monitoring at this location

(site no. 6392). DWLBC site 'Echunga Creek @ U/S Mount Bold Reservoir' (AW503506) is monitoring water levels, salinity, phosphorus and nitrogen. SA Water site 'Onkaparinga River @ Mount Bold Reservoir' (AW503501) is monitoring reservoir level and quality; at the same site, EPA is carrying out ambient and macro-invertebrate monitoring relating to the transfer of water through the pipeline.

5.3.4 CLARENDON WEIR

This is a diversion point whereby water is diverted to the Happy Valley Reservoir to be made available as SA Water supplies to Adelaide and Onkaparinga Catchment urban areas. Water is also released from Clarendon Weir directly into the lower reaches of the Onkaparinga River main channel. SA Water site 'Onkaparinga River @ Clarendon Weir' (AW503500) is monitoring water levels and ambient water quality.

5.3.5 HAPPY VALLEY RESERVOIR

This is an off-stream reservoir situated in the Field River sub-catchment in the Noarlunga Embayment Sub-area. It receives water from Clarendon Weir via the intake channel at Horndale Flume (AW503519) for metropolitan water supplies. SA Water site 'Happy Valley Reservoir @ Metro Telemetry' (AW503535) is monitoring water level.

5.3.6 MYPONGA RESERVOIR TRANSFERS

Although relatively small compared to other water transfers in and out of the catchment, it is suggested that monitoring be expanded to include transfers from Myponga Reservoir to Happy Valley Reservoir. These transfers may become more frequent as one option to support a larger future population in and around Victor Harbor.

5.4 CURRENT SURFACE WATER QUANTITY MONITORING

Current ongoing surface water quantity monitoring data from sub-catchments of the Onkaparinga Catchment are shown in Table 3.

In terms of the Noarlunga Embayment and Willunga Sub-areas, and for any other specific purposes for the entire catchment, meteorological and stream-flow monitoring gaps are outlined below.

5.4.1 METEOROLOGICAL MONITORING

Rainfall monitoring is occurring in most sub-catchments of the Onkaparinga Catchment, the majority of which is managed by BoM and some of which is managed by DWLBC.

5.4.2 SUB-CATCHMENT STREAM FLOW

Stream discharge monitoring in the Charleston sub-catchment (BoM station AW503903) commenced in 1994, Western Branch sub-catchment (BoM station AW503906) began in

Table 3. Current ongoing surface water quantity monitoring for sub-catchments of the Onkaparinga Catchment.

Sub catchment	Current on-going monitoring	
Upper Onkaparinga Sub-area		
Mitchell Creek	None	–
Balhannah	Rainfall	BoM
Biggs Flat	Ambient and macro-invertebrates	OCWMB
Lower Onkaparinga Sub-area		
Angel Gully	None	–
Onkaparinga Main Channel (Lower Onkaparinga)	Rainfall, ambient and macro-invertebrates	BoM, EPA, OCWMB
Noarlunga Embayment Sub-area		
Waterfall Creek	None	–
Christie Creek	Rainfall, Ambient and macro-invertebrates	BoM, OCWMB
Willunga Sub-area		
Maslins	Ambient and macro-invertebrates	EPA, OCWMB
Willunga	Rainfall, ambient and macro-invertebrates	BoM, EPA, OCWMB
Aldinga South	Rainfall, ambient and macro-invertebrates	BoM, OCWMB
Sellicks	Rainfall, ambient and macro-invertebrates	BoM, OCWMB

1995, Upper Onkaparinga (Spoehr) sub-catchment (BoM station AW503902) began in 1996, and flow velocity in Pedler Creek sub-catchment (OCWMB station AW503540) commenced in 2000.

A number of the remaining sub-catchments are being monitored for stream flow by means of flow gaugings. Such flow monitoring is occurring in Cock Creek, Onkaparinga Main Channel (Mount Bold Reservoir), Cox Creek, Aldgate Creek, Scott Creek, Kangarilla and Field River sub-catchments (App. F). A site was maintained in Inverbrackie Creek, but this has recently closed.

All other sub-catchment monitoring sites were determined to be of medium to low priority to DWLBC, as many sites had 20+ years of record, and a calibrated model had been successfully made of the sub-catchment. DWLBC has therefore recently divested full responsibility of these, and entered into cost-sharing arrangements with SA Water, the EPA Watershed Protection Office (WPO), and OCWMB. The cost-sharing proportions that have been agreed to are shown in Table 4.

SA Water, EPA WPO and OCWMB have declared interests in many of these sites for the maintenance of load-based composite sampling, which requires continuous flow recording. Where DWLBC has maintained a 50% share of monitoring costs, the site is of medium priority for surface water assessment. Where DWLBC has 0% share, the site is now of low priority.

Table 4. Cost sharing proportions (percent).

Site	Name	DWLBC	OCWMB	SA Water	EPA WPO	Comments
AW503503	Bakers Gully	50	50	0	0	
AW503502	Scott Creek	50	16.7	16.7	16.7	Composite sampler at this site
AW503529	Burnt Out Creek	100	0	0	0	Project site
AW503506	Echunga Creek	50	16.7	16.7	16.7	Composite sampler at this site
AW503509	Aldgate Creek	0	0	50	50	Composite sampler at this site
AW503526	Cox Creek	0	33	33	33	Composite sampler at this site
AW503507	Lenswood Creek	0	33	33	33	Composite sampler at this site
AW503508	Inverbrackie Creek	0	0	0	0	To be closed
AW503547	Christie Creek D/S Galloway Rd	0	100	0	0	Composite sampler at this site
AW503546	Field River D/S of Main South Road	0	100	0	0	Composite sampler at this site

5.4.3 HYDROLOGICAL MODELLING

Information about the hydrological cycle and water use is lacking for some sub-catchments in the WMLR catchment areas. To calculate a water balance, the following components of the hydrological cycle need to measured — rainfall, evaporation, stream flow (level) and groundwater interaction, as well as calculations of water use which are dictated by land use. The development of water balance models for each sub-catchment (refer to Key Issue 4.3.4, App. D) will provide meaningful baseline information from which management decisions can be made.

Where this is not occurring, it is important that sites representative of relevant hydrological, land use and vegetation type characteristics are used to model water balances for those sub-catchments, particularly where it is inappropriate to construct new gauging stations. For sub-catchments where existing data for hydrological modelling are insufficient, including a lack of representative sites, it is advisable that gauging stations be installed to aid the modelling process.

5.4.4 RAINFALL

To obtain a realistic assessment of run-off, a good understanding of both the volume and variability of rainfall in a catchment is important. Maintenance of existing, as well as establishment of additional, pluviograph stations at higher elevations within the catchments would provide more information about the spatial variability of rainfall with elevation, and improve the rainfall–run-off modelling process (Heneker 2003).

5.4.5 EVAPORATION

The main factors involved in the evaporation process are solar radiation, air temperature, air humidity and wind velocity. Estimates of evaporation are essential for the calculation of water balances in terms of surface water run-off. The availability of long-term daily pan (evaporation from an open water surface) evaporation data in the Mount Lofty Ranges (MLR) is very limited. There should be at least one climate station located within major catchment areas that records both pan data and relevant climate variables required to calculate evaporation.

Evaporation is measured at the Mount Bold (023734) and Happy Valley (023721) Reservoirs, McLaren Vale (023876), and at Lenswood (023801). On a relative scale, this is a reasonable coverage, with values ranging from ~1300 mm (Lenswood) to 1750 mm (Happy Valley).

Evaporation recording stations near reservoir lakes is useful for evaporation losses from the lake, but the waterbody may not make the record representative for the broader catchments. It is suggested that a MLR-wide catchment evaporation network be investigated.

5.4.6 STREAM FLOW

It is important to acquire long-term, good-quality stream flow records in order to calculate levels of run-off over a range of rainfall events. Stream flow data that is inadequate is much more difficult to correct than data for rainfall, as there are many factors that influence run-off.

5.4.7 WATER USE

5.4.7.1 SA Water Infrastructure

SA Water carries out water monitoring in relation to its water supply infrastructure, for example reservoir water levels. However, continuously recorded data for water supply operations, including reservoir releases and spills from weirs, are not monitored in some cases and need to be included in SA Water's monitoring network. This is important as part of estimating natural run-off for hydrological modelling.

It is suggested that SA Water progressively upgrades its monitoring network to include continuous monitoring of all:

- discharges to watercourses (i.e. Hahndorf Dissipator, Mount Bold Reservoir release, Horndale Flume)
- offtakes from waterbodies (i.e. inflows to Happy Valley Water Treatment Plant)
- well-rated volumetric monitoring of spills from storages (i.e. Mount Bold Reservoir, Clarendon Weir, and (at a lower priority) Happy Valley Reservoir spill).

5.4.7.2 Farm Dams

It is estimated that farm dams reduce annual catchment yields by 5–8% for the Onkaparinga Catchment as a whole. At localised sub-catchment scale, flow impacts on annual catchment yield range from 1–20% (Teoh 2002).

The influence of farm dams on flow data is important with regard to hydrological modelling, as are the sources of water whether it be surface water, groundwater or both, or diversions from another catchment.

Data on water use in relation to farm dams are currently derived from land-use data sets. However, more precise investigations into farm dam water use and water sources are advisable for all sub-catchments on a regular and consistent basis.

As part of the prescription and water licensing processes of the WMLR, water use for commercial purposes (mainly irrigation and industrial) will be required to be licensed, and as a condition of that licence are likely to require meters on use of water from farm dams, wells and direct watercourse extractions. The data collected from this process will greatly enhance knowledge of farm dam water balances and agricultural water use in the region, including the Onkaparinga Catchment.

5.4.7.3 Irrigation Water Use

Outside prescribed water resource areas, the area irrigated and application rates have not been measured for all agricultural industries. Research was recently carried out to gather information about irrigation activities that are not within prescribed areas for parts of the Adelaide Metropolitan and MLR region. Results of this research are presented in Binks (2004). Data used to gather information for the project were mainly from on-farm field assessments of irrigation practices for the apple, pear, cherry and viticulture industries, ABS statistics, land status mapping for the MLR watershed, and a survey of apple and pear growers.

For other agricultural industries, on-farm field assessments of irrigation practices for the remaining significant industries, including that for irrigated pasture, olives, citrus, strawberries, brassica vegetables, potatoes, flowers and nuts, would be desirable to gain more insight into actual irrigation water use. Variations in application rates (e.g. due to crop type or seasonal factors), as well as between individual irrigators growing the same crop, soil type and irrigation system capacity needs to be addressed. Data should be collected on irrigation water use for all sub-catchments.

As described above, the prescription and water licensing process will greatly assist in this work being undertaken.

5.4.7.4 Forestry

There is limited information available on the impacts of forestry development on surface run-off and groundwater recharge. Further comprehensive studies would contribute to a greater understanding of the impacts of this industry on water resources. Such studies should include comparisons with the impact of re-establishment of native vegetation on surface runoff and groundwater recharge.

5.4.7.5 Land-Use Changes

Available land-use datasets were current in 1999. Data and information collected for all sub-catchments about changes in land use need to be kept more up-to-date for determining water balances. Information on SA Water infrastructure and changes in water management practices is vital to hydrological modelling (e.g. reservoir operation, change to pipeline network).

Aerial photographs were captured in late 2004 – early 2005, and land-use change is currently limited due to the Notice of Prohibition on new or expanded water use in the region. Irrigated water use and farm dams are being mapped from this process, which should assist in assessment of land-use changes over the last five years.

5.5 CURRENT SURFACE WATER QUALITY MONITORING

Water quality monitoring is occurring in various ways by various agencies, and the following definitions explain the methods by which this is being carried out. Table 5 illustrates the type of monitoring carried out by each agency. Figures 1 and 2 show the location of the current surface water quality monitoring sites for the upper and lower Onkaparinga. Appendix G provides a list of current surface water salinity monitoring sites.

Table 5. Outline of the current parameters being monitored by relevant agencies.

Parameters			Agency
Continuously recorded salinity monitoring	Electrical Conductivity Water temperature		CWMB, DWLBC
Composite monitoring	TDS	Lead	PIRSA
	pH	Zinc	
	Conductivity	Iron	
	Sulphate	Nickel	
	Cadmium	Aluminium	
	Chromium	Manganese	
	Copper		
Ambient monitoring	<u>General data</u>	Bicarbonate	EPA
	pH	Chloride	
	Temperature	Fluoride	
	Organic carbon	Sulphate	
	Dissolved oxygen		
	Total dissolved solids	<u>Nutrients</u>	
	Conductivity	Nitrate	
		Nitrite	
	<u>Physical characteristics</u>	Soluble and total phosphorus	
	Turbidity	Total Kjeldahl nitrogen (TKN)	
	Colour		
		<u>Metals</u>	
	Calcium	Aluminium	
	Magnesium	Copper	
	Potassium	Iron	
	Sodium	Lead	
		Zinc	
		Macro-invertebrates	

Upper Onkaparinga Catchment Surfacewater monitoring - Quantity & Quality

- Towns
- Waste Water Treatment Plant
- Drainage
- Catchments
- Onkaparinga CWMB
- Onkaparinga River Subcatchments
- Prescribed Area
- Reservoirs
- Ambient Monitoring Sites

Monitoring Sites by Funding Agencies

- BOM
- DWLBC
- OCWMB
- SA Water
- EPA
- CLOSED

N

0 2.5 5 10 km

Produced by: Water Information Group
Knowledge and Information Division
Department of Water, Land and Biodiversity Conservation
Date: November 2005

GDA Geocentric Datum of Australia
MGA Zone 54 Transverse Mercator

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

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Figure 1

Lower Onkaparinga Catchment Surfacewater monitoring - Quantity & Quality

- Towns
- Waste Water Treatment Plant
- Drainage
- Catchments
- Onkaparinga CWMB
- Onkaparinga River Subcatchments
- Prescribed Area
- Reservoirs
- Ambient Monitoring Sites

Monitoring Sites by Funding Agencies

- BOM
- DWLBC
- OCWMB
- SA Water
- EPA
- CLOSED

N

0 2.5 5 10 km

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Figure 2

5.5.1 CONTINUOUS SALINITY MONITORING

Continuously recorded salinity monitoring is carried out by measuring salinity using temperature and EC sensors in the field. Most continuously recorded salinity monitoring is carried out by DWLBC, although OCWMB also conducts this kind of monitoring.

5.5.2 COMPOSITE WATER QUALITY MONITORING

Composite monitoring is carried out by extracting a set sample volume from the stream each time a predetermined volume of flow passes the sampling point. Each sample is placed in a single composite container and, at the end of the sampling period (between two and six weeks), the container is stirred and one representative sample removed for analysis. Loads are calculated by multiplying the average concentration of each parameter by the continuous flow record from that site. Most composite water quality monitoring is carried out by DWLBC, although OCWMB also conducts this kind of monitoring.

5.5.3 AMBIENT WATER QUALITY MONITORING

Ambient water quality monitoring aims to capture the overall quality of waterbodies by considering all possible impacts upon water quality, rather than just the effects of particular discharges as in the case of (say) point source monitoring.

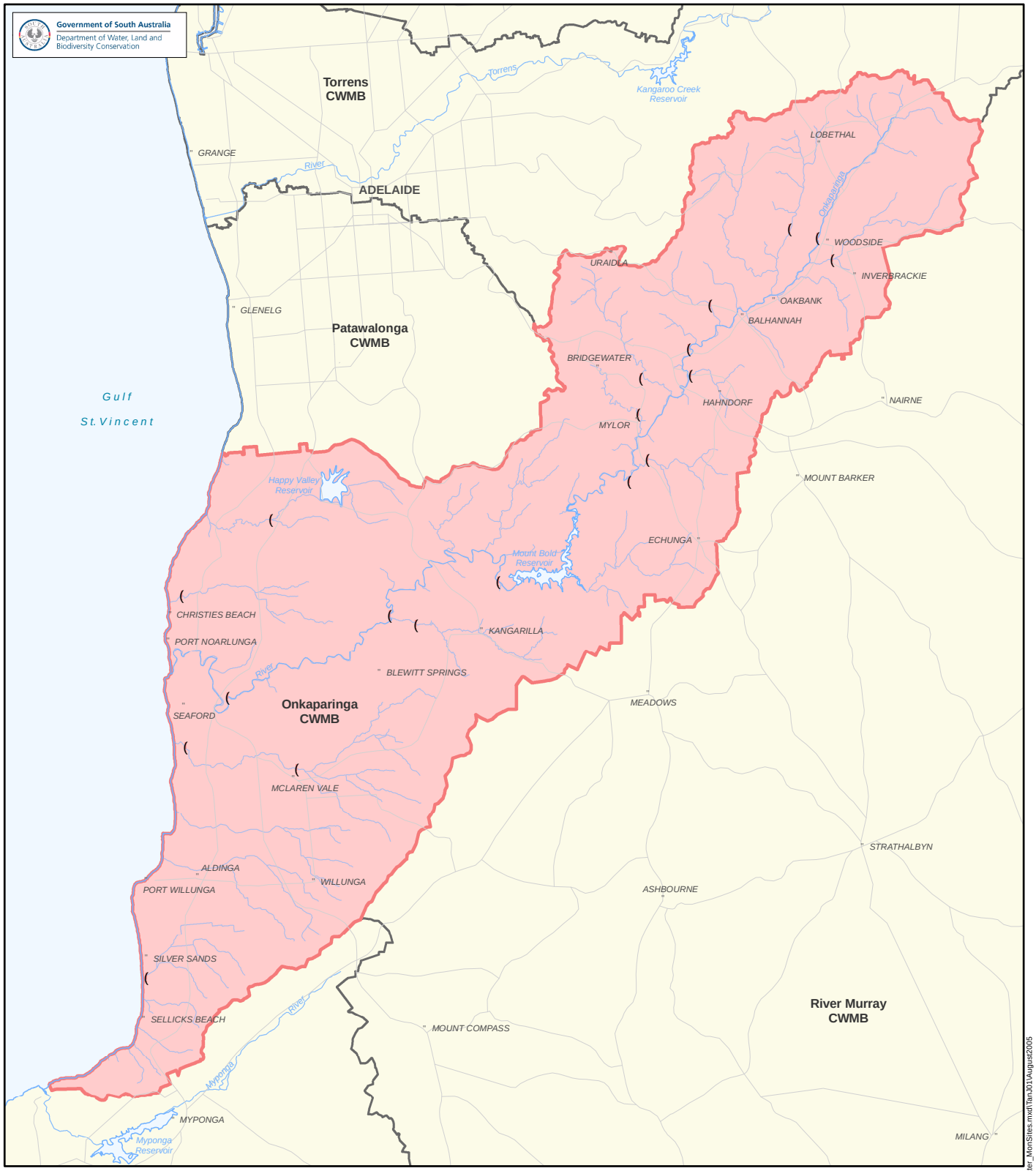
The EPA has an ambient water quality monitoring program whereby ‘grab sampling’ is carried out on a monthly basis when it is known that water is flowing. This provides a ‘snapshot in time’ of water quality, with the aim of studying spatial and temporal trends over the long term. It is open to more variability than composite monitoring (which works with the mean water quality) but would be able to determine sudden changes in water quality that coincide with sampling.

The OCWMB also has an ambient water quality monitoring program and carries out ‘grab sampling’. Both the EPA and OCWMB include macro-invertebrate sampling in their ambient water quality monitoring programs. Water analyses are undertaken monthly, with macro-invertebrates surveyed twice a year. Figure 3 shows the location of the ambient water monitoring sites in the Onkaparinga Catchment.

5.5.4 PHYSICAL–CHEMICAL WATER QUALITY MONITORING

The EPA, catchment boards and SA Water carry out full physical–chemical monitoring at selected sites (refer to section on Water Quality Monitoring for the catchment), but not all sub-catchments are monitored for such water quality parameters. Where it is not practical to carry out continuous composite sampling, it is recommended that all sub-catchments be monitored for ambient water quality.

It is generally accepted that regular measurements over a period of five years is required before statistically significant conclusions can be made about trends or changes in chemical water quality characteristics



Ambient Water Monitoring Sites
Onkaparinga Catchment Water Management Board Area

Towns

Ambient Water Monitoring Sites

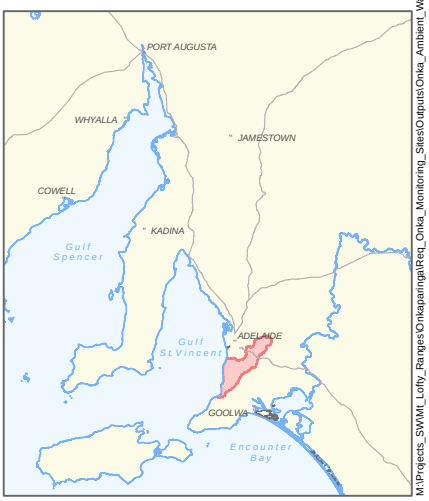
Roads

Drainage

Reservoirs

0 2.5 5 10 km

Produced by: Water Information Group
Knowledge and Information Division
Department of Water, Land and Biodiversity Conservation
Date: August 2005



GDA Geocentric Datum of Australia
MGA Zone 54 Transverse Mercator

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Figure 3

5.5.5 POINT SOURCE POLLUTION MONITORING

Point source pollution is usually related to urban development, for example septic tanks, manufacturing and mining activities. The EPA monitors discharges of pollutants by industry and organisations that are required to provide them with such information through a licence agreement. However, pollution by industry, not already monitored by the EPA because as individual industries they fall within the acceptable limits, needs to be addressed in terms of the cumulative effect of these industries on surface water and groundwater.

5.5.6 DIFFUSE SOURCE POLLUTION MONITORING

Diffuse pollution is either a result of widespread land-use practices or numerous small sources, and is usually associated with rural land-use activities. Diffuse pollution monitoring needs to be developed further as sources of diffuse pollution are not well understood.

Methods to estimate diffuse pollution (e.g. application of pesticides and herbicides) risks and loads are currently in a developmental stage. The most promising method uses detailed information on land management, but this information is not always available (a possible partnership could be established between DWLBC and PIRSA for such information collection). Used in combination with trace sampling, whereby pollutant types and loads are monitored at the 'bottom' of sub-catchments and then traced back to the source, may provide promising results.

5.5.7 PESTICIDES

The EPA has carried out targeted studies of pesticides in sediments of rivers, streams, estuaries and lakes. There is a need to expand monitoring programs for pesticide residues in watercourse sediments as they can be bioavailable and have adverse impacts on aquatic ecosystems.

5.5.8 COMPOSITE WATER QUALITY AND FLOW MONITORING

Composite monitoring is helpful in relation to aquatic ecosystems monitoring. Sub-catchments to currently feature flow and composite monitoring at the same location include Cock Creek (AW503507), Onkaparinga Main Channel (Mount Bold Reservoir) (AW503504), Cox Creek (AW503526), Aldgate Creek (AW503509), Scott Creek (AW503502) and Field River (AW503546, AW503547).

Flow and composite monitoring is also carried out at 'Onkaparinga River @ Houlgraves Weir' (AW503504) base station, which provides good water level and quality information in terms of water entering Mount Bold Reservoir, as well as monitoring outflow from a major yielding section of the Onkaparinga Catchment.

5.5.8.1 Changes in Funding Arrangements for Composite Monitoring

DWLBC has withdrawn funding for 'Lenswood Creek @ Lenswood' (AW503507 for rainfall, flow and composite), 'Cox Creek @ Uraidla' (AW503526 for flow and composite) and 'Aldgate Creek @ Aldgate Railway Station' (AW503509 for rainfall, flow and composite). SA

Water, EPA WPO and OCWMB will equally share the cost of monitoring flow and composite water quality at AW503507 and AW503526 into the future. SA Water and EPA WPO will equally share the cost of flow and composite monitoring at 'Aldgate Creek @ Aldgate Station' (AW503509).

5.5.9 WATER TREATMENT PLANTS

Continuous salinity monitoring is carried out in the Hahndorf sub-catchment for Hahndorf Creek downstream of the Hahndorf Sewage Treatment Works (AW503537).

5.5.10 WATER TREATMENT PLANTS

It appears that Heathfield, Christies Beach and Aldinga–Willunga WWTPs are not being monitored for water quality impacts on surrounding waterways. It is suggested that full physical–chemical monitoring be undertaken where they may impact on nearby waterbodies.

5.5.11 AMBIENT AND MACRO-INVERTEBRATE MONITORING

Most of the water quality monitoring throughout the Onkaparinga Catchment is carried out by OCWMB (see App. H).

5.5.12 ONKAPARINGA ESTUARY

The OCWMB carries out regular monitoring programs for the Onkaparinga Estuary.

5.6 GAPS AND OVERLAPS IN MONITORING

5.6.1 SURFACE WATER QUANTITY

5.6.1.1 Meteorological Monitoring:

There are no rainfall gauging stations in the following sub-catchments:

- Upper Onkaparinga Sub-area
- Mitchell Creek
- Biggs Flat
- Lower Onkaparinga Sub-area
- Angel Gully
- Clarendon Weir
- Noarlunga Embayment Sub-area
- Waterfall Creek
- Willunga Sub-area
- Maslins.

5.6.1.2 Sub-catchment Stream Flow

There are sites for which dates of the most recent gaugings for flow ratings are not on the HYDSTRA database and these are OCWMB-funded sites. In many cases, stations that are not funded or managed by DWLBC do not have information about gaugings on HYDSTRA.

The following sub-catchments are not currently being monitored for stream flow:

- Upper Onkaparinga Sub-area
- Mitchell Creek
- Balhannah
- Biggs Flat
- Lower Onkaparinga Sub-area
- Angel Gully
- Onkaparinga Main Channel (Lower Onkaparinga)
- Noarlunga Embayment Sub-area
- Waterfall Creek
- Christie Creek
- Willunga Sub-area
- Maslins
- Willunga
- Aldinga South
- Sellicks.

In terms of relative priority of monitoring, it is advisable that the following priorities be assigned to these gaps in monitoring:

- *Upper Onkaparinga Sub-area:* **Low priority.** A well-calibrated model has been constructed for this area, and many sub-catchment gauges in nearby catchments are available to assist in the assessment of these catchments.
- *Lower Onkaparinga Sub-area:* **Low priority.** Water use is low, and Scott Creek with Clarendon Weir can be used to assess water from Angels Gully.
- *Noarlunga Embayment Sub-area:* **Medium priority.** Little assessment of water resource has been done, but no significant risk to the water resources have been identified.
- *Willunga sub-area:* **High priority.** The level of surface–groundwater interactions are high, and need to be better understood. No monitoring has been done in this area except for Pedler Creek. Some monitoring of one or more other catchments further south (Aldinga Creek is recommended, as the Washpool Wetland is an area of ecological priority in this catchment) would provide useful information.

5.6.1.3 Recreational Uses of Water

Recreational uses of water include activities such as swimming and fishing in dams and rivers as well as other water sports. No data are collected for recreational use of water resources in any of the WMLR catchments.

Relative to the catchment use as a whole, this water use will be very small. It is therefore recommended that efforts be directed firstly at monitoring the water supply infrastructure and commercial water users ahead of focusing on commercial water use.

5.6.2 SURFACE WATER QUALITY

5.6.2.1 Salinity Monitoring

Most salinity monitoring has been occurring as part of the OCWMB's ambient water quality grab sampling monitoring program. This is not a continuous monitoring of salinity and such monitoring has been performed by DWLBC as part of its composite water quality monitoring program. There has also been considerable salinity monitoring carried out as part of the ad hoc monitoring programs.

Funding for DWLBC's composite monitoring sites is to be withdrawn and negotiations for future funding by other agencies have been carried out. It is suggested that a review of continuous salinity monitoring be carried out for the entire catchment to identify those sub-catchments that are currently or potentially affected by salinity problems and would thus require continuous salinity monitoring.

The EPA and OCWMB would be the primary agencies involved in salinity monitoring, with interest from SA Water and DWLBC.

5.6.2.2 Overlaps in Water Quality Monitoring

Within the Onkaparinga Main Channel (Mount Bold Reservoir) sub-catchment at 'Onkaparinga River @ Mount Bold Reservoir' (AW503501), it appears that both the EPA and SA Water are carrying out ambient monitoring. Some rationalisation may be appropriate for this site.

5.6.2.3 Ambient and Macro-invertebrate Monitoring

Listed below are some areas where no water quality monitoring is occurring at all:

- Mitchell Creek
- Balhannah
- Angel Gully
- Waterfall Creek.

5.7 RECOMMENDATIONS FOR SURFACE WATER MONITORING

5.7.1 RECOMMENDATIONS FOR SURFACE WATER QUANTITY MONITORING

It is suggested that consideration be given to monitoring sub-catchments representative of various catchment characteristics within the Onkaparinga Catchment for determining water balances. (Surface water and groundwater interactions would need to be included in water

balance calculations and there is a significant gap in the understanding of how these processes work.) Consideration should include water requirements of aquatic ecosystems and other features such as particular hydrological characteristics, vegetation cover and land-use practices of sub-catchments.

Ideally, all sub-catchments with a unique set of these characteristics should have monitoring of water balance components carried out at appropriate sites. They can then be used in water balance calculations for other sub-catchments with similar characteristics within the catchment. If it is not practical to establish monitoring stations for all representative sub-catchments then representative sites outside the catchment can be used in water balance calculations.

A hydrological model for the Onkaparinga Catchment has been calibrated by Kim Teoh in his report titled 'Estimating the impact of current dam development on the surface water resources of the Onkaparinga River Catchment' (Teoh 2002).

5.7.1.1 Base Stations

It is suggested that the following three stations and supporting stations remain open:

- Onkaparinga River @ U/S Hahndorf Dissipator (A5031001), with supporting data from:
  - Hahndorf Creek @ downstream Hahndorf WWTP (AW503537).
- Onkaparinga River @ Houlgraves Weir (AW503504), with supporting data from:
  - Onkaparinga River @ U/S Hahndorf Dissipator (A5031001)
  - time series of flows discharged at Hahndorf Dissipator (monitored by SA Water).
- Onkaparinga River @ Clarendon Weir (AW503500), with supporting data from:
  - time series of releases from Mount Bold Reservoir to Clarendon Weir (needs to be monitored by SA Water)
  - time series of transfers to Happy Valley Reservoir measured at Horndale Flume (AW503519)
  - higher sensitivities of low flows over Clarendon Weir (to be determined).

5.7.1.2 River Murray Transfers

It is suggested that site A5031002 be created and maintained, and that the data be provided to the DWLBC State Water Archive. It is recognised by DWLBC that there may be commercial sensitivities associated with these data and, as such, its public availability will need to be negotiated with SA Water.

5.7.1.3 Meteorological Monitoring

Two BoM stations previously operated in the Maslins sub-catchment — 'McLaren Vale Section 171 BoM Met Station' (M023840) and 'Aldinga (Hildas Dale) BoM Met Station' (M023790). M023840 operated from April 1973 until October 1994; M023790 opened in May 1905 and closed in December 1911. If the landscape characteristics within this sub-catchment differ significantly enough to warrant rainfall measurements, then it is suggested that one of these closed rainfall gauging stations be re-opened, or at least the data from site M023840 be used in water balance modelling if appropriate.

Pan evaporation measurements are taking place in the Onkaparinga Main Channel (Mount Bold Reservoir) sub-catchment. BoM is estimating pan evaporation losses daily at 'Mount

Bold Reservoir BoM Met Station' (M023734). It appears that this is also being done at SA Water site 'Mount Bold Reservoir Meteorological Station' (AW503536), and a possible duplication at this location could be reviewed. Pan evaporation is also being monitored in the Field River sub-catchment at 'Happy Valley Reservoir @ Pluviometer' (AW503532). These are the only locations at which evaporation is being monitored for the entire catchment. Investigation into the expansion of evaporation monitoring is justified.

Climate change investigation is taking place at 'Scott Creek @ Scott Bottom' (AW503502), a site which is considered to be a benchmark station for monitoring the impact of climate variability and change.

5.7.1.4 Sub-catchment Stream Flow

It is advisable that most of the flow ratings in Table 6 are updated so that they reflect current flow regimes. Some gaugings have not been updated for a considerable time.

Table 6. Flow ratings for sub-catchments in the Onkaparinga catchment.

Sub-catchment	Site number	Site name	Latest rating
Upper Onkaparinga sub-area			
Cock Creek	AW503507	Lenswood Creek @ Lenswood	1987
Onkaparinga Main Channel (Mount Bold Reservoir)	AW503529	Burnt Out Creek @ U/S Mount Bold Reservoir	1980
Cox Creek	AW503526	Cox Creek @ Uraidla	1988
	AW503525	Sutton Creek @ Piccadilly Valley	1987
Lower Onkaparinga sub-area			
Kangarilla	AW503503	Baker Gully @ 4.5 km WNW of Kangarilla	1986

DWLBC site 'Onkaparinga River @ Noarlunga' (AW503522), located in the Onkaparinga Main Channel (Lower Onkaparinga) sub-catchment, was monitoring flow from 1973–88. It is advisable that this site be re-opened (see section 5.2) and that the flow rating be updated as the latest rating was carried out in 1983.

In addition, it is recommended that an expansion of stream-flow monitoring be considered for the sub-catchments listed in Table 6. Table 7 shows where the gaps in monitoring are occurring.

5.7.2 SUGGESTIONS FOR SURFACE WATER QUALITY MONITORING

5.7.2.1 Waste Water Treatment Plants (WWTP)

It is suggested that potential pathogen and nutrient levels associated with the Hahndorf WWTP need to be monitored at this site. This may be achieved via the EPA setting appropriate monitoring conditions on the discharge licence, if they have not already done so.

Table 7. Summary of Gaps for System Inflow–Outflow Monitoring

Location	Gaps in monitoring	Suggested monitoring
River Murray transfers	Flow into the Onkaparinga River	Flow and water quality be measured at a proposed SA Water site 'Murray Bridge – Onkaparinga Pipeline @ Outlet to Onkaparinga River' (A5031002).
	Discharge from Hahndorf Dissipator	SA Water to measure flow and water quality
Mount Bold Reservoir	Spill from the reservoir	SA Water site 'Onkaparinga River @ Mount Bold Reservoir' (AW503501) warrants a flow rating across all ranges of flow to monitor spills from the reservoir.
	Outflows from the reservoir	SA Water to monitor controlled releases from the reservoir to Clarendon Weir.
		Re-open DWLBC site 'Onkaparinga @ D/S Mount Bold Reservoir' (503528); this was last operated 15 years ago for levels with a rating for flows. Update the rating as this was last done in 1983.
Clarendon Weir	Inflows to the weir	DWLBC – SA Water to establish a monitoring station to measure flows and water quality upstream of the weir. This could be achieved by a new site, or by re-instrumenting AW503528, as described above.
	Outflows from the weir	DWLBC – SA Water are establishing a monitoring station to measure flows and water quality downstream of the weir
	Spills from the weir	SA Water site 'Onkaparinga River @ Clarendon Weir' (AW503500) warrants a flow rating and an accuracy assessment of its ranges of flow.
	Transfers to Happy Valley Reservoir	SA Water to establish a monitoring station to measure flows and water quality for water transfers. 'Happy Valley Reservoir intake channel @ Horndale Flume' (AW503519) may be able to satisfy this need.
	Evaporation losses	SA Water to include measurement of evaporation losses at 'Onkaparinga River @ Clarendon Weir' (AW503500).
Happy Valley Reservoir	Inflows to the reservoir	Re-open DWLBC site 'Happy Valley Reservoir intake channel @ Horndale Flume' (AW503519) that ceased monitoring water levels and flow in 1994. Update the flow rating as the latest was done in 1985.
	Within the reservoir	SA Water to do a flow rating at 'Happy Valley Reservoir @ Metro Telemetry' (AW503535) where it is currently measuring levels, and to measure spills if necessary.
	Transfers from the reservoir to Happy Valley Water Treatment Plant	SA Water to monitor flow and water quality of transfers to the treatment plant.
Myponga Reservoir	Transfers to Happy Valley Reservoir	SA Water to monitor flow and water quality.

5.7.2.2 Composite Water quality and Flow Monitoring

Composite water quality sampling was originally set up to examine pollutant generation from various land uses, and total pollutant loads entering Mount Bold Reservoir. It is one of the more costly forms of water quality monitoring available, both in establishment and operation. Establishment of new sites would require significant long-term (~10 year) commitment to implement and gain meaningful additional information.

Composite monitoring is helpful in relation to aquatic ecosystems monitoring and it is advisable that it be carried out at all stations currently monitoring water levels, and that a rating be done across all ranges of flow for flow monitoring (a necessary part of the composite sampling process).

Stream-flow monitoring is occurring in Charleston (BoM station AW503903), Western Branch (BoM station AW503906), Upper Onkaparinga (Spoehr; BoM station AW503902), Pedler Creek (OCWMB station AW503540), Inverbrackie Creek (DWLBC station AW503508), Hahndorf (DWLBC station AW503537) and Kangarilla (DWLBC station AW503503) sub-catchments. It is suggested that consideration be given to establishing composite water quality monitoring sites at the same locations. It is important that gaugings across all ranges of flow be carried out where possible.

Refer to Appendix F for surface water level and flow monitoring sites, and Appendix E for the complete list of all on-going monitoring sites for the Onkaparinga Catchment.

5.7.2.3 Ambient and Macro-invertebrate Monitoring

If stream-flow monitoring is established for any of the sub-catchments in Table 6, then it is suggested that water quality monitoring be carried out at the same locations for assessing aquatic ecosystem health. The EPA (2005) recommended that pesticide studies (hotspot and passive sampling) are of high importance. Water quality requirements of unique habitats and macro-invertebrate response to land-use pressures are also considered as important.

6. GROUNDWATER MONITORING

6.1 OVERVIEW OF CURRENT GROUNDWATER MONITORING

The McLaren Vale PWA is extensively monitored for water quality and quantity, but further refinement of this monitoring is required to allow for investigations into leakage between aquifers and to achieve greater accuracy in determining recharge rates.

Quaternary aquifer — only a small number of observation wells continually monitor water levels in this aquifer as there is little demand placed upon it for irrigation use. However, some expansion of the observation well network is suggested in areas where the water requirements of groundwater-dependent ecosystems need to be considered.

Port Willunga Formation — a large number of observation wells monitor this aquifer, which is widely developed for irrigation.

Maslin Sands aquifer — only a few observation wells monitor this aquifer in the southern and central parts of the PWA.

Fractured rock aquifers are complex, and more understanding of their hydrogeology, recharge rates and surface water – groundwater interactions is required. Pollution of aquifer recharge areas needs to be monitored more closely, particularly in the case of unconfined aquifers.

More comprehensive salinity monitoring of groundwater is advisable. Groundwater resources are vulnerable to contamination which could occur predominantly along preferential flow paths that provide little opportunity for attenuation of contaminants. Examples of sources of groundwater contamination are urban run-off, diffuse nutrients from fertiliser run-off, animal and industrial waste, pesticides from agricultural activities, as well as corroded bore casings and water transfer pipes. Groundwater residence times in shallow aquifers are often less than 50 years, which means that contaminants can move relatively quickly and in unpredictable directions from their source to points of groundwater discharge.

Because groundwater resources do not necessarily follow the catchment boundary, groundwater quality issues and surface–groundwater flow interactions also need to be considered beyond the catchment boundary. In essence, primary mechanisms of groundwater movement and recharge must be well understood.

DWLBC undertakes the majority of groundwater monitoring for levels and salinity. Water levels are read on a six-monthly basis in the Upper Onkaparinga Sub-area, and monthly in the McLaren Vale PWA. Salinity measurements are made on a yearly basis in the Upper Onkaparinga Sub-area, and monthly in the McLaren Vale PWA. DWLBC also carries out sampling for chemical analysis in the Adelaide Metropolitan areas every seven to eight years.

6.2 CURRENT GROUNDWATER QUANTITY MONITORING

6.2.1 GROUNDWATER LEVELS

In the McLaren Vale PWA, the Willunga Observation Well Network provides water level and salinity information. Figures 4 and 5 show the location of the current groundwater quantity monitoring sites for the Upper and Lower Onkaparinga Catchment.

6.2.2 SURFACE WATER – GROUNDWATER INTERACTIONS

The OCWMB has been carrying out a surface water – groundwater interaction study in Pedler Creek. However, these interactions need to be investigated for all aquifers throughout the Onkaparinga Catchment.

6.3 CURRENT GROUNDWATER QUALITY MONITORING

DWLBC has mainly focused on groundwater salinity monitoring although it is planning to expand its water quality monitoring parameters. Figures 6 and 7 show the location of the current groundwater quality monitoring sites for the Upper and Lower Onkaparinga Catchment.

6.3.1 GROUNDWATER SALINITY

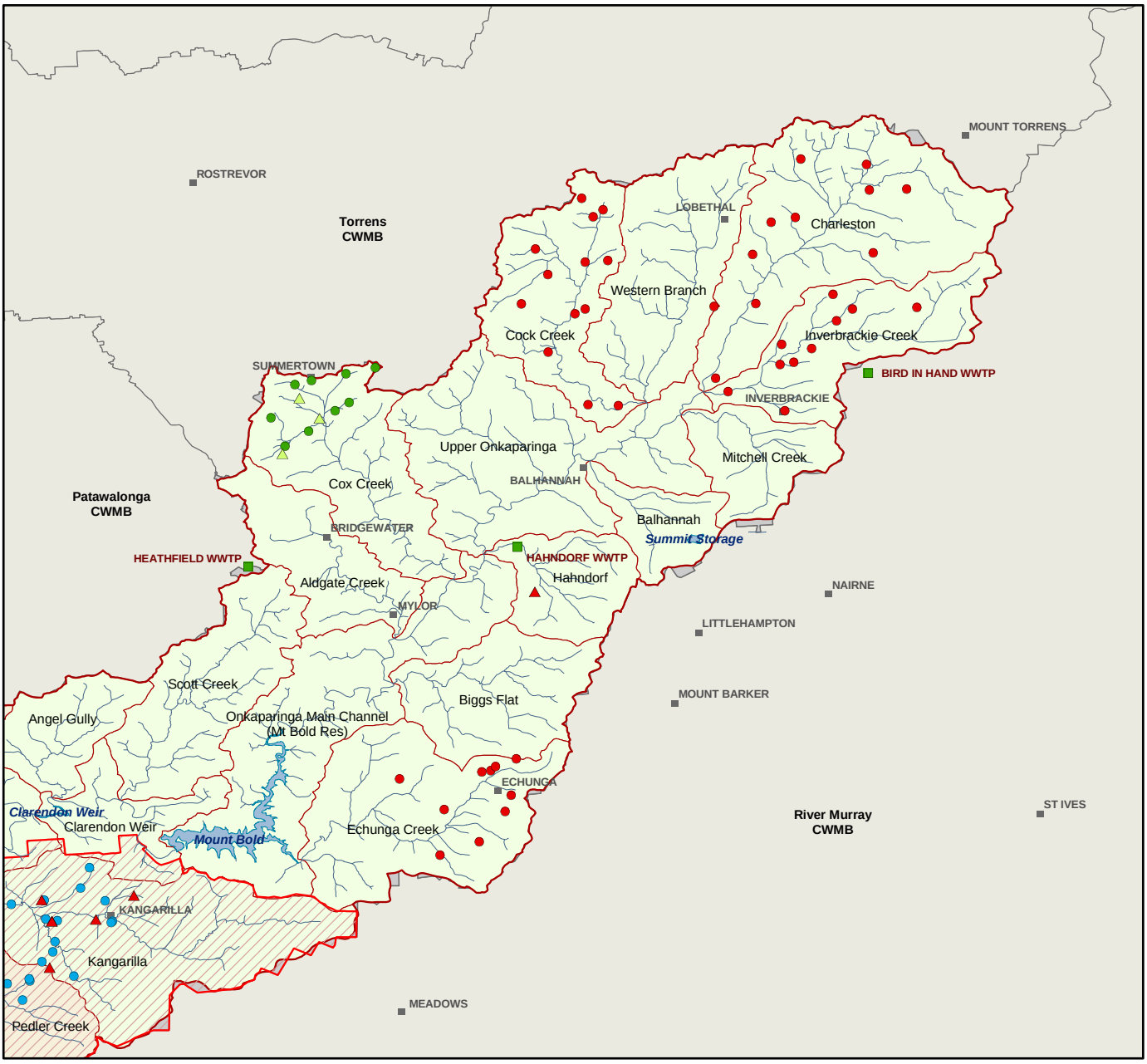
There is one groundwater salinity monitoring site in the Noarlunga Embayment Sub-area, in the Field River sub-catchment. However, Cox Creek, Cock Creek, Charleston, Inverbrackie Creek and Echunga Creek sub-catchments in the Upper Onkaparinga Sub-area have a reasonable coverage of groundwater salinity monitoring.

6.3.2 PESTICIDES

Pesticides have been detected at low concentrations in a small number of groundwater samples from the Piccadilly Valley and Upper Onkaparinga sub-catchments. It is advisable that these areas, as well other sub-catchments within which pesticides are applied (e.g. to horticultural crops), be monitored for pesticides into the future as they may become areas for concern.

6.3.3 SHALLOW GROUNDWATER MONITORING

OCWMB established a partnership with DWLBC to design an ongoing program to monitor water quality within the shallow groundwater system throughout the catchment. The first stage of this program was to identify areas where these shallow aquifers are potentially threatened by point-source pollution and to establish an on-going monitoring program in groundwater quality.



Upper Onkaparinga Catchment Groundwater monitoring - Quantity

- Towns
- Waste Water Treatment Plant
- Drainage
- Catchments
- Onkaparinga CWMB
- Onkaparinga River Subcatchments
- Prescribed Area
- Reservoirs

- Piccadilly Valley Group - Current
- Upper Onkaparinga Group - Current
- Willunga Group - Current
- Onkaparinga Valley - Historical
- Piccadilly Valley Group - Historical

N

0 2.5 5 10 km

Produced by: Water Information Group
Knowledge and Information Division
Department of Water, Land and Biodiversity Conservation
Date: November 2005

GDA Geocentric Datum of Australia
MGA Zone 54 Transverse Mercator

Government of South Australia
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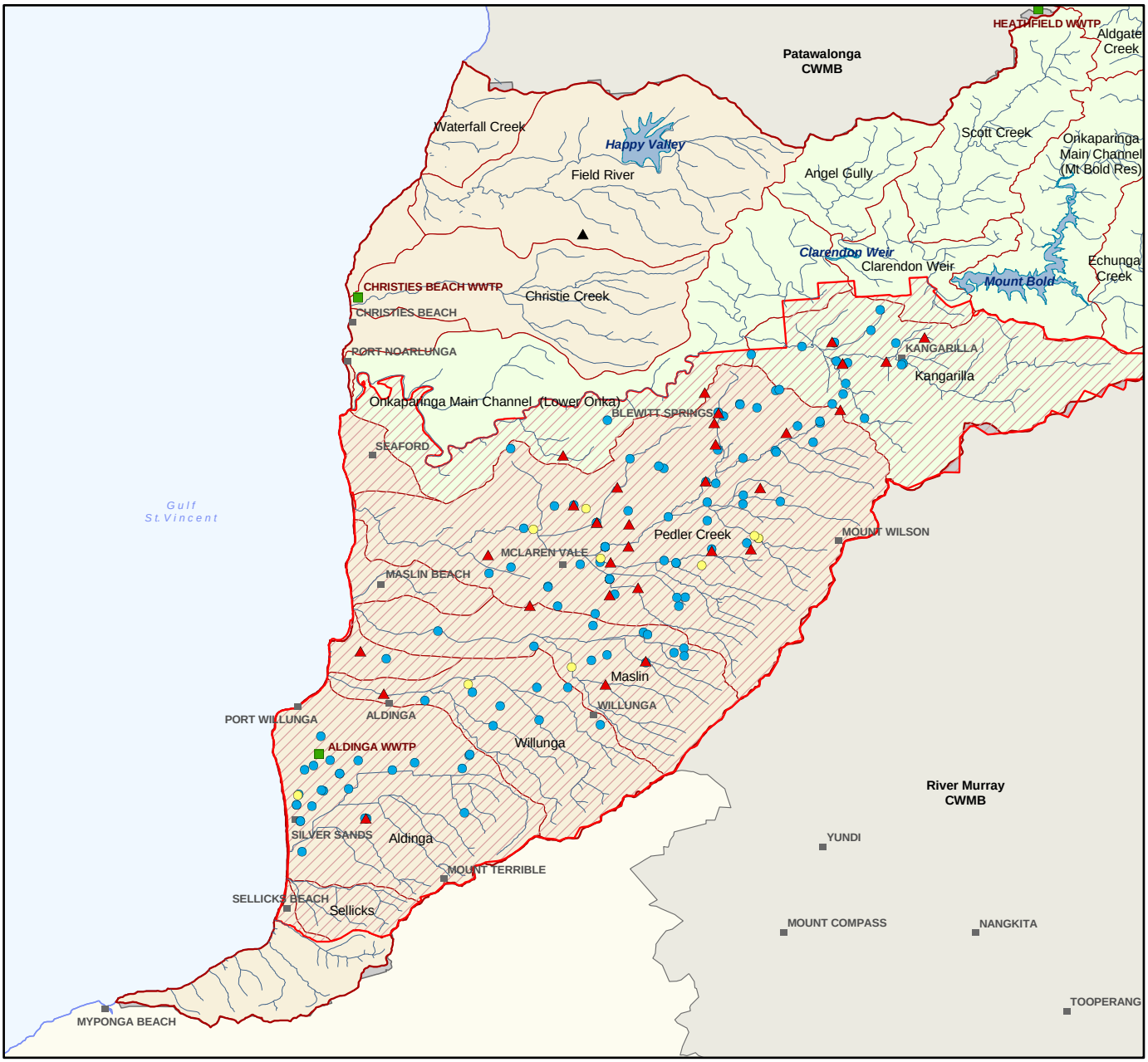
Figure 4



Lower Onkaparinga Catchment Groundwater monitoring - Quantity

- Towns
- Waste Water Treatment Plant
- Drainage
- Catchments
- Onkaparinga CWMB
- Onkaparinga River Subcatchments
- Prescribed Area
- Reservoirs

- ASR Sites
- Willunga Group - Current
- Metro. Adelaide - Historical
- Onkaparinga Valley - Historical

N

0 2.5 5 10 km

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MGA Zone 54 Transverse Mercator

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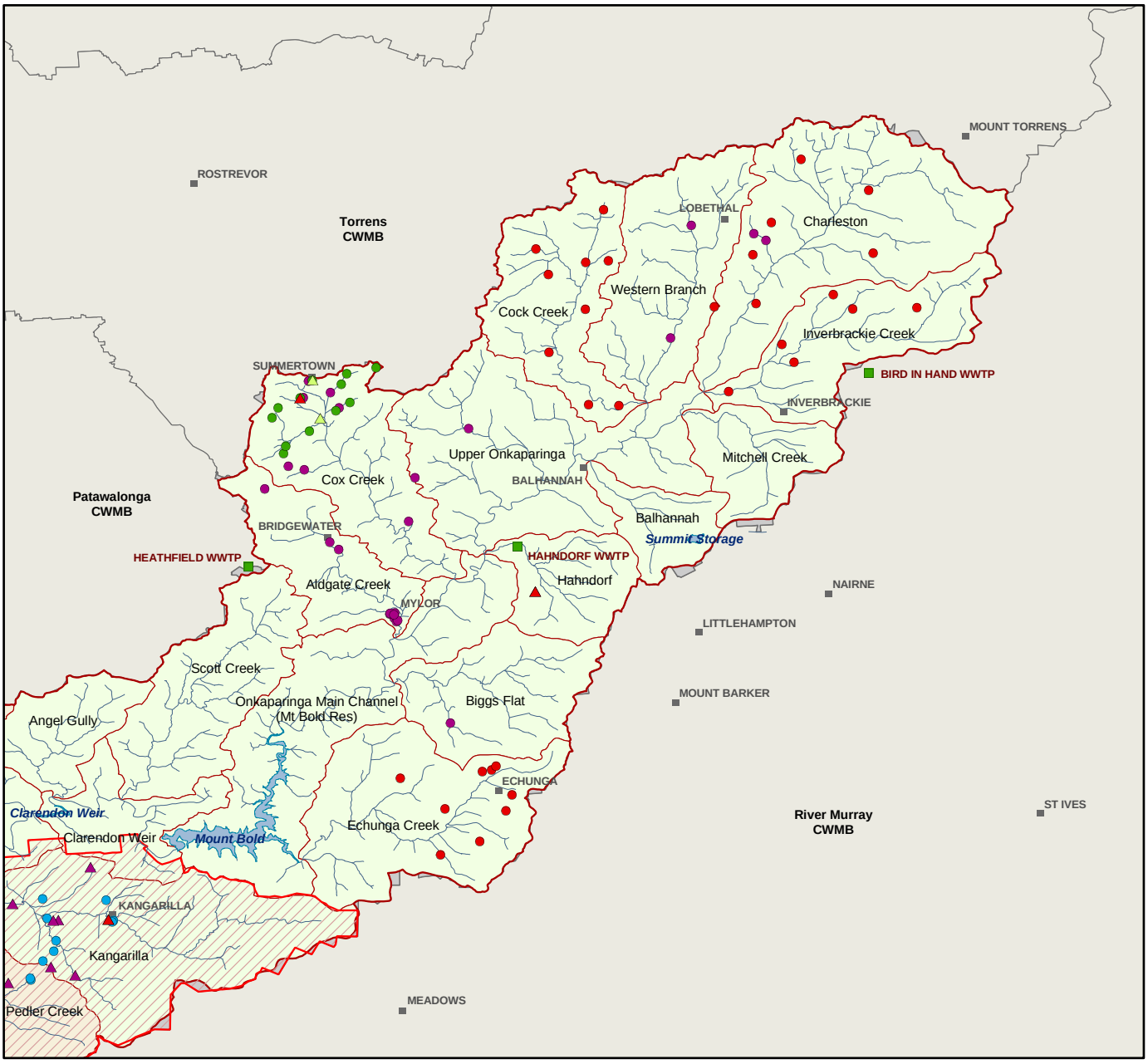
Figure 5



Upper Onkaparinga Catchment Groundwater monitoring - Quality

- Towns
- Waste Water Treatment Plant
- Drainage
- Catchments
- Onkaparinga CWMB
- Onkaparinga River Subcatchments
- Prescribed Area
- Reservoirs

- Onkaparinga Group - Current
- Piccadilly Valley Group - Current
- Upper Onkaparinga Group - Current
- Willunga Group - Current
- Onkaparinga Valley - Historical
- Piccadilly Valley Group - Historical
- Willunga Group - Historical

N

0 2.5 5 10 km

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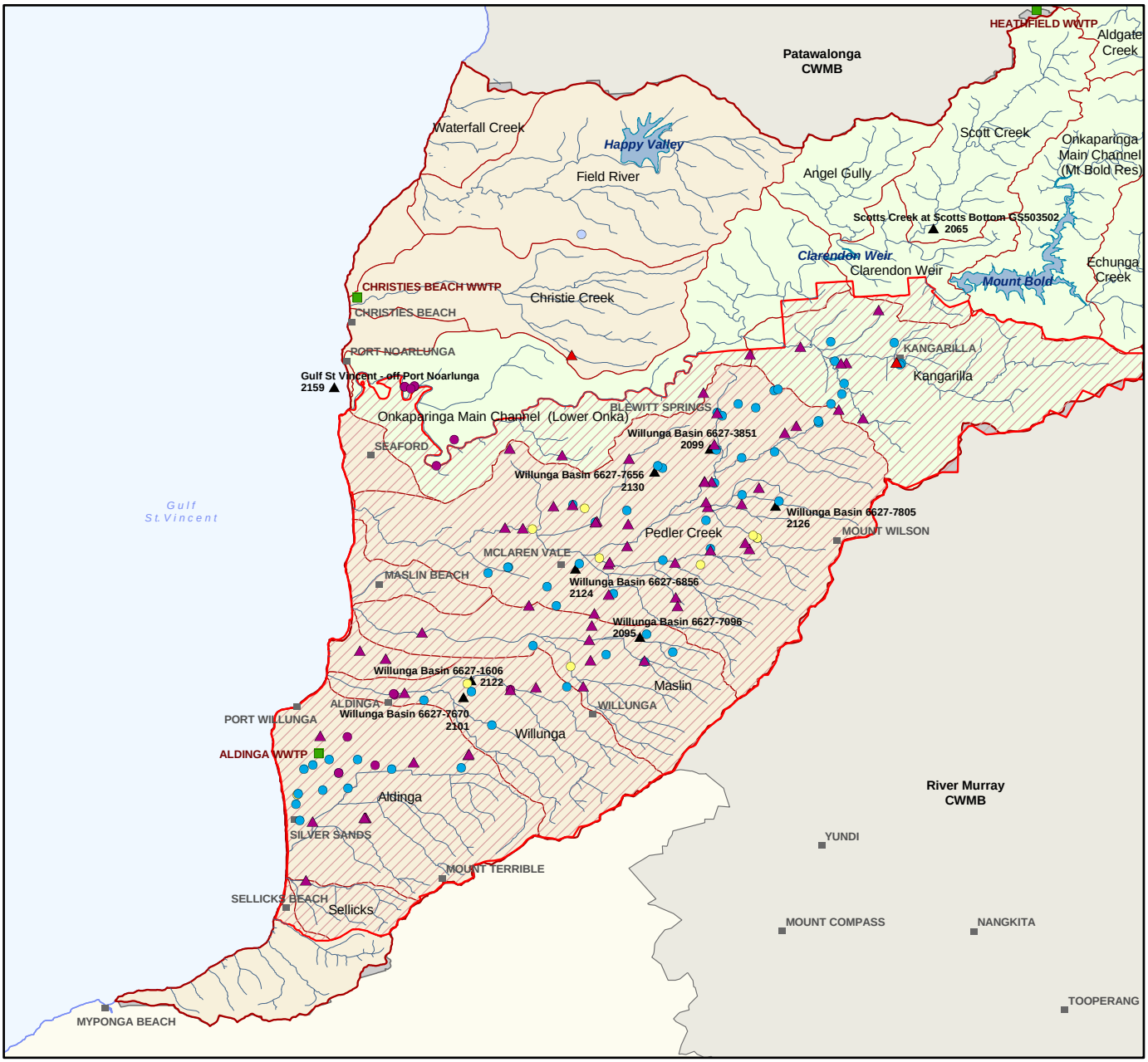
Figure 6



Lower Onkaparinga Catchment Groundwater monitoring - Quality

- Towns
- Waste Water Treatment Plant
- Drainage
- Catchments
- Onkaparinga CWMB
- Onkaparinga River Subcatchments
- Prescribed Area
- Reservoirs
- ASR Sites
- EPA Sites
- Onkaparinga Group - Current
- Willunga Group - Current
- Onkaparinga Valley - Historical
- Willunga Group - Historical

N

0 2.5 5 10 km

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Figure 7

The shallow Quaternary aquifer is potentially subject to direct pollution from land-use activities. Land use, including unsewered residential areas, abattoirs, waste depots and wineries within the board's area, were selected as possible point-source pollution threats. Using well depth and aquifer type as selection criteria, existing shallow boreholes located down gradient of areas considered to be at risk were identified as potential sample points. Sampling occurred during 5–20 March 2001, and analyte suites were tailored to measure contaminants expected from the targeted land uses (refer Table 8; Clarke 2001). Although diffuse pollution may also have an impact on the shallow aquifer, the focus of this program was point-source pollution.

Table 8. Analyte suites of each potential pollution source (from Clarke 2001).

Wineries	Effluent and sludge ponds, unsewered area, chicken sheds and abattoirs	Forests
Total phosphorus	Total phosphorus	Total phosphorus
Nitrate	Nitrate	Nitrate
Nitrite	Nitrite	
Ammonia	Ammonia	
Total dissolved solids (TDS)	TDS	TDS
Electrical conductivity (EC)	Electrical conductivity	
Heterotrophic iron bacteria (FeB)	FeB	
Total organic carbon (TOC)	TOC	
Sulphate		
Potassium		
	FS includes enterococci count	
	FC includes *E. coli* count	
		Organo-phosphate and triazine pesticides. Hexazionone, Atrazine, Simazine.

6.4 GAPS AND OVERLAPS IN MONITORING

6.4.1 GROUNDWATER LEVELS

Apart from within the PWA, groundwater levels are not monitored for most of the Onkaparinga Catchment, except in Cox, Cock, Charleston, Inverbrackie and Echunga Creek sub-catchments.

6.4.2 WATER USE

Water use is not monitored outside the McLaren Vale PWA although, through the prescription process in the WMLR, all irrigation and industrial bores will eventually be metered.

6.4.3 GROUNDWATER SALINITY

Apart from Cox Creek, Cock Creek, Charleston, Inverbrackie Creek and Echunga Creek sub-catchments in the Upper Onkaparinga Sub-area, other areas are either not monitored or have minimal coverage.

6.5 FUTURE DIRECTIONS FOR GROUNDWATER MONITORING

6.5.1 SUGGESTIONS FOR GROUNDWATER QUANTITY MONITORING

6.5.1.1 Groundwater Levels

It is suggested that groundwater levels be monitored for the Noarlunga Embayment Sub-area and expanded in the Upper Onkaparinga Sub-area. This is the responsibility of DWLBC, which is in the early planning stages of expanding the groundwater levels monitoring network for the Upper Onkaparinga Sub-area.

6.5.1.2 Water Use

Through the prescription process in the WMLR, all irrigation and industrial bores will eventually be metered. The water use surveys carried out on irrigation properties will enable preliminary estimates of groundwater extraction to be made. It is suggested that water use in relation to the various land-use practices be monitored by DWLBC in partnership with PIRSA for the remainder of the catchment outside the PWA, especially in the Upper Onkaparinga Sub-area.

6.5.1.3 Surface Water – Groundwater Interactions

It is advisable that surface water – groundwater interactions be investigated for all aquifers throughout the catchment.

Rainfall gauging stations located near recharge areas, used in conjunction with groundwater levels, quality and extraction rates, would provide a realistic idea of changes in water levels as well as dilution effects on pollutants. For example, ‘Willunga BoM Meteorological Station’ (M023753), ‘Clarendon Post Office BoM Meteorological Station’ (M023710) and ‘Mount Bold Reservoir BoM Meteorological Station’ (M023734) are located near recharge points.

6.5.2 SUGGESTIONS FOR GROUNDWATER QUALITY MONITORING

6.5.2.1 Groundwater Salinity

It is suggested that an expansion of groundwater salinity monitoring occur in all areas outside the PWA. This is the responsibility of DWLBC which is in the early planning stages of expanding the groundwater salinity monitoring network for the Upper Onkaparinga Sub-area.

6.5.2.2 Shallow Groundwater Monitoring

Clarke (2001) made the following recommendations for on-going groundwater monitoring (Table 9).

Table 9. Sample points to retain for the ongoing monitoring program of the shallow aquifer system in the OCWMB area (Clarke 2001).

Potential risk land-use activity or area	Well Unit Number	Comments
Aldinga effluent pond	6527-1023	
Aldinga unsewered	6527 6527 6527 6527	It is advisable that all wells showing a positive Faecal Indicator Bacteria (FIB) result be included in the ongoing monitoring program. Resampling of 6527-1183 is suggested to establish an FC count..
McLaren Vales wineries	No wells	No contamination apart from iron bacteria was revealed.
Old Noarlunga abattoir	6627-10 034	
Old Noarlunga unsewered	6527-1350	
Onkaparinga estuary sludge ponds	6527-1364 6527-1365 6527-1366 6527-1363 6527-1367	High-level FIB contamination. It is advisable that this area be included in the ongoing monitoring program.
Willunga effluent pond	6627-8935	
Bridgewater chicken sheds	6628-13802	Investigate waste source — it may be human.
Echunga effluent pond	6627-6395	Include another sample point up gradient.
Lobethal abattoir	6628-10 476 6628-10 489	Although well 6628-10 489 shows no contamination, continued sampling is advisable because it is down gradient to 6628-10 476.
Mylor unsewered	6627-2803 6627-2806 6627-6016 6627-7212 6627-7302 6627-7356 6627-2807	It is advisable that all the wells in the township continue to be sampled.

Potential risk land-use activity or area	Well Unit Number	Comments
Piccadilly	6628-6583 6628-6742 6628-6776	The level of contamination has decreased in these wells since the 1994 sampling; it is advisable that these wells be included in the ongoing program.
Piccadilly wineries	No wells	No contamination apart from a low count of iron bacteria was revealed.
Southern Mount Lofty	6628-10285 6628-10626 6628-15950	The level of contamination of these wells has decreased; only three wells now show positive results. It is advisable that these wells be included in the ongoing program.
Stirling unsewered	6627-2482 6627-6097 6628-6677 6627-8170 6628-11171	It is suggested that all wells showing a positive FIB result be included in the ongoing monitoring program.
Summertown unsewered	6628-6755 6628-6862	It is suggested that all wells showing a positive FIB result be included in the ongoing monitoring program. Investigate origin of FIB contamination in well 6628-6862.

Clarke (2001) also recommended that groundwater sampling points be established down hydraulic gradient of all intensive livestock land-use activities within the catchment.

It is also advisable that petrol retail outlets, with underground petrol storage tanks that are defective or older than 20 years, have sampling points established within 100 m down hydraulic gradient and be included in the ongoing sampling program.

It is also suggested that areas where mines are active (or no longer active but have not been properly rehabilitated) be identified, and sampling points be established down hydraulic gradient and included in the ongoing monitoring program.

The inclusion of chloride in future sampling for potassium and sulphate will provide information on the sources of these ions.

6.5.2.3 Fertilisers

Indications of nitrogenous fertilisers have been found in groundwater in the Upper Onkaparinga Sub-area. It is advisable that groundwater be monitored for fertilisers in the sub-catchments shown in Table 10 within which orchards occur.

Table 10. Sub-catchments in which orchards occur.

Sub-area	Sub-catchment	Sub-area	Sub-catchment
Upper Onkaparinga	Charleston	Willunga	Pedler Creek
	Western Branch		Willunga
	Cock Creek		Aldinga South
	Cox Creek		Sellicks
Noarlunga Embayment	Christie Creek		

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 AQUATIC ECOSYSTEM MONITORING SUGGESTIONS

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 11 offers a number of characteristic definitions, their purpose and their source.

Table 11. 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. CATCHMENT CHARACTERISTICS

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 12.

Table 12. 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
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

What	Who	Why
	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
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 stream flow from the major yielding section/s of the catchment, basin or region.	Water level and stream flow; 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.	Stream flow from areas with particular hydrological characteristics arising from distinct features for example, vegetation types or land-use practices.	Water level and stream flow; 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–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 and compliance monitoring	Monitoring to evaluate the impact of regulation or development, often as part of compliance with water management plans, statutory reporting, auditing or law.	System inflow–outflow.	Relates to stream flow 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 and stream flow; salinity (EC and temperature). May be subject to other parameters specified in management plan.	For duration of the development or as per the relevant management requirements (years, decades?).	Continuous.	High, subject to resource management requirements.
		Basin outflow station.	Stream flow 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 and stream flow; 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

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
	Effluent.	Additional water supplies.	SA Water	EPA, NRMB, Local Councils, DWLBC	DEH

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

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

Onkaparinga Catchment Water Management Board — Key Issues and Actions considered Relevant to this Review (from Table 4.1 in OCWMB Plan)

4.1 Rehabilitation and Management of Watercourses

	Key issue	Current condition and trend	Action	Responsibilities and partnership	Actual outcome (2000–05)
4.1.2	Inadequate environmental flows due to dams, reservoirs, pumping, other diversions and obstructions.	Catchment flows have been modified. Water dependent ecosystems have been altered.	Where appropriate, re-activate dormant flow gauging stations. Expand network of stations to cover all sub-catchments.	OCWMB (lead agency), DWLBC, EPA, SA Water	Detailed flow records for all sub-catchments.
			Expand network of macro-invertebrate sites.	OCWMB (lead agency)	Representative macro-invertebrate data for all sub-catchments.
4.1.3	Low riparian biodiversity due to altered watercourse flow regime, pollution impact.	Degraded to varying degrees.	In conjunction with principles from the State Water Plan, negotiate with SA Water on environmental water requirements in areas of the Onkaparinga River affected by SA Water activities.	OCWMB, SA Water (lead agency)	Improved environmental water flow regime.
			Undertake further investigation of trends in reduction of biodiversity demonstrated by own data at sites associated with River Murray water.	OCWMB (lead agency), SA Water	Clarification regarding effects of River Murray water on biodiversity.

4.2 Maintenance and Enhancement of the Quality of Surface and Groundwater

	Key issue	Current condition and trend	Action	Responsibilities and partnership	Actual outcome (2000–05)
4.2.1	High suspended solids, nutrients, parasites, pesticides and faecal contamination of watercourses from inappropriate rural land management practices.	Lack of native vegetation and ground cover in riparian zone. Stock generally have open access to streams.	Continue program of watercourse management action plans and encourage matching land capability to land use via property management plans.	OCWMB (lead agency)	Reduced erosion, sedimentation and pollution.
4.2.4	Potential pollution under flood conditions from Hahndorf WWTP.	High flows in Hahndorf Creek under flood conditions can wash sludge into creek.	Undertake investigation into opportunity to increase flood protection at Hahndorf WWTP.	OCWMB, SA Water (lead agency)	Reduced pollution potential in Hahndorf Creek under flood conditions.
4.2.5	Discharge of treated wastewater from Hahndorf WWTP into Hahndorf Creek.	Reduced levels of N and P were implemented in 1994, but still additional nutrient input into watercourse.	Investigate with SA Water potential reduction in wastewater input into Hahndorf Creek.	OCWMB (lead agency), SA Water (lead agency), EPA (lead agency)	Decreased nutrient levels in Hahndorf Creek.
4.2.6	Inadequate data to evaluate Board programs and monitor effects.	Ambient monitoring programs of surface waters is underway.	Continue Board's existing ambient monitoring program and expand monitoring to cover gaps in existing program.	OCWMB (lead agency), Community Groups, Waterwatch (lead agency)	New gauging stations with automatic water sampling at additional sites.
			Finalise and implement a groundwater quality and quantity monitoring program.	DWLBC (lead agency), OCWMB	
			Collect baseline information linking farm dam data with land use, land capability run-off and environmental flow data (when available).	OCWMB (lead agency), PIRSA (lead agency)	
			In conjunction with EPA, establish monitoring programs for pesticide residues in watercourse sediments and water in areas of high hazard.	OCWMB (lead agency), SA Water (lead agency), EPA (lead agency), DWLBC	

4.3 Sustainable Use of Water

	Key issue	Current condition and trend	Action	Responsibilities and partnership	Actual outcome (2000–05)
4.3.3	Lack of knowledge regarding the groundwater resources of the Upper Onkaparinga rural catchment.	A study has been undertaken of the Piccadilly region only. No information on how much water is available, or being extracted in non-prescribed areas.	Progressively survey the location, quality and quantity of the groundwater resources and determine sustainable yield. Utilise the information to investigate surface–groundwater interactions (long term) with a view to ultimately determining a water allocation system for the area.	DWLBC (lead agency), OCWMB DWLBC, OCWMB, PIRSA	Bores. Monitoring in place. Determination of the sustainable yield.
4.3.4	Impact of dams on surface water flows in the McLaren Vale Prescribed Wells Area and the Mt Lofty Ranges Watershed.	Number and density of dams has an impact on availability of surface water and watercourse water, and on groundwater recharge areas.	Develop a water balance model for each sub-catchment to establish a meaningful baseline of comparability for assessment of equitable water storage.	DWLBC, OCWMB	Gauging stations constructed in sub-catchments.
4.3.5	Inadequate information to support decision making due to: • lack of surface flow and groundwater data • heavy utilisation of resources with no record of diversions.	Few or no observation bores in large areas of the Upper Onkaparinga, Noarlunga, Lower Onkaparinga. No records of diversions from streams. No stream flow records in Willunga Basin or Noarlunga Embayment areas. Flow stations currently being established in Pedler Creek.	Establish a network of flow stations across the Board's area. In partnership with landholders, establish water usage via landholder input and, if appropriate, meter new bores and selected existing bores (under voluntary arrangement with landholders) with regular measuring and monitoring of Upper Onkaparinga area. Collate information on diversions from streams. Continue to work with PIRSA and landholders to investigate surface–groundwater interactions (currently in the Willunga Basin).	DWLBC (lead agency), SA Water (lead agency), OCWMB (lead agency), Landholders	To be able to fully quantify all components of water use, enabling accurate assessment of the state of the water resource. Establish network of flow stations across the Board's area. Increase number of observation bores. Record of all diversions. Gauging of all major surface flows. Commence understanding of surface–groundwater interactions.
4.3.7	Need for irrigation efficiency due to some current inefficient practices that waste the water resource.	Variations in watering regimes between individual irrigators growing the same crop.	Negotiate with PIRSA to establish an irrigation data collection framework and monitoring program.	PIRSA (lead agency), OCWMB	

	Key issue	Current condition and trend	Action	Responsibilities and partnership	Actual outcome (2000–05)
4.3.12	Data collection and monitoring within the Board's area. Catchment boundaries are not aligned with existing administrative areas for which data are currently collected. Lack of water-use data.	ABS horticultural data out of date due to rapidly growing wine grape industry and other changes in land use. No data on recreation uses of water.	Target principal water-use areas, benchmark water usage and establish key social and economic indicators to measure the costs of water use.	OCWMB (lead agency), Other CWMBs (lead agencies), PIRSA, SA Water	Increase in data and focused analysis which will aid the Board to prioritise water resources management actions.
4.3.13	Projected urban growth and associated growing demand for domestic and industrial supplies.	Inefficient practices and management, marine pollution, lack of individual relevance or responsibility for water consumption.	Liaise with relevant councils, Planning SA and SA Water regarding SA Water's predicted needs of Metropolitan Adelaide, and link to current and future land use and practices. Survey major industry groups (agricultural and manufacturing) to determine their current and future water resource requirements.	OCWMB (lead agency), EPA (lead agency), DWLBC, Councils, SA Water, Planning SA	Future sustainable re-use of water in an urban context.

4.4 An Aware and Committed Community

	Key issue	Current condition and trend	Action	Responsibilities and partnership	Actual outcome (2000–05)
4.4.3	Continuing support for programs that encourage participation, celebration and ownership of catchment care.	The Board's area encompasses a wide variety of committed and active community groups.	Participate financially and in kind in the Waterwatch Program.	OCWMB (lead agency)	Ongoing Waterwatch Program.

4.5 Partnerships and Integration between Stakeholders

	Key issue	Current condition and trend	Action	Responsibilities and partnership	Actual outcome (2000–05)
4.5.2	Need for effective partnerships to avoid uncoordinated action across the Board's area.	The Board is already working closely with a large number of partners.	Continue development of partnerships. Continue partnership with DWLBC and EPA on the whole of catchment groundwater monitoring program, including surface–groundwater interaction activities in the McLaren Vale area.	Various	Optimum use of available resources through efficient partnerships with all stakeholders.

E. CURRENT AND HISTORIC SURFACE WATER MONITORING

Onkaparinga Catchment Complete List On-going Surface Water Monitoring — Current and Historic

Site number	Site name	Type	Purpose, comments	Parameters	Funding agency	Data collection	Data custodian
Upper Onkaparinga sub-area							
Charleston							
UO1	Onkaparinga River @ Woodside	Natural stream		Ambient and macro-invertebrates	OCWMB	OCWMB	OCWMB
M023800	Charleston BoM Station	Meteorological station	Closed.	Daily read Rainfall SKM disag + infill Rainfall	BoM	BoM	BoM
M023829	Woodside BoM Station	Meteorological station	Closed.	Daily read Rainfall SKM disag + infill Rainfall	BoM	BoM	BoM
M023882	Lobethal Maidment Road BoM Station	Meteorological station		Daily read Rainfall	BoM	BoM	BoM
AW503531	Juers Creek @ Charleston	Natural stream	Project — dairy waste management. Closed.	Recording Rainfall Water level Ad hoc field reading Water level Water temperature TDS pH DO Conductivity	Closed	Closed	DWLBC
AW503903	Onkaparinga River @ Woodside	Natural stream		Recording Rainfall Water level Stream discharge	BoM	BoM	BoM

Site number	Site name	Type	Purpose, comments	Parameters	Funding agency	Data collection	Data custodian
AW503905	Onkaparinga River @ near Charleston	Natural stream		Flood warning	SA Water	SA Water	SA Water
AW503902	Onkaparinga River @ Oakbank	Natural stream		Recording Rainfall Stream discharge	BoM	BoM	BoM
Inverbrackie Creek							
UI1	Inverbrackie Creek	Natural stream		Ambient and macro-invertebrates	OCWMB	OCWMB	OCWMB
AW503508	Inverbrackie Creek @ Craigbank	Natural stream	Pollution study within the Onkaparinga Catchment on a sub-catchment predominantly used for dairy farming (1970). Flood warning. Study on the influence of soils and land use on clay movement and water quality (Waite Agricultural Research Institute 1981). Closed.	Recording Rainfall Water level Ad hoc field reading Water level Stream discharge Water temperature TDS pH DO Conductivity	BoM	BoM	BoM
AW503513	Inverbrackie Creek @ Woodside	Natural stream	Site used for infrequent discharge measurements only. Closed.	Ad hoc field reading Water level Stream discharge Water temperature TDS pH DO Conductivity	Closed	Closed	DWLBC
AW503530	Kerber Creek @ near Woodside	Natural stream	Project — dairy waste management. Closed.	Recording Rainfall Water level Ad hoc field reading Water level Water temperature TDS	Closed	Closed	DWLBC

Site number	Site name	Type	Purpose, comments	Parameters	Funding agency	Data collection	Data custodian
				pH DO Conductivity			
Mitchell Creek							
–	–	–	–	–	–	–	–
Balhannah							
M023893	Oakbank BoM Station	Meteorological station		Daily read Rainfall	BoM	BoM	BoM
AW503908	Killara Park Pluvio @ Balhannah	Meteorological station		Recording Rainfall	BoM	BoM	BoM
Hahndorf							
UH1	Hahndorf	Natural stream		Ambient and macro-invertebrates	OCWMB	OCWMB	OCWMB
M023720	Hahndorf Post Office BoM Station	Meteorological station		Daily read Rainfall SKM disag + infill Rainfall	BoM	BoM	BoM
AW503537	Hahndorf Creek @ D/S Sewage Treatment Works	Natural stream	To assess the impact of discharge of effluent from Hahndorf Sewerage Treatment Works into Hahndorf Creek.	Recording Water level Water temperature Conductivity Ad hoc field reading Water level Water temp. TDS pH Conductivity	DWLBC	DWLBC	DWLBC
Biggs Flat							
UB1	Biggs Flat	Natural stream		Ambient and macro-invertebrates	OCWMB	OCWMB	OCWMB
Echunga Creek							
UE1	Echunga Creek	Natural stream		Ambient and macro-invertebrates	OCWMB	OCWMB	OCWMB

Site number	Site name	Type	Purpose, comments	Parameters	Funding agency	Data collection	Data custodian
AW503506	Echunga Creek @ U/S Mount Bold Reservoir	Natural stream	Water resources assessment (established as part of National Water Resources Assessment program). Nutrient Budget Study — nutrient inflows to Mount Bold Reservoir to provide long-term monitoring of catchment management performance (commenced 1988).	Recording Water level Water temperature Ad hoc field reading Water level Stream discharge Water temperature TDS pH DO Conductivity Composite Water temperature TDS Suspended solids Conductivity Phosphorus Nitrogen Copper Lead Zinc	DWLBC	Water Data Services	DWLBC
AW503533	Echunga Creek Catchment Pluvio @ Echunga	Meteorological station	Catchment run-off modelling. Flood warning.	Recording Rainfall	DWLBC	Water Data Services	DWLBC
Western Branch							
UO2	Western Branch	Natural Stream		Ambient and macro-invertebrates	OCWMB	OCWMB	OCWMB
M023862	Lobethal Treatment Works BoM Station	Meteorological station		Daily read Rainfall SKM disag + infill Rainfall	BoM	BoM	BoM
AW503510	Nitschke Hill Creek @ Lobethal No. 2 Reservoir	Dam	The reservoir was used as storage for water supply for the township of Lobethal. The source of water to fill this reservoir is not	Ad hoc field reading Water level Water temperature	Closed	Closed	DWLBC

Site number	Site name	Type	Purpose, comments	Parameters	Funding agency	Data collection	Data custodian
			known. Closed.	TDS pH Conductivity			
AW503901	Nitschke Hill Pluvio @ Nitschke Hill	Meteorological station	ALERT station (no hydrometric).	Recording Rainfall	BoM	BoM	BoM
AW503906	Onkaparinga River @ Western Branch	Natural stream	ALERT station	Recording Rainfall Water level Stream discharge	BoM	BoM	BoM
AW503907	Lobethal Pluvio @ Sewage Treatment Works	Meteorological station	ALERT station (no hydrometric)	Recording Rainfall	BoM	BoM	BoM
Cock Creek							
UK1	Cock Creek	Natural stream		Ambient and macro-invertebrates	OCWMB	OCWMB	OCWMB
6414	Lenswood Creek 2 km south of Lenswood	Natural stream		Ambient	EPA	EPA	EPA
M023801	Lenswood Research Centre BoM Station	Meteorological station		Daily read Rainfall SKM disag + infill Rainfall	BoM	BoM	BoM
AW503507	Lenswood Creek @ Lenswood	Natural stream	Pollution study of sub-catchment within the Onkaparinga Catchment predominantly used for orchard cultivation (1972). Study — 'Water balance of a small catchment in the Mount Lofty Ranges, South Australia' 1975). Nutrient Budget Study — nutrient inflows to Mount Bold Reservoir to provide long-term monitoring of catchment management performance (Commenced 1994).	Recording Rainfall Water level Water temperature Ad hoc field reading Water level Stream discharge Water temperature TDS pH DO Conductivity Composite sampling Water temperature	OCWMB	Water Data Services	DWLBC

Site number	Site name	Type	Purpose, comments	Parameters	Funding agency	Data collection	Data custodian
				TDS Suspended solids Conductivity Phosphorus Nitrogen Copper Lead Zinc			
Upper Onkaparinga (Spoehr)							
UO3	Upper Onkaparinga	Natural stream		Ambient and macro-invertebrates	OCWMB	OCWMB	OCWMB
UO4	Upper Onkaparinga	Natural stream		Ambient and macro-invertebrates	OCWMB	OCWMB	OCWMB
UO5	Upper Onkaparinga	Natural stream		Ambient and macro-invertebrates	OCWMB	OCWMB	OCWMB
US1	Spoehr	Natural stream		Ambient and macro-invertebrates	OCWMB	OCWMB	OCWMB
M023866	Verdun (Sutton) BoM Station	Meteorological station		Daily read Rainfall SKM disag + infill Rainfall	BoM	BoM	BoM
AW503512	Onkaparinga River @ Verdun	Natural stream	A supplementary gauging station forming part of a Eutrophication Study during early 1970s. Closed.	Unknown	Closed	Closed	DWLBC
AW503521	Gallasch Creek @ Verdun	Natural stream	Project established to study surface and interflow of water within a small catchment. Closed.	Recording Rainfall Water level Ad hoc field reading Water level Stream discharge Water temperature TDS pH DO	Closed	Closed	DWLBC

Site number	Site name	Type	Purpose, comments	Parameters	Funding agency	Data collection	Data custodian
AW503902	Onkaparinga River @ Oakbank	Natural stream	ALERT Station	Conductivity Recording Rainfall Stream discharge	BoM	BoM	BoM
AW503910	Verdun East Pluvio @ Verdun East	Meteorological station	ALERT Station (No Hydrometric)	Unknown	BoM	BoM	BoM
UO3	Upper Onkaparinga	Natural stream		Ambient and macro-invertebrates	OCWMB	OCWMB	OCWMB
Cox Creek							
UC1	Cox Creek	Natural stream		Ambient and macro-invertebrates	OCWMB	OCWMB	OCWMB
UC2	Cox Creek Lower	Natural stream		Ambient and macro-invertebrates	OCWMB	OCWMB	OCWMB
M023707	Bridgewater Post Office BoM Station	Meteorological station		Daily read Rainfall SKM disag + infill Rainfall	BoM	BoM	BoM
M023736	Mount Lofty Summit BoM Station	Meteorological station	Closed	Daily read Rainfall SKM disag + infill Rainfall	BoM	BoM Closed	BoM
M023750	Uraidla BoM Met Station	Meteorological station		Daily read Rainfall SKM disag + infill Rainfall	BoM	BoM	BoM
M023757	Crafers St Michaels House BoM Station	Meteorological station	Closed	Daily read Rainfall SKM disag + infill Rainfall	BoM	BoM Closed	BoM
M023764	Mount Lofty (Hardys) BoM Station	Meteorological station	Closed	Daily read Rainfall SKM disag + infill Rainfall	BoM	BoM Closed	BoM
M023765	Mount Lofty (Korralla) BoM Station	Meteorological station	Closed	Daily read Rainfall	BoM	BoM Closed	BoM

Site number	Site name	Type	Purpose, comments	Parameters	Funding agency	Data collection	Data custodian
				SKM disag + infill Rainfall			
M023788	Piccadilly (Mount Lofty Botanic Garden) BoM Station	Meteorological station		Daily read Rainfall	BoM	BoM	BoM
M023809	Mount Bonython BoM Station	Meteorological station	Closed	Daily read Rainfall SKM disag + infill Rainfall	BoM	BoM Closed	BoM
M023883	Piccadilly (Petaluma) BoM Met Station	Meteorological station	Closed	Daily read Rainfall SKM disag + infill Rainfall	BoM	BoM Closed	BoM
M023891	Piccadilly (Woodhouse) BoM Station	Meteorological station		Daily read Rainfall	BoM	BoM	BoM
AW503514	Cox Creek @ south of Vimy Ridge	Natural stream	Site used for infrequent discharge measurements only. Closed.	Ad hoc field reading Water level Water temperature TDS pH Conductivity	Closed	Closed	DWLBC
AW503524	Vince Creek @ Piccadilly Valley	Natural stream	Study of non-point source pollution in the Piccadilly Valley commencing 1982 (joint project between E&WS Department and Department of Agriculture). Water Resource Assessment (part of National Water Resources Assessment program). Closed.	Recording Rainfall Water level Ad hoc field reading Water level Stream discharge Water temperature TDS pH DO Conductivity	Closed	Closed	DWLBC
AW503525	Sutton Creek @ Piccadilly Valley	Natural stream	Study of non-point source pollution in the Piccadilly Valley commencing 1982 (joint project	Recording Rainfall	DWLBC	Water Data Services	DWLBC

Site number	Site name	Type	Purpose, comments	Parameters	Funding agency	Data collection	Data custodian
			between E&WS Department and Department of Agriculture). Water Resource Assessment (part of National Water Resources Assessment program).	Water level (closed) Ad hoc field reading Water level Stream discharge Water temperature TDS pH DO Conductivity			
AW503526	Cox Creek @ Uraidla	Natural stream	Water resources assessment, as part of the National Water Resources Assessment program (1976). Waite Institute project examining the influence of soils and land use on clay movement and water quality (1981). Nutrient Budget Study — nutrient inflows to Mount Bold Reservoir to provide long-term monitoring of catchment management performance (commenced 1994).	Recording Water level Water temperature Ad hoc field reading Water level Stream discharge Water temperature TDS pH DO Conductivity Composite Water temperature TDS Suspended solids Conductivity Phosphorus Nitrogen Copper Lead Zinc	OCWMB	Water Data Services	DWLBC
Aldgate Creek							
UA1	Aldgate Creek Lower	Natural stream		Ambient and macro-invertebrates	OCWMB	OCWMB	OCWMB

Site number	Site name	Type	Purpose, comments	Parameters	Funding agency	Data collection	Data custodian
M023766	Mount Lofty Railway Station BoM Station	Meteorological station	Closed	Daily read Rainfall SKM disag + infill Rainfall	BoM	BoM Closed	BoM
M023768	Aldgate State School BoM Station	Meteorological station	Closed	Daily read Rainfall SKM disag + infill Rainfall	BoM	BoM Closed	BoM
M023785	Stirling Post Office BoM Station	Meteorological station	Closed	Daily read Rainfall SKM disag + infill Rainfall	BoM	BoM Closed	BoM
M023817	Aldgate BoM Station	Meteorological station		Daily read Rainfall SKM disag + infill Rainfall	BoM	BoM	BoM
AW503509	Aldgate Creek @ Aldgate Railway Station	Natural stream	Pollution study within the Onkaparinga Catchment from a sub-catchment, which is predominantly residential (1972). Water resources assessment, as part of the National Water Resources Assessment program (1972). Waite Institute project examining the influence of soils and land use on clay movement and water quality (1981). Nutrient Budget Study — nutrient inflows to Mount Bold Reservoir to provide long-term monitoring of catchment management performance (commenced 1994)	Recording Rainfall Water level Water temperature Ad hoc field reading Water level Stream discharge Water temperature TDS pH DO Conductivity Composite Water temperature TDS Suspended solids Conductivity Phosphorus	SAWC	Water Data Services	DWLBC

Site number	Site name	Type	Purpose, comments	Parameters	Funding agency	Data collection	Data custodian
				Nitrogen Copper Lead Zinc			
AW503515	Leslie Creek @ Mylor	Natural stream	Site used for infrequent discharge measurements only. Closed.	Ad hoc field reading Water level Water temperature TDS pH Conductivity	Closed	Closed	DWLBC
AW503516	Aldgate Creek @ Mylor	Natural stream	Site used for infrequent discharge measurements only. Closed.	Ad hoc field reading Water level Water temperature TDS pH DO Conductivity	Closed	Closed	DWLBC
AW503517	Aldgate Creek @ U/S Aldgate Railway Station	Natural stream	Site used for infrequent discharge measurements only. Closed.	Ad hoc field reading Water level Water temperature TDS pH DO Conductivity	Closed	Closed	DWLBC
AW503518	Aldgate Creek @ Pomona Road Stirling	Natural stream	Site used for infrequent discharge measurements only. Closed.	Ad hoc field reading Water level Water temperature TDS pH Conductivity	Closed	Closed	DWLBC
Onkaparinga Main Channel (Mount Bold Reservoir)							
UO6	Mount Bold Reservoir			Ambient and macro-invertebrates	OCWMB	OCWMB	OCWMB
6392	Houlgrave Weir	Water supply weir		Ambient	EPA	EPA	EPA

Site number	Site name	Type	Purpose, comments	Parameters	Funding agency	Data collection	Data custodian
M023734	Mount Bold Reservoir BoM Station	Meteorological station	Estimation of evaporation losses from Mount Bold Reservoir.	Daily read Rainfall Evaporation SKM disag + infill Rainfall	BoM	BoM	BoM
M023793	Mylor BoM Station	Meteorological station	Closed.	Daily read Rainfall SKM disag + infill Rainfall	BoM	BoM	BoM
M023794	Warrakilla BoM Station	Meteorological station	Closed.	Daily read Rainfall SKM disag + infill Rainfall	BoM	BoM	BoM
AW503501	Onkaparinga River @ Mount Bold Reservoir	Dam, water storage	Flood warning. Water resource assessment. Catchment yield analysis. Operational control of water supply.	Recording Reservoir level	SA Water	Water Data Services	SA Water
AW503504	Onkaparinga River @ Houlgraves Weir	Water supply weir	Base station. Study of factors influencing eutrophication in metropolitan reservoirs. Measurement of inflows to Mount Bold Reservoir to assist reservoir management. Flood warning. Nutrient Budget Study — nutrient inflows to Mount Bold Reservoir to provide long-term monitoring of catchment management performance (commenced 1988).	Recording Rainfall Water level Inflow from pipeline Water temperature Turbidity Ad hoc field reading Water level Stream discharge Water temperature TDS pH DO Conductivity Composite: Water temperature	DWLBC	Water Data Services	DWLBC

Site number	Site name	Type	Purpose, comments	Parameters	Funding agency	Data collection	Data custodian
				TDS Suspended solids Conductivity Phosphorus Nitrogen Copper Lead Zinc			
AW503511	Onkaparinga @ Hacks Bridge	Natural stream	Used for infrequent discharge measurements of Onkaparinga River. Flood warning station.	Ad Hoc Field Reading Water level Stream discharge Water temperature TDS pH Conductivity	BoM	BoM	BoM
AW503520 (close to 506)	Jupiter Creek @ U/S Echunga Creek	Natural stream	Site used for infrequent discharge measurements only. Closed.	Ad hoc field reading Water level Water temperature TDS pH DO Conductivity	Closed	Closed	DWLBC
AW503529	Burnt Out Creek @ U/S Mount Bold Reservoir	Natural stream	A project station established to assess the effect fire plays on water quality and quantity within a catchment undergoing pine plantation regrowth.	Recording Rainfall Water level Ad hoc field reading Water level Stream discharge Water temperature TDS pH DO Conductivity	DWLBC	Water Data Services	DWLBC

Site number	Site name	Type	Purpose, comments	Parameters	Funding agency	Data collection	Data custodian
AW503534	Mount Bold Reservoir Automatic Weather Station on Island	Meteorological station	Collection of meteorological parameters required for modelling reservoir water quality behavior. Closed.	Recording Rainfall Dry temperature Humidity Wind velocity Sunshine duration Solar radiation	Closed	Closed	DWLBC
AW503536	Mount Bold Reservoir Meteorological Station	Meteorological station	Estimation of evaporation losses from Mount Bold Reservoir.	Unknown	SA Water	SA Water	SA Water
AW503904	Onkaparinga River @ Verdun (U/S Hahndorf Dissipator)	Natural stream	ALERT Station.	Unknown	BoM	BoM	BoM
A5031001	Onkaparinga @ U/S Hahndorf Dissipator	Natural stream	Mount Lofty Ranges surface water monitoring upgrade.	Recording Water level Water temperature Conductivity Composite TDS Suspended solids Conductivity Phosphorus Nitrogen Copper Lead Zinc	OCWMB	WDS/ DWLBC	DWLBC
A5031002	Murray Bridge – Onkaparinga Pipeline @ outlet to Onkaparinga River	Water supply system, pipe	Measurement of water transferred from the River Murray (at Murray Bridge) into Onkaparinga River to supplement natural flow into Mount Bold Reservoir. Abandoned.	Unknown	SA Water	SA Water	SA Water
Lower Onkaparinga Sub-Area							
Scott Creek							
SC1	Scott Creek	Natural stream		Ambient and macro-invertebrates	OCWMB	OCWMB	OCWMB

Site number	Site name	Type	Purpose, comments	Parameters	Funding agency	Data collection	Data custodian
2065	Scott Creek @ Scott Bottom	Natural stream	Same location as AW503502.	Ambient	EPA	EPA	EPA
M023108	Longwood Ridge (Healy) BoM Station	Meteorological station		Daily read Rainfall	BoM	BoM	BoM
M023709	Cherry Gardens BoM Station	Meteorological station		Daily read Rainfall SKM disag + infill Rainfall	BoM	BoM	BoM
M023727	Longwood BoM Station	Meteorological station		Daily read Rainfall SKM disag + infill Rainfall	BoM	BoM	BoM
M023745	Stirling BoM Station	Meteorological station	Closed	Daily read Rainfall SKM disag + infill Rainfall	BoM	BoM	BoM
M023794	Warrakilla BoM Station	Meteorological station	Closed	Daily read Rainfall SKM disag + infill Rainfall	BoM	BoM	BoM
M023796	Scotts Creek BoM Station	Meteorological station	Closed	Daily read Rainfall SKM disag + infill Rainfall	BoM	BoM	BoM
AW503502	Scott Creek @ Scott Bottom	Natural stream	Originally constructed to maintain long-term monitoring of flow characteristics of the Onkaparinga River following loss of Mount Bold spillway as a gauging control after dam wall was raised. Benchmark station for monitoring impact of climate variability and change. Flood warning.	Recording Rainfall Water level Water temperature Ad hoc field reading Water level Stream discharge Water temperature TDS pH	DWLBC	Water Data Services	DWLBC

Site number	Site name	Type	Purpose, comments	Parameters	Funding agency	Data collection	Data custodian
			Water resource assessment. Nutrient Budget Study — nutrient inflows into Happy Valley Reservoir to provide long-term monitoring of catchment management performance (commenced 1994). DWLBC will keep site as a representative site for native vegetation.	DO Conductivity Composite Water temperature TDS Suspended solids Conductivity Phosphorus Nitrogen Copper Lead Zinc			
AW503545	Mackreath Creek @ U/S Scott Creek	Natural stream		Recording Water level	OCWMB	Water Data Services	DWLBC
AW503909	Longwood Pluvio @ Longwood	Meteorological station		Unknown	BoM	BoM	BoM
Clarendon Weir							
AW503500	Onkaparinga River @ Clarendon Weir	Natural stream	Operational control (regulation) of water supply. Flood warning. Water resource assessment. Regulated releases from Mount Bold Reservoir upstream of this site. Water supply diversions from this weir pool to Happy Valley Reservoir via Horndale Flume and to Onkaparinga Valley System.	Recording Water level SA reservoir's yield Catchment yield NLWRA 2000 Catchment yield	SA Water	Water Data Services	SA Water
AW503528	Onkaparinga River @ D/S Mount Bold Reservoir	Natural stream	The station was installed in 1977 to calibrate both the control valves and the spillway of Mount Bold Reservoir. Closed.	Recording Water level Ad hoc field reading Water level Stream discharge Water temperature	Closed	Closed	DWLBC

Site number	Site name	Type	Purpose, comments	Parameters	Funding agency	Data collection	Data custodian
				TDS pH DO Conductivity			
Kangarilla							
KA1	Baker Gully	Natural stream		Ambient and macro-invertebrates	OCWMB	OCWMB	OCWMB
M023887	Kuitpo Forest Reserve BoM Station	Meteorological station		Daily read Rainfall SKM disag + infill Rainfall	BoM	BoM	BoM
AW503503	Baker Gully @ 4.5 km WNW of Kangarilla	Natural stream	Bakers Gully Weir was constructed in response to a program (initiated around 1960) to investigate suitable sites for the construction of future reservoirs to supplement Metropolitan Adelaide's water supply.	Recording Water level Water temperature Suspended solids Conductivity Ad hoc field reading Water level Stream discharge Water temperature TDS pH DO Conductivity	DWLBC	Water Data Services	DWLBC
AW503505	Dashwood Gully @ Snow Hill	Natural stream	Pollution study within the Onkaparinga Catchment on a sub-catchment predominantly used for managed afforestation 1970). Determine run-off within a pine plantation (used as a baseline to Burnt Out Creek study). National assessment station. Closed.	Recording Water level Ad hoc field reading Water level Stream discharge Water temperature TDS pH DO Conductivity	Closed	Closed	DWLBC

Site number	Site name	Type	Purpose, comments	Parameters	Funding agency	Data collection	Data custodian
Onkaparinga Main Channel (Lower Onkaparinga)							
LO1	Lower Onkaparinga			Ambient and macro-invertebrates	OCWMB	OCWMB	OCWMB
LO2	Onkaparinga River immediately downstream of gorge			Ambient and macro-invertebrates	OCWMB	OCWMB	OCWMB
LO3	Onkaparinga River immediately downstream of Gorge			Ambient and macro-invertebrates	OCWMB	OCWMB	OCWMB
LO4	Downstream of sludge lagoons			Ambient and macro-invertebrates	OCWMB	OCWMB	OCWMB
6581	Noarlunga	Natural stream		Ambient	EPA	EPA	EPA
M023710	Clarendon Post Office BoM Station	Meteorological station		Daily read Rainfall SKM disag + infill Rainfall	BoM	BoM	BoM
M023740	Old Noarlunga Post Office BoM Station	Meteorological station		Daily read Rainfall SKM disag + infill Rainfall	BoM	BoM	BoM
M023833	Hackham BoM Station	Meteorological station	Closed	Daily read Rainfall SKM disag + infill Rainfall	BoM	BoM	BoM
M023885	Noarlunga (Noarlunga AWS) BoM Station	Meteorological station		Daily read Rainfall	BoM	BoM	BoM
AW503522	Onkaparinga River @ Noarlunga	Natural stream	Established as part of the Onkaparinga Estuary Study. Flow at the site is regulated by Mount Bold Reservoir and diversion of water from the Onkaparinga River at Clarendon Weir for urban water supply usage. Closed.	Recording Water level Ad Hoc Field Reading Water level Stream discharge Water temperature TDS pH DO	Closed	Closed	DWLBC

Site number	Site name	Type	Purpose, comments	Parameters	Funding agency	Data collection	Data custodian
				Conductivity NLWRA 2000 Catchment yield			
AW503523	Onkaparinga River @ Saltfleet Street	Natural stream	Hydrometric — previous infrequent observations. Water Quality — previous infrequent grab samples. Recorder tower removed due to instability. Closed.	Unknown	Closed	Closed	DWLBC
Noarlunga Embayment sub-area							
Field River							
FR1	Field River	Natural stream		Ambient and macro-invertebrates	OCWMB	OCWMB	OCWMB
FR2	Field River	Natural stream		Ambient and macro-invertebrates	OCWMB	OCWMB	OCWMB
M023721	Happy Valley Reservoir E&WS BoM Station	Meteorological station		Daily read Rainfall SKM disag + infill Rainfall	BoM	BoM	BoM
M023775	Clarendon (Bloxholme) BoM Station	Meteorological station	Closed	Daily read Rainfall SKM disag + infill Rainfall	BoM	BoM	BoM
M023828	Adelaide Aberfoyle Park BoM Station	Meteorological station	Closed	Daily read Rainfall SKM disag + infill Rainfall	BoM	BoM	BoM
AW503519	Happy Valley Reservoir intake channel @ Horndale Flume	Channel, drain, aqueduct	Provide an in dependent check on the Horndale flume flow meter. Flow at Horndale flume is entirely regulated by operation of Clarendon Weir. Closed.	Recording Water level	Closed	Closed	DWLBC
AW503532	Happy Valley Reservoir @ Pluviometer	Meteorological station	The site was originally established to collect various meteorological parameters to	Recording Rainfall Daily read	DWLBC	Water Data Services	DWLBC

Site number	Site name	Type	Purpose, comments	Parameters	Funding agency	Data collection	Data custodian
			assist in modelling reservoir water quality behaviour. (Changing priorities and poor instrument performance resulted in only rainfall and evaporation data being archived.) Flood warning.	Rainfall Evaporation			
AW503535	Happy Valley Reservoir @ Metro Telemetry	Dam or water storage		Recording Water level	SA Water	SA Water	SA Water
AW503546	Field River @ D/S Main South Road	Natural stream		Recording Water level Composite TDS SS Turbidity pH Conductivity Phosphorus Nitrogen Calcium Magnesium Potassium Sodium Bicarbonate Carbonate Chloride Sulphate Arsenic Cadmium Chromium Copper Lead Mercury Zinc	OCWMB	Water Data Services	DWLBC

Site number	Site name	Type	Purpose, comments	Parameters	Funding agency	Data collection	Data custodian
Waterfall Creek							
–	–	–	–	–	–	–	–
Christie Creek							
CH1	Christie Creek			Ambient and macro-invertebrates	OCWMB	OCWMB	OCWMB
CH2	Christie Creek			Ambient and macro-invertebrates	OCWMB	OCWMB	OCWMB
M023732	Morphett Vale BoM Station	Meteorological station		Daily read Rainfall SKM disag + infill Rainfall	BoM	BoM	BoM
AW503547	Christie Creek @ D/S Galloway Road	Natural Stream		*Recording* Water Level Composite TDS Suspended Solids Turbidity pH Conductivity Phosphorus Nitrogen Calcium Magnesium Potassium Sodium Bicarbonate Carbonate Chloride Sulphate Arsenic Cadmium Chromium Copper Lead	OCWMB	Water Data Services	DWLBC

Site number	Site name	Type	Purpose, comments	Parameters	Funding agency	Data collection	Data custodian
				Mercury			
				Zinc			
Willunga Basin sub-area							
Pedler Creek							
PE1	Pedler Creek	Natural stream		Ambient and macro-invertebrates	OCWMB	OCWMB	OCWMB
PE2	Pedler Creek	Natural stream		Ambient and macro-invertebrates	OCWMB	OCWMB	OCWMB
2099	Willunga Basin	Natural stream		Ambient and macro-invertebrates	EPA	EPA	EPA
2124	Willunga Basin	Natural stream		Ambient and macro-invertebrates	EPA	EPA	EPA
2126	Willunga Basin	Natural stream		Ambient and macro-invertebrates	EPA	EPA	EPA
2130	Willunga Basin	Natural stream		Ambient and macro-invertebrates	EPA	EPA	EPA
M023358	Kangarilla Section 6 BoM Station	Meteorological station	Closed.	Daily read Rainfall SKM disag + infill Rainfall	BoM	BoM	BoM
M023729	McLaren Vale BoM Station	Meteorological station	Closed.	Daily read Rainfall SKM disag + infill Rainfall	BoM	BoM	BoM
M023831	Kangarilla (Jindabyne) BoM Station	Meteorological station	Closed.	Daily read Rainfall SKM disag + infill Rainfall	BoM	BoM	BoM
M023861	McLaren Flat (Beltunga) BoM Station	Meteorological station		Unknown	BoM	BoM	BoM
M023872	McLaren Vale Chalk Hill Road BoM Station	Meteorological station	Closed.	Daily read Rainfall SKM disag + infill Rainfall	BoM	BoM	BoM

Site number	Site name	Type	Purpose, comments	Parameters	Funding agency	Data collection	Data custodian
M023876	McLaren Vale (Pirramimma) BoM Station	Meteorological station		Daily read Rainfall SKM disag + infill Rainfall	BoM	BoM	BoM
AW503538	Pedler Creek @ North Branch	Natural stream		Recording Water level	Closed	Closed	DWLBC
AW503539	Pedler Creek @ South Branch	Natural stream		Recording Water level	Closed	Closed	DWLBC
AW503540	Pedler Creek @ Rifle range Road	Natural stream		Recording Water level Flow velocity Water temperature	Closed	Closed	DWLBC
AW503541	Pedler Creek @ D/S Wirra Wirra	Natural stream		Recording Water level	Closed	Closed	DWLBC
AW503542	Pedler Creek @ Chalkhill Road	Natural stream		Recording Water level	Closed	Closed	DWLBC
AW503543	Pedler Creek @ Stump Hill Road	Natural stream		Recording Water level Water temperature Conductivity	OCWMB	Water Data Services	DWLBC
AW503544	Pedler Creek @ D/S Maxwells	Natural stream		Recording Water level	Closed	Closed	DWLBC
AW503911	McLaren Flat Pluvio @ Beltunga	Meteorological station	Flood warning.	Recording Rainfall	BoM	BoM	BoM
Maslins							
MA1	Maslins			Ambient and macro-invertebrates	OCWMB	OCWMB	OCWMB
2095	Willunga Basin			Ambient and macro-invertebrates	EPA	EPA	EPA
M023790	Aldinga (Hildas Dale) BoM Station	Meteorological station	Closed.	Daily read Rainfall SKM disag + infill Rainfall	BoM	BoM	BoM

Site number	Site name	Type	Purpose, comments	Parameters	Funding agency	Data collection	Data custodian
M023840	McLaren Vale Section 171 BoM Station	Meteorological station	Closed.	Daily read Rainfall SKM disag + infill Rainfall	BoM	BoM	BoM
Willunga							
WI1	Willunga			Ambient and macro-invertebrates	OCWMB	OCWMB	OCWMB
WI2	Willunga			Ambient and macro-invertebrates	OCWMB	OCWMB	OCWMB
2101	Willunga Basin			Ambient and macro-invertebrates	EPA	EPA	EPA
2122	Willunga Basin			Ambient and macro-invertebrates	EPA	EPA	EPA
M023753	Willunga BoM Station	Meteorological station		Daily read Rainfall SKM disag + infill Rainfall	BoM	BoM	BoM
M023857	Willunga Hill BoM Met Station	Meteorological station		Unknown	BoM	BoM	BoM
AW503912	Willunga Hill Pluvio @ Willunga Hill	Meteorological station		Recording Rainfall	BoM	BoM	BoM
Aldinga South							
WA1	Aldinga			Ambient and macro-invertebrates	OCWMB	OCWMB	OCWMB
M023700	Aldinga Post Office BoM Station	Meteorological station	Closed.	Daily read Rainfall SKM disag + infill Rainfall	BoM	BoM	BoM
M023886	Sellicks Hill (Mount Terrible Radar) BoM Station	Meteorological station		Unknown	BoM	BoM	BoM
Sellicks							
SE1	Sellicks			Ambient and macro-invertebrates	OCWMB	OCWMB	OCWMB
M023871	Sellicks Beach BoM Station	Meteorological station		Daily read	BoM	BoM	BoM

Site number	Site name	Type	Purpose, comments	Parameters	Funding agency	Data collection	Data custodian
				Rainfall SKM Disag + Infill Rainfall			
Marine							
2159	Gulf St Vincent; off Port Noarlunga			Ambient and macro-invertebrates	EPA	EPA	EPA

Recording relates to parameters continuously monitored in the field

Composite relates to parameters continuously monitored in the field

Ad hoc Field Reading relates to parameters monitored in conjunction with ad hoc water quality sampling. Results of this monitoring are not comprehensive enough to use for measuring trends

SKM Disag + Infill Dec 2000 Rainfall is a process of infilling of missing data

F. CURRENT AND HISTORIC SURFACE WATER LEVEL AND FLOW MONITORING

Site number	Site name	Commenced	Ceased	Level continuous recording	Stream flow	Easting	Northing
Upper Onkaparinga sub-area							
Charleston							
AW503903	Onkaparinga River @ Woodside	18/8/1994	–	Yes	Recording Stream discharge	305822.0	6130378.0
AW503531	Juers Creek @ Charleston	10/8/1987	1/11/1989	Yes	Yes (latest gauging 8/8/1989)	308222.0	6134828.0
Inverbrackie Creek							
AW503508	Inverbrackie Creek @ Craigbank	17/5/1972	30/12/2003	Yes	Yes (latest gauging 30/7/2003)	310568.0	6130835.0
AW503530	Kerber Creek @ Woodside	30/7/1987	8/11/1989	Yes	Yes	307892.0	6129918.0
Hahndorf Creek							
AW503537	Hahndorf Creek @ D/S Sewage Treatment Works	25/3/1993	–	Yes	Yes (latest gauging 21/6/2005)	298622.0	6122518.0
Echunga Creek							
AW503506	Echunga Creek @ U/S Mount Bold Reservoir	22/3/1973	–	Yes	Yes (latest gauging 18/8/2003)	292958.0	6110469.0
Western Branch							
AW503906	Onkaparinga River @ Western Branch	04/4/1995	–	Yes	Recording Stream discharge	304322.0	6130778.0
Cock Creek							
AW503507	Lenswood Creek @ Lenswood	18/5/1972	–	Yes	Yes (latest gauging 3/8/2004)	301136.0	6131963.0
Upper Onkaparinga (Spoehr)							
AW503902	Onkaparinga River @ Oakbank	15/5/1996	–	No	Recording Stream discharge	303122.0	6126978.0
AW503521	Gallasch Creek @ Verdun	30/6/1977	4/11/1982	Yes	Yes	298772.0	6125008.0
Cox Creek							
AW503526	Cox Creek @ Uraidla	23/6/1976	–	Yes	Yes (latest gauging 3/8/2004)	293264.0	6127554.0

Site number	Site name	Commenced	Ceased	Level continuous recording	Stream flow	Easting	Northing
AW503525	Sutton Creek @ Piccadilly Valley	23/7/1982	4/7/1988	Yes	Yes (latest gauging 17/8/1987)	293763.0	6128001.0
AW503524	Vince Creek @ Piccadilly	8/6/1982	1/4/1987	Yes	Yes (latest gauging 30/71986)	292152.0	6128878.0
Aldgate Creek							
AW503509	Aldgate Creek @ Aldgate Railway Station	13/7/1972	–	Yes	Yes (latest gauging 30/7/2003)	293041.0	6122962.0
Onkaparinga Main Channel (Mount Bold Reservoir)							
A5031001	Onkaparinga @ U/S Hahndorf Dissipator	22/6/2002	–	Yes	Yes (latest gauging 3/11/2004)	298162.0	6121678.0
AW503504	Onkaparinga River @ Houlgrave	17/4/1973	–	Yes	Yes (latest gauging 28/7/1999)	292589.0	6115458.0
AW503529	Burnt Out Creek @ U/S Mount Bold Reservoir	12/1/1978	–	Yes	Yes (latest gauging 25/8/2003)	290822.0	6110378.0
Lower Onkaparinga sub-area							
Scott Creek							
AW503502	Scott Creek @ Scott Bottom	28/5/1964	–	Yes	Yes (latest gauging 17/9/1991)	288033.0	6113400.0
AW503545	Mackreath Creek @ U/S Scott Creek	9/2/2001	–	Yes	Yes (latest gauging 24/8/2001)	288522.0	6138178.0
Clarendon Weir							
AW503528	Onkaparinga @ D/S Mount Bold Reservoir	4/8/1977	7/2/1989	Yes	Yes (latest gauging 12/7/1983)	288021.0	6110828.0
Kangarilla							
AW503505	Dashwood Gully @ Snow Hill	6/11/1972	19/1/1983	Yes	Yes (latest gauging 3/9/1981)	292621.0	6107978.0
AW503503	Baker Gully @ 4.5 km WNW of Kangarilla	11/4/1969	–	Yes	Yes (latest gauging 25/8/2003)	282021.0	6108878.0
Onkaparinga Main Channel (Lower Onkaparinga)							
AW503522	Onkaparinga River @ Noarlunga	27/6/1973	14/7/1988	Yes	Yes (latest gauging 11/7/1984)	274121.0	6105178.0
Noarlunga Embayment sub-area							
Field River							
AW503546	Field River @ D/S Main South Road	19/12/2000	–	Yes	Yes (latest gauging 8/6/2001)	276215.0	6115482.0
AW503547	Christie Creek @ D/S Galloway Road	28/11/2000	–	Yes	Yes (latest gauging 2/9/2002)	270321.0	6110078.0

Site number	Site name	Commenced	Ceased	Level continuous recording	Stream flow	Easting	Northing
Willunga Basin sub-area							
Pedler Creek							
AW503543	Pedler Creek @ Stump Hill Road	4/7/2000	–	Yes	No (latest gauging 4/9/2001)	274330.0	6101476.0
AW503544	Pedler Creek @ D/S Maxwells	11/7/2000	22/9/2004	Yes	No (latest gauging 7/9/2000)	275577.0	6101003.0
AW503542	Pedler Creek @ Chalkhill Road	17/8/2000	22/9/2004	Yes	No	275594.0	6100933.0
AW503538	Pedler Creek @ North Branch	23/8/1999	22/9/2004	Yes	No	277555.0	6100456.0
AW503539	Pedler Creek @ South Branch	23/8/1999	22/9/2004	Yes	No	277616.0	6099829.0
AW503541	Pedler Creek @ D/S Wirra Wirra	14/12/2000	22/9/2004	Yes	No (latest gauging 4/9/2001)	278053.0	6099051.0
AW503540	Pedler Creek @ Rifle Range Road	7/7/2000	15/8/2004	Yes	Recording Flow velocity (latest gauging 7/9/2000)	279584.0	6097762.0

G. SURFACE WATER SALINITY MONITORING SITES

Site number	Site name	Commenced	Ceased	Levels and salinity	Easting	Northing
Upper Onkaparinga sub-area						
Cock Creek						
AW503507	Lenswood Creek @ Lenswood	18/5/1972	–	Yes	301136.0	6131963.0
Upper Onkaparinga (Spoehr)						
AW503537	Hahndorf Creek @ D/S Sewage Treatment Works	25/3/1993	–	Yes	298622.0	6122518.0
Cox Creek						
AW503526	Cox Creek @ Uraidla	23/6/1976	–	Yes	293264.0	6127554.0
Aldgate Creek						
AW503509	Aldgate Creek @ Aldgate Railway Station	13/7/1972	–	Yes	293041.0	6122962.0
Onkaparinga Main Channel (Mount Bold Reservoir)						
A5031001	Onkaparinga @ U/S Hahndorf Dissipator	22/6/2002	–	Yes	298162.0	6121678.0
AW503504	Onkaparinga River @ Houlgrave	17/4/1973	–	Yes	292589.0	6115458.0
AW503506	Echunga Creek @ U/S Mount Bold Reservoir	22/3/1973	–	Yes	292958.0	6110469.0
Lower Onkaparinga sub-area						
Scott Creek						
AW503502	Scott Creek @ Scott Bottom	28/5/1964	–	Yes	288033.0	6113400.0
Kangarilla						
AW503503	Baker Gully @ 4.5 km WNW of Kangarilla	11/4/1969	–	Yes	282021.0	6108878.0
Noarlunga Embayment sub-area						
Field River						
AW503546	Field River @ D/S Main South Road	19/12/2000	–	Yes	276215.0	6115482.0
AW503547	Christie Creek @ D/S Galloway Road	28/11/2000	–	Yes	270321.0	6110078.0
Willunga Sub-Area						
Pedler Creek						
AW503543	Pedler Creek @ Stump Hill Road	4/7/2000	–	Yes	274330.0	6101476.0

H. WATER SUPPLY INFRASTRUCTURE WATER QUALITY MONITORING

Location	Frequency	Site number	Site type	Parameters		
Mount Bold Reservoir Location 1	Nominated day, week and month	1241	Indirect storage offtake at surface	Algal enumeration Ammonia Chlorophyll Colour Cryptosporidium Dissolved Organic Carbon DO	FILT Reactive Phosphorus Giardia Iron Manganese Nitrate Nitrite Organophosphorus and Triazine	Organochlorine Phosphorus Temperature TKN Turbidity
Mount Bold Reservoir Location 1 at 10 m depth	Nominated day, week and month	1251	Indirect storage offtake at depth	Algal enumeration Chlorophyll Colour	DO Iron Manganese	Temperature Turbidity
Mount Bold Reservoir Location 1 at 20 m depth	Nominated day, week and month	1252	Indirect storage offtake at depth	Algal enumeration Chlorophyll Colour	DO Iron Manganese	Temperature Turbidity
Mount Bold Reservoir Location 1 at 30 m Depth	Nominated day, week and month	1253	Indirect storage offtake at depth	Algal enumeration Chlorophyll Colour	DO Iron Manganese	Temperature Turbidity
Happy Valley Reservoir Clarendon Weir	Nominated day, week and month	1625	Inlet to service reservoir	Algal enumeration Chlorophyll Cryptosporidium	Giardia Organochlorine Organophosphorus and Triazine	Temperature
Happy Valley Reservoir Location 1	Nominated day, week and month	1201	Service reservoir offtake at surface	Algal enumeration Ammonia Chlorophyll Coliforms Colour Conductivity Dissolved Organic Carbon	DO E Coli FILT Reactive Phosphorus Iron Manganese Nitrate	Nitrite Phosphorus TDS Temperature TKN Turbidity

Location	Frequency	Site number	Site type	Parameters		
Happy Valley Reservoir Location 1 at 7 m	Nominated day, week and month	1202	Service reservoir offtake at depth	Algal enumeration	Iron	Temperature
				Colour	Manganese	Turbidity
				DO		
Happy Valley Reservoir Location 4	Nominated day, week and month	1204	Service reservoir other location	Algal enumeration		
Happy Valley Reservoir Location 5	Nominated day, week and month	1205	Service reservoir other location	Algal enumeration		
Happy Valley Reservoir Location 6	Nominated day, week and month	1206	Service reservoir other location	Algal enumeration		
Happy Valley Reservoir Location 10	Nominated day, week and month	1210	Service reservoir other location	DO	Temperature	
Happy Valley Reservoir Location 12	Nominated day, week and month	1220	Service reservoir other location	Algal enumeration		
Happy Valley WTP Inlet	Nominated day, week and month	1270	Water treatment plant inlet	Alkalinity	Copper	Nitrate
				Aluminium	Cryptosporidium	Nickel
				Ammonia	Cyanide	Nitrite
				Antimony	Dissolved Organic Carbon	Odour
				Arsenic	DO	Organochlorine
				Barium	E coli	Organophos and Triazine
				Beryllium	FILT Reactive Phosphorus	pH
				Bicarbonate	Fluoride	Phosphorus
				Boron	Giardia	Potassium
				Cadmium	Iodide	Selenium
				Calcium	Ion Balance	Silver
				Carbon Dioxide	Iron	Sodium
				Carbonate	Lead	Sulphate
				Chloride	Magnesium	TDS
				Chromium	Manganese	Temperature
				Coliforms	Mercury	Tin
				Colour	Molybdenum	TKN
				Conductivity	MIB (cyanobacteria)	Turbidity

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.

OCWMB — Onkaparinga Catchment Water Management Board.

P — Phosphorus.

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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