Water Monitoring Report

June 1995 - December 1997

Ambient Water Quality Monitoring of South Australia's Rivers and Streams

(Chemical and Physical Quality)

Report No 1

Environment Protection Agency
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SUMMARY

In South Australia the physical and chemical water quality of our rivers and streams varies from good to poor but is moderate in most cases.

This assessment arises from the monitoring of 15 rivers and streams across the State between June 1995 and December 1997 at sites that are considered to give representative pictures of those waterbodies.

The samples are collected monthly and analysed for nutrients, heavy metals and major ions, and for dissolved organic carbon, water clarity, salinity and physical characteristics such as temperature and pH.

The results of these analyses are then compared against national guidelines for each variable measured to designate if the quality is good, moderate or poor.

First Creek and Rocky River generally have good water quality but the River Torrens, Bremmer River, Mosquito Creek and Hill River are generally moderate to poor in quality. All other streams and rivers are classified as having generally moderate water quality.

Waterbodies have poor or moderate water quality in South Australia because they have:

- high salinity
- moderate to high levels of nutrients
- poor or moderate water clarity
- periods when the dissolved oxygen level is depleted
- elevated concentrations of some heavy metals.

Initiatives in South Australian catchments that should improve water quality include:

- **Environmental Improvement Programmes** and **Codes of Practice** for agricultural industries such as dairies and wineries, to improve environmental management and reduce pollutant runoff into streams
- an **Environment Protection (Water Quality) Policy** to deal with point and diffuse sources of pollution
- catchment management boards
- mapping of riparian vegetation and erosion in Mt Lofty catchments
- community education and monitoring programmes.

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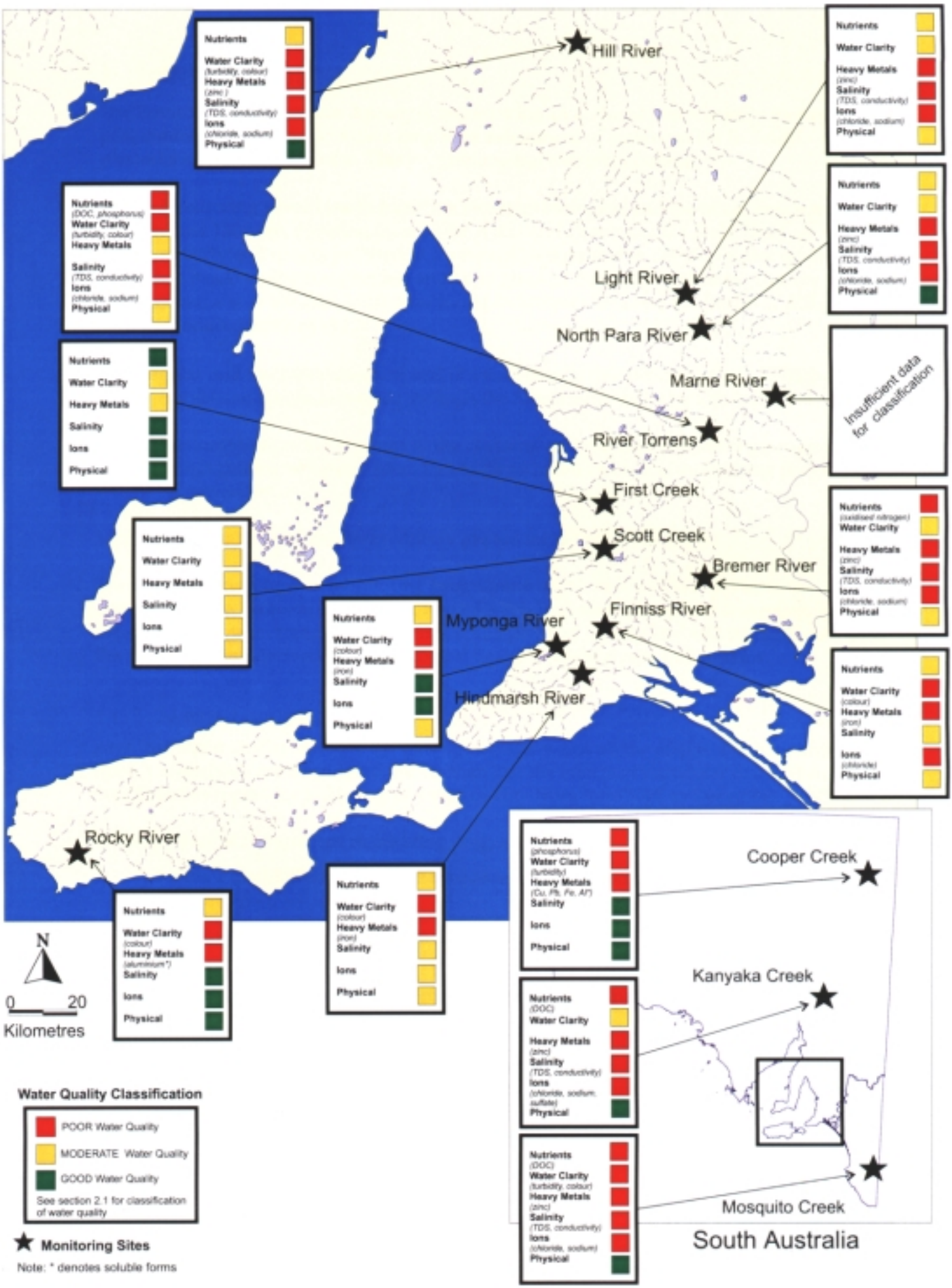
Figure 1

Ambient Water Quality Monitoring Sites South Australia's Rivers & Streams



1 INTRODUCTION

The Environment Protection Agency is undertaking an ambient water quality monitoring programme designed to provide a long term assessment of water quality in South Australia's rivers and streams. This programme has two components:

- The Monitoring River Health Initiative monitors biological and chemical characteristics from over 130 sites, covering most of the rivers and streams in the State. Sites are visited twice yearly and results are used in a national programme to develop water quality models based on the composition and abundance of macroinvertebrates. The aim of this programme is to use biological monitoring techniques to assess the health of different waterbodies (Norris et al 1993).

- A regular and intensive chemical and physical monitoring programme of 15 high priority reference sites identified through the Monitoring River Health Initiative.

This report summarises the findings of the chemical and physical monitoring programme of the 15 high priority reference sites. The findings of the biological monitoring programme will be reported later.

Monitoring results from the River Murray are not included in this report.

The chemical and physical monitoring programme began in June 1995 and aims to complement the National Monitoring River Health Initiative. The data are required to determine long term trends in the chemical and physical quality and will be correlated with the patterns being derived on the biological health of these rivers and streams.

1.1 AMBIENT WATER QUALITY

Ambient water quality refers to the quality of water when all the effects that may impact upon a waterbody are considered, rather than just the effects of particular discharges. The results in this report are indicative of water quality from June 1995 to December 1997.

The objectives of the ambient monitoring programme are 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.

In order for these objectives to be realised it is essential that data be collected for many years without substantial changes to the monitoring programme. It takes time before the statistical power associated with large data sets can be used to make reliable statements about changes and trends, particularly when natural variations are already large.

1.2 SOUTH AUSTRALIA'S RIVERS AND STREAMS

Ambient water quality monitoring is carried out in catchment areas of the Mt Lofty Ranges, Mid North, Flinders Ranges, Far North, Kangaroo Island and South East. The rivers and streams in some of these catchments are often dry, with significant changes in annual flow from one year to the next. As a consequence, some measured characteristics are highly variable.

Nevertheless a monthly monitoring programme is useful because, over time, it indicates the water quality conditions that prevail most of the time. It is this water quality that will largely determine whether the river or stream can support a healthy aquatic ecosystem. Data from such a programme can be assessed against national water quality criteria which characterise the environmental values of these waterbodies.

The environmental values for these rivers and streams are:

- the protection of the aquatic ecosystems
- aesthetic uses
- potable use
- agricultural uses of the water.

1.3 WHAT IS MONITORED

The characteristics measured in the chemical and physical monitoring programme are based on the water quality requirements to support the designated environmental values as contained in the Australian Guidelines for Fresh and Marine Waters (ANZECC 1992), the Australian Drinking Water Guidelines (NHMRC and ARMCANZ 1996), and the Australian Guidelines for Recreational Use of Water (NHMRC 1990).

Samples were collected each month (where some evidence of surface flow was present) and analysed for:

- nutrients (Total Kjeldahl Nitrogen or TKN, total phosphorus, orthophosphate, oxidised nitrogen (nitrate and nitrite as N), dissolved organic carbon and silica)
- metals (lead, zinc, copper, iron and aluminium)
- water clarity (turbidity) and salinity (total dissolved solids)
- major ions (chloride, fluoride, sulfate, calcium, magnesium, potassium, sodium and bicarbonate)
- physical characteristics (dissolved oxygen, temperature and pH).

From 1978 to 1984, water quality monitoring of surface waters was carried out by the Engineering and Water Supply Department (now SA Water) (Glatz 1985). That programme collected samples every six months from 89 sites and measured flow, salinity, turbidity, colour, dissolved organic carbon, the relative composition of cations and anions, dissolved oxygen, heavy metals and pesticides. Microbiological parameters were measured from some sites.

2. ASSESSMENT METHODS

The purpose of the monitoring programme is to assess the continuing water quality of the whole system by taking occasional, small and representative samples. It is clearly an uncertain process and if the data are to represent the true situation, the degree of uncertainty must be quantified. Some relatively simple statistical procedures can be used to assist in this understanding, including the use of confidence intervals (a known degree of confidence that the interval covers the true value) and control charts.

Tables of values listed in this report quote the mean, the 95% confidence intervals for the mean and the standard deviation. Other statistical parameters used are the median, and the 90th and 10th percentiles. The percentiles are used in lieu of a maximum and minimum to indicate the range, whereas the standard deviation indicates the spread of the data from the mean. The 90^{th} percentile and the median (the 50^{th} percentile) are used to determine broad water quality classifications.

2.1 WATER QUALITY CLASSIFICATION

It is useful to broadly classify the water quality at each site as either good, moderate or poor. As there are no accepted national criteria that can be used for such classifications the following criteria have been developed based on the percentage of time that the water quality conditions exceed the Australian Water Quality Guidelines for Fresh and Marine Waters (ANZECC 1992), the Australian Drinking Water Guidelines (NHRMC and ARMCANZ 1996), the Australian Guidelines for Recreational Use of Water (NHMRC 1990), and other criteria. It is recognised that the classifications used are somewhat arbitrary but they do provide a useful and relatively simple means of broadly classifying the water quality.

A. Toxicants and health related characteristics

- GOOD: 90th percentile is less than or equal to a criterion given below. (The water quality is less than a criterion most of the time. This means that, for samples taken monthly, if more than one measurement in a year exceeds a criterion then the water quality would not be classified as good).

- MODERATE: 90th percentile is greater than a criterion given below but the median is less than this criterion.

- POOR: Median is greater than or equal to a criterion given below OR any single measurement is more than 10 times this criterion. (The water quality exceeds a criterion more than 50% of the time or a single measurement is at the concentration where acute toxic effects may be observed in some organisms).

The water quality criteria listed in Table 1 below are based on national guidelines (ANZECC 1992, NHMRC and ARMCANZ 1996, NHMRC 1990) but adapted where appropriate for South Australian conditions and taking into consideration analytical detection limits.

Table 1 Criteria used to broadly classify water quality for toxicants and health related characteristics

Characteristic	Criterion	Comment
Soluble aluminium	0.1 mg/L	The national guideline for the protection of aquatic ecosystems is 0.1 mg/L if pH>6.5 (ANZECC 1992). Toxicity is due to soluble forms of aluminium.
Total copper	0.01 mg/L	The national guideline for the protection of aquatic ecosystems is 0.005 mg/L (ANZECC 1992) which is the same as the analytical detection limit for fresh waters. A higher criterion is used to overcome difficulties associated with measurements being at detection levels.
Total iron	1 mg/L	From national guidelines for the protection of the aquatic ecosystem (ANZECC 1992).
Total lead	0.005 mg/L	From national guidelines for the protection of the aquatic ecosystem (ANZECC 1992).
Total zinc	0.05 mg/L	From national guidelines for the protection of the aquatic ecosystem (ANZECC 1992).
Chloride	250 mg/L	From national drinking water guidelines (NHMRC and ARMCANZ 1996).
Fluoride	1.5 mg/L	From national drinking water guidelines (NHMRC and ARMCANZ 1996).
Sodium	180 mg/L	From national drinking water guidelines (NHMRC and ARMCANZ 1996).
Sulfate	500 mg/L	From national drinking water guidelines (NHMRC and ARMCANZ 1996).

B. Nutrients

There are no specific guidelines for nutrients in freshwater streams and rivers, only range concentrations indicative of freshwaters (ANZECC 1992). Table 1 describes a broad classification for nutrients in South Australia's rivers and streams based on:

- background levels from unimpacted sites in South Australia
- criteria used elsewhere to classify ambient water (EPA 1997a and b)
- range criteria for freshwaters (ANZECC 1992).

Dissolved organic carbon criteria were adapted from Hart and McKelvie (1986).

The 90th percentile of the measurements is used to determine the appropriate classification.

Table 2 Criteria used to broadly classify water quality for nutrients for the protection of freshwater ecosystems (all characteristics in mg/L).

	TKN-N	Oxidised nitrogen	Total phosphorus	Dissolved organic carbon
· GOOD:	<1.0	<0.1	<0.1	<10
· MODERATE	1.0-10	0.1-1.0	0.1-1.0	10-20
· POOR:	>10	>1.0	>1.0	>20

C. pH, Water Clarity, Dissolved Oxygen and Salinity

Broad water quality classifications for pH, dissolved oxygen and salinity are based on criteria to protect the aquatic ecosystem and recreational use (ANZECC 1992, in press; NHMRC 1990). Criteria for total dissolved solids were derived from the Australian drinking water guidelines (NHMRC and ARMCANZ 1996). Criteria for turbidity were based on water clarity requirements for swimming (NHMRC 1990).

The 90th percentile of the measurements is used to determine the appropriate classification. For dissolved oxygen, the 10th percentile is used to classify water quality. For pH, the 10th and 90th percentiles are used to classify water quality.

Table 3 Criteria used to broadly classify water quality for physical characteristics

	pH (pH units)	Dissolved oxygen (mg/L)	Colour (Hazen units)	Turbidity (NTU)	Salinity (µS/cm)	TDS (mg/L)
· GOOD:	6.5-9.0	>6	<25	<20	<1000	<500
· MODERATE	-	4-6	25-100	20-50	1000-2000	500-1000
· POOR:	<6.5 or >9.0	<4	>100	>50	>2000	>1000

3. ASSESSMENT OF THE DATA

Figure 1 shows the location of monitoring sites throughout South Australia.

3.1 SOURCES AND IMPACTS OF MEASURED CHARACTERISTICS

Nutrients

Nitrogen is an important nutrient that can stimulate plant growth in surface waters and lead to eutrophication. Total Kjeldahl Nitrogen (TKN) is a measure of organically bound nitrogen and includes both dissolved and particulate forms, whereas oxidised nitrogen includes only dissolved forms (nitrate and nitrite). Nitrite concentrations are normally low in well oxygenated surface waters.

Glatz (1985) found that nitrate and TKN are the most significant forms of nitrogen found in South Australian waters. The highest concentrations of nitrate were measured in surface waters of the Mt Lofty Ranges, believed to be caused by a combination of agricultural runoff and fertilisers.

Phosphorus is also an important nutrient and is an essential requirement for plants. Soluble phosphate is a measure of the biologically available dissolved form of phosphorus whereas total phosphate includes dissolved, particulate and organically bound phosphorus.

South Australian top soils are generally low in phosphorus and hence sources originate primarily from fertilisers and gully and channel erosion of sub soils. Glatz (1985) found that the highest phosphorus concentrations in surface waters are found in areas of the Mt Lofty Ranges used by agriculture and in waters associated with high turbidities and suspended solids.

Total organic carbon in water is composed of humic substances resulting from partly degraded plant and animal materials. Organic compounds adversely affect surface water taste, odour and colour.

Silica is widespread in surface waters and exists in dissolved and particulate forms and arises from the chemical weathering of siliceous materials. Silica is an essential element for some algae, particularly diatoms.

Physical Characteristics

The *pH* of water influences many biological and chemical processes. Changes in pH, particularly lower pH, can increase the toxicity of some pollutants including aluminium and ammonia, and cause greater solubilisation of heavy metals.

Temperature in surface waters varies with normal seasonal climatic fluctuations. Temperature affects the physical, chemical and biological processes in waterbodies, and therefore has an important role in determining the concentration of various water quality variables.

Dissolved oxygen (DO) is important for most aquatic organisms and varies with temperature, salinity, rainfall and runoff containing oxygen demanding organic material. Concentrations in unpolluted waters are generally between 7 and 10 mg/L. DO concentrations vary seasonally or even daily in response to temperature and biological activity. DO is used to

indicate the degree of pollution caused by organic matter. DO concentrations below 5 mg/L are stressful to most aquatic animals (ANZECC in press).

Water Clarity

Turbidity (measured in Nephelometric turbidity units or NTU) is influenced by the concentration of suspended matter, which consists of clay, silt and fine particles of inorganic and organic matter. Turbidity is a measure of the amount of scattering of light and can be approximately related to visibility as follows:

2 NTU	10 metres depth
5 NTU	4 metres depth
10 NTU	2 metres depth
25 NTU	0.9 metres depth
100 NTU	0.2 metres depth

A turbidity of 20 NTU would give a visibility of about 1.2 metres which is required for primary contact recreation (NHMRC 1990).

Water *colour* (the colour of water after particulate matter is removed) is influenced by the presence of dissolved organic and inorganic compounds. Colour is measured in Hazen units (Hu). A colour of 25 Hu would be acceptable for drinking, provided the turbidity is low.

Heavy Metals

Some metals, such as zinc and copper, are important in trace concentrations for biological processes in aquatic organisms. The same metals when discharged from sewage, industrial or agricultural runoff into streams at greater concentrations can be toxic.

Although the guideline for protection of the aquatic ecosystem (ANZECC 1992) lists a criterion for total aluminium (table 1) it is known that the toxicity is due to certain dissolved forms of the metal and not particulate aluminium. Soluble aluminium is therefore considered to be a better indicator of possible aluminium toxicity.

Salinity

Conductivity (specific conductance) is a measure of the ability of water to conduct an electric current and is influenced by dissolved mineral solids.

Total dissolved solids (TDS) consists of inorganic salts (major ions) and organic matter (nutrients) that are dissolved in water. TDS varies widely with flow.

Salinity can affect aquatic organisms directly through physiological changes or indirectly by changing the species composition of the ecosystem; for example, food webs.

Major Ions

Bicarbonate influences the hardness and alkalinity of water. The major source of bicarbonate is from weathering of rocks containing salts or minerals in a carbonate form such as limestone. Carbon dioxide from the atmosphere and biological respiration will also contribute to the bicarbonate content of surface waters.

Calcium is present in all waters and is dissolved from rocks such as limestone. The salts of calcium and magnesium contribute to water hardness. Calcium also derives from industrial sources and wastewater discharges. It is an essential element in the shells of molluscs and bones of vertebrates.

Chloride enters surface waters from the leaching of naturally occurring salt deposits, atmospheric deposition of oceanic aerosols, from the weathering of sedimentary rocks, industrial and sewage effluents, and agricultural and road runoff.

Fluoride originates from weathering of minerals containing fluoride. At concentrations of about 1 mg/L fluoride prevents dental corrosion in young children. Concentrations above 1.5 mg/L can cause dental fluorosis or mottling of the teeth. Regular consumption of water with fluoride concentrations in excess of 4 mg/L increases the risk of skeletal fluorosis.

Magnesium, like calcium, is common in surface waters. It derives from the weathering of rocks and is also found in organic matter. Magnesium is an essential element.

Potassium salts are highly soluble and widely used in industry and in fertilisers used for agriculture and enters waterbodies from discharges and run-off from agricultural land. Potassium salts are an essential element for some aquatic species.

Sodium is highly soluble in water and is one of the most abundant elements on earth. High sodium concentrations are undesirable in drinking water and can cause damage to soil structure when used in irrigation.

Sulfate is naturally present and arises from atmospheric deposition from oceanic aerosols, the leaching of sulfur compounds and from industrial discharges. It is readily soluble in water. Concentrations greater than 500 mg/L may make water unpleasant to drink and can cause purgative effects.

3.2 RIVER AND STREAM WATER QUALITY

Mosquito Creek (Struan at GS239519)

The Mosquito Creek catchment land uses include sheep and cattle grazing and some cropping. Some remnant Eucalypts, in open woodland, remain. Most native vegetation has been cleared from the catchment of this south eastern stream.

The results (table 4) indicated that Mosquito Creek had generally moderate to poor water quality based on the following:

- Salinity and concentrations of some major ions (sodium and chloride) were elevated.
- Water clarity (turbidity and colour) was poor.
- Copper, iron, zinc and soluble aluminium concentrations were elevated.
- Nutrients were present in moderate to poor concentrations.

Of interest is the relatively low concentration of nitrate in the surface water compared with the high concentration of nitrate in groundwater in the region (EPA in press).

Table 4 Mosquito Creek Water Quality

	Water Quality Characteristics (all values in mg/L unless specified).	Mean ± Confidence Interval	Median	Number of samples	Standard deviation	10th percentile	90th percentile	Water quali classificatic
Nutrients	Oxidised nitrogen	0.398 ± 0.149	0.341	21	0.341	0.010	0.952	moderate
	TKN	1.30 ± 0.48	0.765	20	1.07	0.39	2.64	moderate
	Total phosphorus	0.064 ± 0.030	0.022	21	0.069	0.008	0.171	moderate
	Soluble phosphorus	0.010 ± 0.006	0.005	21	0.013	0.005	0.019	-
	Dissolved organic carbon	11.7 ± 4.8	6.2	21	11.0	2.3	26.8	poor
	Silica	14.1 ± 2.4	15.0	21	5.4	6.0	21.0	-
Physical	pH (pH units)	7.9 ± 0.1	7.9	21	0.22	7.5	8.1	good
	Temperature (deg C)	14.8 ± 3.6	13.3	7	4.8	-	-	-
	Dissolved oxygen	9.3 ± 1.0	8.8	12	1.7	6.7	11.7	good
Clarity	Turbidity (NTU)	20 ± 12	4.7	21	28	0.8	70	poor
	Colour (Hu)	113 ± 58	36	21	133	11.3	293	poor
Heavy Metals	Total copper	0.007 ± 0.002	0.005	21	0.004	0.005	0.013	moderate
	Total lead	0.0013 ± 0.0002	0.001	21	0.0006	0.001	0.002	good
	Total zinc	0.063 ± 0.016	0.053	21	0.036	0.022	0.113	poor
	Soluble zinc	0.059 ± 0.015	0.051	21	0.035	0.019	0.110	-
	Total iron	1.068 ± 0.674	0.171	21	1.545	0.049	3.285	moderate
	Total aluminium	1.422 ± 0.933	0.259	21	2.137	0.086	3.960	-
	Soluble aluminium	0.231 ± 0.214	0.051	21	0.492	0.040	0.493	moderate
Salinity	Conductivity (µS/cm)	2104 ± 407	2510	21	932	531	2970	poor
	Total dissolved solids	1167 ± 227	1400	21	519	296	1680	poor
Ions	Chloride	498 ± 100	600	21	229	118	706	poor
	Fluoride	0.433 ± 0.055	0.460	21	0.125	0.222	0.546	good
	Sulfate	62 ± 12	71	21	28.1	15	88	good
	Bicarbonate	332 ± 66	424	21	152	94	469	-
	Calcium	89 ± 18	114	21	41.9	18	123	-
	Magnesium	44 ± 8	52	21	19	10	58	-
	Potassium	5.7 ± 0.6	6.3	21	1.5	3.6	7.1	-
	Sodium	287 ± 59	338	21	136	61	408	poor

Water quality classification based on criteria listed in section 2.1 of this report.

Rocky River (upstream of Gorge Falls at GS513501)

The Rocky River (Kangaroo Island) catchment is covered with native vegetation (Conservation Reserve) consisting of open forest, woodland, heath and shrubland.

The results (table 5) indicated that Rocky River had generally good water quality based on the following:

- Salinity and concentrations of major ions were low.
- Heavy metal concentrations, except for soluble aluminium, were low to moderate.
- Nutrient concentrations were low, although the dissolved organic carbon was moderate.
- Turbidity was low although colour was quite high.

Table 5 Rocky River Water Quality

	Water Quality Characteristics (all values in mg/L unless specified).	Mean ± Confidence Interval	Median	Number of samples	Standard deviation	10th percentile	90th percentile	Water quali classificatic
Nutrients	Oxidised nitrogen	0.011 ± 0.008	0.007	15	0.016	0.005	0.010	good
	TKN	0.519 ± 0.086	0.490	15	0.168	0.30	0.725	good
	Total phosphorus	0.020 ± 0.008	0.014	15	0.015	0.007	0.034	good
	Soluble phosphorus	0.0052 ± 0.0004	0.005	14	.0008	0.005	0.005	-
	Dissolved organic carbon	8.9 ± 1.1	8.2	15	2.15	6.3	11.2	moderate
	Silica	10.8 ± 1.9	11.0	15	3.7	4.5	15.5	-
Physical	pH (pH units)	7.1 ± 0.2	7.1	15	0.47	6.4	7.6	good
	Temperature	19.1± 8.8	17	5	9.9	-	-	
Clarity	Turbidity (NTU)	4.9 ± 3.6	3.0	15	7.1	1.4	5.7	good
	Colour (Hu)	79 ± 21	98	15	40	6.5	112	poor
Heavy Metals	Total copper	0.006 ± 0.002	0.005	15	0.003	0.005	0.010	moderate
	Total lead	0.0011 ± 0.0003	0.001	15	0.0005	0.001	0.001	good
	Total zinc	0.016 ± 0.005	0.015	15	0.009	0.005	0.028	good
	Soluble zinc	0.013 ± 0.004	0.011	15	0.007	0.005	0.023	-
	Total iron	0.865 ± 0.197	0.821	15	0.380	0.305	1.310	moderate
	Total aluminium	0.550 ± 0.360	0.400	15	0.699	0.119	0.742	-
	Soluble aluminium	0.151 ± 0.057	0.126	15	0.111	0.032	0.254	poor
Salinity	Conductivity (µS/cm)	537 ± 71	505	15	138	356	703	good
	Total dissolved solids	296 ± 39	280	15	76	195	385	good
Ions	Chloride	138 ± 15	144	15	29	91	168	good
	Fluoride	0.082 ± 0.036	0.050	15	0.070	0.05	0.11	good
	Sulfate	11.2 ± 4.5	8.9	15	8.65	3.3	22	good
	Bicarbonate	29 ± 20	13	15	39	5.5	81	-
	Calcium	6.8 ± 4.5	3.3	15	8.7	2.2	18	-
	Magnesium	10.9 ± 1.7	10.8	15	3.2	6.5	14	-
	Potassium	2.49 ± 0.44	2.3	15	0.86	1.2	3.7	-
	Sodium	77 ±8	77	15	14.7	53	91	good

Water quality classification based on criteria listed in section 2.1 of this report.

Hindmarsh River (Hindmarsh Valley at GS501500)

The Hindmarsh River catchment includes the land uses of sheep and cattle grazing, dairy farming and, covering a small area, remnant open woodland and pine forestry.

The results (table 6) indicated that the Hindmarsh River had generally moderate water quality based on the following:

- Water was highly coloured.
- Copper, iron and soluble aluminium concentrations were elevated and at times exceeded national criteria.
- Concentrations of nutrients (nitrogen and phosphorus) and some ions (chloride and sodium) were elevated.
- Based on salinity concentrations water quality was classified as moderate.
- Dissolved oxygen concentrations were low at times.

Table 6 Hindmarsh River Water Quality

	Water Quality Characteristics (all values in mg/L unless specified).	Mean ± Confidence Interval	Median	Number of samples	Standard deviation	10th percentile	90th percentile	Water quali classificatic
Nutrients	Oxidised nitrogen	0.145 ± 0.070	0.031	22	0.166	0.006	0.40	moderate
	TKN	0.964 ± 0.268	0.745	22	0.630	0.466	1.61	moderate
	Total phosphorus	0.132 ± 0.051	0.088	22	0.120	0.038	0.23	moderate
	Soluble phosphorus	0.048 ± 0.017	0.032	22	0.039	0.018	0.092	-
	Dissolved organic carbon	9.94 ± 1.48	8.5	23	3.56	6.3	15.3	moderate
	Silica	12.8 ± 1.9	12.5	22	4.39	8.0	19.4	-
Physical	pH (pH units)	7.9 ± 0.1	7.9	22	0.23	7.7	8.2	good
	Temperature (deg C)	13.4 ± 2.0	13	18	4.41	7.8	17.2	-
	Dissolved oxygen	9.6 ± 1.0	9.6	21	2.34	5.3	12.8	moderate
Clarity	Turbidity (NTU)	13.2 ± 8.5	6.1	23	20.4	3.0	26.8	moderate
	Colour (Hu)	95.5 ± 19.6	79	23	47	52	168	poor
Heavy Metals	Total copper	0.0075 ± 0.0017	0.005	22	0.0041	0.005	0.013	moderate
	Total lead	0.0015 ± 0.0004	0.001	22	0.0010	0.001	0.003	good
	Total zinc	0.0274 ± 0.0062	0.023	22	0.015	0.012	0.046	good
	Soluble zinc	0.0250 ± 0.0056	0.023	22	0.013	0.011	0.042	-
	Total iron	1.71 ± 0.37	1.51	22	0.88	0.68	2.7	poor
	Total aluminium	0.82 ± 0.46	0.33	22	1.07	0.096	2.08	-
	Soluble aluminium	0.22 ± 0.17	0.08	22	0.40	0.034	0.39	moderate
Salinity	Conductivity (µS/cm)	984 ± 129	994	22	305	535	1338	moderate
	Total dissolved solids	541 ± 71	550	22	169	292	738	moderate
Ions	Chloride	234± 34	236	22	80	117	331	moderate
	Fluoride	0.28± 0.03	0.27	22	0.067	0.192	0.37	good
	Sulfate	20.8 ± 3.3	17.5	22	7.9	13.4	33	good
	Bicarbonate	118 ± 18	114	22	44	60	188	-
	Calcium	24.5 ± 3.1	25.8	22	7.3	13	33	-
	Magnesium	18.6 ± 2.1	19.2	22	5.1	10	23	-
	Potassium	5.66 ± 0.76	5.3	22	1.8	3.7	7.2	-
	Sodium	144 ± 21	140	22	50	71	207	moderate

Water quality classification based on criteria listed in section 2.1 of this report.

Myponga River (upstream of reservoir and road bridge at GS502502)

The Myponga River catchment is mainly used for dairy farming and stock grazing. Some remnant open forest and woodland remains.

The results (table 7) indicated that the Myponga River had generally moderate to good water quality based on the following:

- Copper, iron and soluble aluminium concentrations were elevated.
- Dissolved oxygen concentrations were low at times.
- Nutrient (nitrogen and phosphorus) levels were moderate.
- Water colour was quite high.
- Turbidity was low.
- Water quality based on salinity and concentrations of major ions was classified as good.

Table 7 Myponga River Water Quality

	Water Quality Characteristics (all values in mg/L unless specified).	Mean ± Confidence Interval	Median	Number of samples	Standard deviation	10th percentile	90th percentile	Water quali classificatic
Nutrients	Oxidised nitrogen	0.058 ± 0.024	0.042	26	0.063	0.005	0.136	moderate
	TKN	0.903 ± 0.142	0.850	26	0.362	0.460	1.37	moderate
	Total phosphorus	0.090 ± 0.021	0.069	26	0.054	0.038	0.165	moderate
	Soluble phosphorus	0.023 ± 0.008	0.018	26	0.020	0.006	0.038	-
	Dissolved organic carbon	10.1 ± 1.3	9.6	26	3.4	4.9	15.14	moderate
	Silica	8.5 ± 1.1	8.0	26	2.7	4.0	12.0	-
Physical	pH (pH units)	7.1 ± 0.1	7.2	26	0.20	6.8	7.4	good
	Temperature (deg C)	12.7 ± 1.7	12.5	20	3.7	8.0	16.0	-
	Dissolved oxygen	7.1 ± 0.9	7.2	25	2.3	4.1	9.9	moderate
Clarity	Turbidity (NTU)	9.8 ± 2.1	9.3	26	5.3	3.9	16.8	good
	Colour (Hu)	90 ± 17	86	26	43	34	162	poor
Heavy Metals	Total copper	0.009 ± 0.003	0.006	26	0.007	0.005	0.018	moderate
	Total lead	0.0012 ± 0.0002	0.001	26	0.0005	0.001	0.002	good
	Total zinc	0.025 ± 0.005	0.023	26	0.013	0.010	0.042	good
	Soluble zinc	0.019 ± 0.004	0.020	26	0.010	0.007	0.033	-
	Total iron	1.78 ± 0.33	1.77	26	0.86	0.67	2.71	poor
	Total aluminium	0.56 ± 0.17	0.35	26	0.44	0.13	1.16	-
	Soluble aluminium	0.114 ± 0.039	0.078	26	0.100	0.029	0.255	moderate
Salinity	Conductivity (µS/cm)	653± 73	634	26	186	450	830	good
	Total dissolved solids	358 ± 40	350	26	102	246	456	good
Ions	Chloride	163 ± 18	155	26	46	107	217	good
	Fluoride	0.131 ± 0.015	0.120	26	0.038	0.092	0.180	good
	Sulfate	17.8 ± 3.7	15.9	26	9.6	6	32	good
	Bicarbonate	51 ± 15	38.5	26	39	26	81	-
	Calcium	18.7± 4.5	17.3	26	11.4	11	22	-
	Magnesium	15.6 ± 1.9	13.9	26	5.0	11	22	-
	Potassium	3.8 ± 0.6	3.6	26	1.5	2.0	5.9	-
	Sodium	82 ± 8	80	26	21	58	104	good

Water quality classification based on criteria listed in section 2.1 of this report.

Finniss River (4 km east of Yundi at GS426504)

The Finniss River catchment land uses include forestry, dairy farming and mixed agriculture. Some remnant woodland, open forest and shrubland remains. Agricultural runoff is likely to impact on water quality. The Finniss discharges into Lake Alexandrina.

The results (table 8) indicated that the Finniss River had generally moderate water quality based on the following:

- Copper, iron, zinc and soluble aluminium concentrations were elevated.
- Water colour was high and turbidity was moderate.
- Dissolved oxygen concentrations were low at times.
- Salinity and concentrations of some major ions (chloride and sodium) were slightly elevated.
- Nutrients (nitrogen and phosphorus) were present in moderate concentrations.

Table 8 Finniss River Water Quality

	Water Quality Characteristics (all values in mg/L unless specified).	Mean ± Confidence Interval	Median	Number of samples	Standard deviation	10th percentile	90th percentile	Water quali classificatic
Nutrients	Oxidised nitrogen	0.082 ± 0.038	0.050	22	0.089	0.005	0.191	moderate
	TKN	0.91 ± 0.19	0.79	22	0.454	0.41	1.56	moderate
	Total phosphorus	0.069 ± 0.023	0.052	22	0.055	0.021	0.148	moderate
	Soluble phosphorus	0.012 ± 0.005	0.005	22	0.012	0.005	0.027	-
	Dissolved organic carbon	9.04 ± 1.65	7.95	22	3.86	4.38	14.48	moderate
	Silica	9.4 ± 1.4	10.0	22	3.18	5.2	13.0	-
Physical	pH (pH units)	7.4 ± 0.1	7.4	22	0.27	6.9	7.6	good
	Temperature (deg C)	13.9 ± 2.0	12.5	22	4.67	8.2	19.8	-
	Dissolved oxygen	8.6 ± 1.4	9.1	18	2.9	4.3	12.0	moderate
Clarity	Turbidity (NTU)	12.5 ± 5.5	7.8	22	12.8	3.0	27.2	moderate
	Colour (Hu)	68 ± 10	50.5	22	46.9	22	142	poor
Heavy Metals	Total copper	0.009 ± 0.003	0.005	22	0.007	0.005	0.020	moderate
	Total lead	0.0015± 0.0004	0.001	22	0.0010	0.001	0.003	good
	Total zinc	0.047 ± 0.015	0.034	22	0.036	0.017	0.076	moderate
	Soluble zinc	0.032 ± 0.009	0.025	22	0.020	0.015	0.056	-
	Total iron	1.323 ± 0196	1.380	22	0.459	0.646	1.946	poor
	Total aluminium	0.496 ± 0.275	0.179	22	0.647	0.062	1.10	-
	Soluble aluminium	0.092 ± 0.039	0.045	22	0.092	0.024	0.232	moderate
Salinity	Conductivity (µS/cm)	1227 ± 147	1200	22	346	645	1636	moderate
	Total dissolved solids	672 ± 80	660	22	187	358	898	moderate
Ions	Chloride	314 ± 42	309	22	98	164	435	poor
	Fluoride	0.244 ± 0.032	0.235	22	0.076	0.16	0.298	good
	Sulfate	31 ± 5	29	22	12	17	46	good
	Bicarbonate	102 ± 12	104	22	29.3	52	134	-
	Calcium	35 ± 5	37	22	11.0	17.4	47	-
	Magnesium	32 ± 5	33	22	10.9	16.3	44	-
	Potassium	4.8 ± 0.4	4.5	22	1.1	3.8	5.5	-
	Sodium	159 ± 19	155	22	45	81	208	moderate

Water quality classification based on criteria listed in section 2.1 of this report.

Bremer River (near Hartley at GS426533)

The Bremer River catchment land uses include sheep grazing and cropping. Pockets of remnant open forest, woodland and scrub still remain. The river discharges into Lake Alexandrina which, along with Lake Albert, has been the subject of a separate monitoring programme (EPA 1997a).

The results (table 9) indicated that the Bremer River had generally poor to moderate water quality based on the following:

- Salinity and concentrations of some major ions (sodium and chloride) were quite high.
- Copper, zinc and soluble aluminium concentrations were elevated.
- Dissolved oxygen concentrations were low at times.
- Water clarity (turbidity and colour) was moderate.
- Concentrations of nutrients (nitrogen and phosphorus) were elevated.

Table 9 Bremer River Water Quality

	Water Quality Characteristics (all values in mg/L unless specified).	Mean ± Confidence Interval	Median	Number of samples	Standard deviation	10th percentile	90th percentile	Water quali classificatic
Nutrients	Oxidised nitrogen	1.24 ± 0.75	0.38	22	1.75	0.006	3.20	poor
	TKN	1.32 ± 0.37	1.11	22	0.876	0.71	1.60	moderate
	Total phosphorus	0.148 ± 0.096	0.094	22	0.226	0.027	0.234	moderate
	Soluble phosphorus	0.036 ± 0.022	0.009	22	0.052	0.005	0.098	-
	Dissolved organic carbon	8.49 ± 0.73	8.40	22	1.72	6.4	9.8	good
	Silica	2.59 ± 1.04	1.0	22	2.4	1.0	6.6	-
Physical	pH (pH units)	7.9 ± 0.1	7.9	22	0.27	7.4	8.2	good
	Temperature (deg C)	14.5 ± 3.9	13.0	15	4.5	10.5	21	-
	Dissolved oxygen	8.3 ± 1.0	8.3	20	2.2	5.4	11.3	moderate
Clarity	Turbidity (NTU)	26 ± 39	4.1	22	92	2.34	21	moderate
	Colour (Hu)	28 ± 7	23	22	16	18	37	moderate
Heavy Metals	Total copper	0.012 ± 0.005	0.009	22	0.012	0.005	0.018	moderate
	Total lead	0.0018 ± 0.0012	0.001	22	0.003	0.001	0.002	good
	Total zinc	0.117 ± 0.028	0.117	22	0.064	0.041	0.176	poor
	Soluble zinc	0.091 ± 0.022	0.081	22	0.051	0.029	0.140	-
	Total iron	0.725 ± 0.782	0.228	22	1.835	0.103	0.875	good
	Total aluminium	0.849 ± 0.834	0.216	22	1.955	0.086	1.87	-
	Soluble aluminium	0.093 ± 0.030	0.073	22	0.071	0.027	0.162	moderate
Salinity	Conductivity (µS/cm)	3361± 420	3475	22	987	1518	3984	poor
	Total dissolved solids	1871 ± 236	1900	22	554	840	2200	poor
Ions	Chloride	863 ± 121	889	22	285	352	1060	poor
	Fluoride	0.951 ± 0.113	0.970	22	0.266	0.436	1.218	good
	Sulfate	215 ± 25	215	22	58	105	279	good
	Bicarbonate	254 ± 44	253	22	104	122	344	-
	Calcium	84 ± 9.2	83	22	22	41	103	-
	Magnesium	75 ± 10	76	22	23	31	92	-
	Potassium	23 ± 2.9	22	22	6.9	15	32	-
	Sodium	502 ± 75	506	22	176	207	625	poor

Water quality classification based on criteria listed in section 2.1 of this report.

Scott Creek (Scotts Bottom at GS 503502)

The Scott Creek catchment includes cattle grazing, hobby farming and some remnant open forests and woodlands.

The results (table 10) indicated that Scott Creek had generally good to moderate water quality based on the following:

- Copper, zinc, iron and soluble aluminium concentrations were elevated.
- Dissolved oxygen concentrations were low at times.
- Water was coloured.
- Water quality based on salinity and concentrations of some ions (chloride and sodium) was moderate.
- Concentrations of nutrients were generally quite low.
- Turbidity was low.

Table 10 Scott Creek Water Quality

	Water Quality Characteristics (all values in mg/L unless specified).	Mean ± Confidence Interval	Median	Number of samples	Standard deviation	10th percentile	90th percentile	Water quali classificatic
Nutrients	Oxidised nitrogen	0.032 ± 0.018	0.012	22	0.042	0.005	0.070	good
	TKN	0.544 ± 0.118	0.415	22	0.277	0.270	0.910	good
	Total phosphorus	0.051 ± 0.016	0.043	22	0.038	0.028	0.054	good
	Soluble phosphorus	0.015 ± 0.004	0.012	22	0.010	0.006	0.024	-
	Dissolved organic carbon	6.47 ± 1.16	5.60	21	2.66	3.6	10.9	moderat
	Silica	15.4 ± 1.6	13.0	22	3.8	11.2	20.8	-
Physical	pH (pH units)	7.8 ± 0.1	7.9	22	0.2	7.6	8.0	good
	Temperature (deg C)	14.1 ± 1.5	14.0	19	3.4	8.9	17.2	-
	Dissolved oxygen	8.0± 0.8	7.8	21	2.0	4.5	10.0	moderate
Clarity	Turbidity (NTU)	3.8 ± 1.3	3.0	23	3.2	1.1	7.67	good
	Colour (Hu)	46 ± 13	32	23	32	21	90	moderate
Heavy Metals	Total copper	0.012 ± 0.008	0.005	22	0.020	0.005	0.018	moderate
	Total lead	0.0013 ± 0.0002	0.001	22	0.0004	0.001	0.002	good
	Total zinc	0.047 ± 0.011	0.041	22	0.026	0.020	0.073	moderat
	Soluble zinc	0.037 ± 0.006	0.034	22	0.015	0.020	0.060	-
	Total iron	0.514 ± 0.152	0.376	22	0.357	0.140	1.07	moderate
	Total aluminium	0.233 ± 0.120	0.096	22	0.282	0.047	0.717	-
	Soluble aluminium	0.093 ± 0.050	0.038	22	0.117	0.023	0.292	moderate
Salinity	Conductivity (µS/cm)	1200 ± 185	1260	22	434	540	1774	moderate
	Total dissolved solids	662 ± 103	695	22	242	294	976	moderate
Ions	Chloride	224 ± 38	230	22	90	94	340	moderate
	Fluoride	0.542 ± 0.073	0.585	22	0.172	0.28	0.734	good
	Sulfate	43.2 ± 5.8	45.1	22	13.6	20	57	good
	Bicarbonate	285 ± 51	303	22	120	106	420	-
	Calcium	48 ± 8.6	48	22	20	17	72	-
	Magnesium	50 ± 8	51	22	20	18	71	-
	Potassium	5.6 ± 0.6	5.5	22	1.4	3.5	7.6	-
	Sodium	125 ± 20	123	22	46	57	184	moderate

Water quality classification based on criteria listed in section 2.1 of this report.

First Creek (Waterfall Gully at GS504517)

The majority of the catchment of First Creek is covered by native vegetation (Cleland Conservation Park). Samples were taken at the Waterfall Gully gauge station.

The results (table 11) indicated that First Creek had generally good water quality based on the following:

- Salinity and concentrations of major ions were low.
- Water colour was slightly elevated but turbidity was low.
- Copper and soluble aluminium concentrations were slightly elevated but concentrations of other heavy metals were low.
- Concentrations of nutrients were low.

The slightly elevated colour, copper and soluble aluminium concentrations were probably indicative of background concentrations in the Mt Lofty ranges. The confidence intervals for the means were quite narrow indicating low variability in the quality of water from the upstream catchment.

Table 11 First Creek Water Quality

	Water Quality Characteristics (all values in mg/L unless specified).	Mean ± Confidence Interval	Median	Number of samples	Standard deviation	10th percentile	90th percentile	Water quali classificatic
Nutrients	Oxidised nitrogen	0.022 ± 0.013	0.010	25	0.032	0.005	0.043	good
	TKN	0.274 ± 0.055	0.270	25	0.138	0.115	0.435	good
	Total phosphorus	0.009 ± 0.001	0.007	25	0.004	0.005	0.014	good
	Soluble phosphorus	0.0050 ± 0.0001	0.005	24	.0004	0.005	0.005	-
	Dissolved organic carbon	4.82 ± 0.90	4.20	25	2.26	2.25	7.95	good
	Silica	17.0 ± 2.4	18.0	25	6.2	6.5	23.5	-
Physical	pH (pH units)	7.5 ± 0.1	7.5	25	0.3	7.1	7.7	good
	Temperature (deg C)	13.0 ± 1.4	13.0	23	3.3	9.0	17	
	Dissolved oxygen	9.93 ± 0.73	9.7	23	1.76	7.5	11.9	good
Clarity	Turbidity (NTU)	3.6 ± 2.7	1.0	25	6.9	0.4	8.5	good
	Colour (Hu)	47 ± 11	38	25	27	20	73	moderate
Heavy Metals	Total copper	0.013 ± 0.009	0.005	25	0.022	0.005	0.018	moderate
	Total lead	0.0013± 0.0003	0.001	25	0.0008	0.001	0.002	good
	Total zinc	0.019 ± 0.005	0.016	25	0.014	0.005	0.031	good
	Soluble zinc	0.015 ± 0.004	0.012	25	0.012	0.005	0.025	
	Total iron	0.244 ± 0.055	0.223	25	0.138	0.102	0.360	good
	Total aluminium	0.179 ± 0.072	0.117	25	0.180	0.045	0.401	-
	Soluble aluminium	0.100 ± 0.027	0.085	25	0.070	0.032	0.196	moderate
Salinity	Conductivity (µS/cm)	307± 34	333	25	84	160	394	good
	Total dissolved solids	169 ± 18	180	25	46	88	220	good
Ions	Chloride	70 ± 8	76	25	20	37.5	91	good
	Fluoride	0.130 ± 0.060	0.100	25	0.150	0.055	0.135	good
	Sulfate	12 ± 5	9	25	11	7	15	good
	Bicarbonate	25 ± 4	28	25	10	9	37	
	Calcium	4.9 ± 0.6	5.0	25	1.6	2.4	6.3	
	Magnesium	7.2 ± 0.8	7.8	25	2.1	3.8	9.0	
	Potassium	3.1 ± 0.3	3.2	25	0.8	2	3.8	
	Sodium	41 ± 4	44	25	11.1	22	51	good

Water quality classification based on criteria listed in section 2.1 of this report.

River Torrens (Mt Pleasant at GS504512)

The River Torrens catchment includes the land uses of sheep and cattle grazing, hobby farming and urban development. Some remnant open forest and woodland remains.

The results (table 12) indicated that the River Torrens had generally moderate to poor water quality based on the following:

- Salinity and concentrations of some major ions (sodium and chloride) were quite high.
- Water colour and turbidity were often poor.
- Copper, iron, soluble aluminium and zinc concentrations were elevated.
- Concentrations of nutrients (including dissolved organic carbon) were quite high.
- Dissolved oxygen concentrations were low at times.

Table 12 River Torrens Water Quality

	Water Quality Characteristics (all values in mg/L unless specified).	Mean ± Confidence Interval	Median	Number of samples	Standard deviation	10th percentile	90th percentile	Water quali classificatic
Nutrients	Oxidised nitrogen	0.371 ± 0.163	0.285	26	0.416	0.005	0.948	moderate
	TKN	2.313 ± 0.532	2.055	26	1.357	1.24	3.108	moderate
	Total phosphorus	0.508 ± 0.164	0.371	26	0.420	0.109	1.144	poor
	Soluble phosphorus	0.275 ± 0.104	0.172	26	0.264	0.024	0.632	-
	Dissolved organic carbon	18.0 ± 1.8	18.0	26	4.54	13.0	24.4	poor
	Silica	4.84 ± 1.65	3.0	26	4.2	1.0	10.2	-
Physical	pH (pH units)	7.93 ± 0.24	7.85	26	0.61	7.0	8.6	good
	Temperature (deg C)	13.2 ± 1.7	13.0	20	3.8	9.0	18.0	-
	Dissolved oxygen	8.9 ± 0.9	9.2	24	2.2	5.4	11.6	moderate
Clarity	Turbidity (NTU)	18.3 ± 8.7	9.6	26	22.1	2.3	55.4	poor
	Colour (Hu)	82 ± 18	65	26	46	44	156	poor
Heavy Metals	Total copper	0.012 ± 0.007	0.005	26	0.019	0.005	0.019	moderate
	Total lead	0.0011 ± 0.0002	0.001	26	0.0005	0.001	0.001	good
	Total zinc	0.077 ± 0.051	0.046	26	0.131	0.023	0.104	moderate
	Soluble zinc	0.046 ± 0.010	0.038	26	0.025	0.018	0.074	-
	Total iron	1.058 ± 0.318	0.850	26	0.810	0.144	2.268	moderate
	Total aluminium	0.721 ± 0.336	0.420	26	0.858	0.059	1.49	-
	Soluble aluminium	0.084 ± 0.024	0.062	26	0.062	0.030	0.150	moderate
Salinity	Conductivity (µS/cm)	2756 ± 434	2835	26	1107	1144	3974	poor
	Total dissolved solids	1536 ± 242	1600	26	617	630	2200	poor
Ions	Chloride	755 ± 131	782	26	334	299	1114	poor
	Fluoride	0.74 ± 0.13	0.74	26	0.32	0.26	1.17	good
	Sulfate	72 ± 10	71	26	24.9	39	105	good
	Bicarbonate	207 ± 40	198	26	103	46	323	-
	Calcium	51 ± 6	51	26	14.4	29	66	-
	Magnesium	65 ± 10	67	26	26.8	28	94	-
	Potassium	11.3 ± 2.3	8.6	26	5.8	5.9	19	-
	Sodium	422 ± 75	424	26	192	158	616	poor

Water quality classification based on criteria listed in section 2.1 of this report.

Marne River (upstream of Cambrai at GS426529)

The Marne River catchment land uses include sheep grazing, cropping and viticulture. Some remnant low woodland vegetation remains. The Marne River drains from the eastern side of the Mt Lofty Ranges and discharges into the River Murray.

There were insufficient data to classify the water quality of the Marne River based on the criteria given in section 2.1. With the limited data available the results in Table 13 indicated that:

- Salinity concentrations were quite high.
- Nutrients (TKN and dissolved organic carbon) were elevated.
- Concentrations of major ions (chloride and sodium) were quite high.
- Turbidity was low but colour was elevated.
- Heavy metals were generally low.

There was little data available for the Marne River because of difficulties in obtaining regular samples. Steps have been recently made to overcome these problems.

Table 13 Marne River Water Quality

	Water Quality Characteristics (all values in mg/L unless specified).	Mean ± Confidence Interval	Median	Number of samples	Standard deviation	10th percentile	90th percentile	Water quali classificatic
Nutrients	Oxidised nitrogen	0.059 ± 0.044	0.036	8	0.063	-	-	-
	TKN	1.29 ± 0.27	1.26	8	0.389	-	-	-
	Total phosphorus	0.040 ± 0.012	0.034	8	0.018	-	-	-
	Soluble phosphorus	0.012 ± 0.011	0.005	8	0.015	-	-	-
	Dissolved organic carbon	16.1 ± 2.5	17.4	8	3.6	-	-	-
	Silica	7.1 ± 6.1	5.0	8	8.5	-	-	-
Physical	pH (pH units)	7.9 ± 0.2	8.1	8	0.3	-	-	-
	Temperature (deg C)	16.8 ± 5.3	19.0	4	5.3	-	-	-
Clarity	Turbidity (NTU)	3.4 ± 2.4	2.6	8	3.4	-	-	-
	Colour (Hu)	82 ± 33	85	8	47	-	-	-
Heavy Metals	Total copper	0.008 ± 0.003	0.006	8	0.005	-	-	-
	Total lead	0.001	0.001	8	-	-	-	-
	Total zinc	0.059 ± 0.035	0.043	8	0.050	-	-	-
	Soluble zinc	0.058 ± 0.035	0.042	8	0.050	-	-	-
	Total iron	0.318 ± 0.225	0.229	8	0.319	-	-	-
	Total aluminium	0.212 ± 0.200	0.070	8	0.283	-	-	-
	Soluble aluminium	0.068 ± 0.039	0.046	8	0.055	-	-	-
Salinity	Conductivity (µS/cm)	2508 ± 703	2155	8	995	-	-	-
	Total dissolved solids	1400 ± 402	1200	8	568	-	-	-
Ions	Chloride	642 ± 195	533	8	275	-	-	-
	Fluoride	0.850 ± 0.250	0.785	8	0.352	-	-	-
	Sulfate	79 ± 32	65	8	46	-	-	-
	Bicarbonate	265 ± 75	258	8	107	-	-	-
	Calcium	65 ± 18	59	8	26	-	-	-
	Magnesium	61 ± 16	54	8	23	-	-	-
	Potassium	9.6 ± 2.5	8.0	8	3.6	-	-	-
	Sodium	357 ± 104	305	8	147	-	-	-

Water quality classification based on criteria listed in section 2.1 of this report.

North Para River (Penrice at GS505517)

The North Para River catchment land uses include viticulture, sheep and cattle grazing, and some areas of low open forest and woodland. Agriculture and viticultural runoff would be expected to impact on water quality due to the extent of these activities in the North Para River's catchment.

The results (table 14) indicated that the North Para River had generally moderate water quality based on the following:

- Salinity and concentrations of some major ions (sodium and chloride) were quite high.
- Zinc and copper concentrations were elevated.
- Oxidised nitrogen, TKN and dissolved organic carbon concentrations were elevated.
- Colour was slightly elevated but turbidity was low.

Table 14 North Para River Water Quality

	Water Quality Characteristics (all values in mg/L unless specified).	Mean ± Confidence Interval	Median	Number of samples	Standard deviation	10th percentile	90th percentile	Water quali classificatic
Nutrients	Oxidised nitrogen	0.100 ± 0.058	0.050	24	0.142	0.006	0.309	moderate
	TKN	0.965 ± 0.179	0.805	24	0.440	0.472	1.572	moderate
	Total phosphorus	0.048 ± 0.019	0.029	24	0.064	0.012	0.094	good
	Soluble phosphorus	0.011 ± 0.008	0.005	24	0.020	0.005	0.015	-
	Dissolved organic carbon	9.1 ± 1.8	7.3	24	4.4	4.5	15.9	moderate
	Silica	10.4 ± 1.9	11.5	24	4.7	3.4	16.6	-
Physical	pH (pH units)	8.1 ± 0.1	8.1	24	0.2	7.7	8.4	good
	Temperature (deg C)	15.5 ± 2.1	14	23	5.0	9.3	22	-
	Dissolved oxygen	9.6 ± 0.9	9.8	23	2.2	6.2	12.4	good
Clarity	Turbidity (NTU)	3.94 ± 2.6	1.6	24	6.3	0.84	7.1	good
	Colour (Hu)	45 ± 16	32	24	38	15	89	moderate
Heavy Metals	Total copper	0.016 ± 0.009	0.005	24	0.022	0.005	0.041	moderate
	Total lead	0.0013± 0.0007	0.001	24	0.002	0.001	0.001	good
	Total zinc	0.074 ± 0.019	0.062	24	0.047	0.025	0.125	poor
	Soluble zinc	0.069 ± 0.019	0.061	24	0.046	0.024	0.111	-
	Total iron	0.302 ± 0.134	0.180	24	0.328	0.079	0.698	good
	Total aluminium	0.235 ± 0.165	0.084	24	0.405	0.040	0.545	-
	Soluble aluminium	0.053 ± 0.011	0.046	24	0.028	0.030	0.097	good
Salinity	Conductivity (µS/cm)	2509 ± 289	2465	24	708	1434	3462	poor
	Total dissolved solids	1383 ± 158	1400	24	388	788	1900	poor
Ions	Chloride	561 ± 72	534	24	178	303	794	poor
	Fluoride	0.723 ± 0.056	0.760	24	0.138	0.486	0.85	good
	Sulfate	144 ± 28	124	24	70	66	254	good
	Bicarbonate	367 ± 34	387	24	83	217	446	-
	Calcium	89 ± 10	86	23	24	54	118	-
	Magnesium	70 ± 9	67	23	23	37	100	-
	Potassium	14 ± 2	13	24	4.4	7.6	20	-
	Sodium	335 ± 42	320	24	105	175	477	poor

Water quality classification based on criteria listed in section 2.1 of this report.

Light River (Mingay's Waterhole at GS505532)

The Light River catchment land uses include sheep and cattle grazing, viticulture and cropping. Some remnant woodland remains.

The results (table 15) indicated that the Light River had generally moderate water quality based on the following:

- Salinity and concentrations of some major ions (sodium and chloride) were very high.
- Zinc concentrations were elevated but concentrations of other heavy metals were low.
- Water colour was slightly elevated but turbidity was low.
- Oxidised nitrogen and TKN concentrations were elevated but phosphorus concentrations were low.
- Dissolved oxygen concentrations were low at times.

Table 15 Light River Water Quality

	Water Quality Characteristics (all values in mg/L unless specified).	Mean ± Confidence Interval	Median	Number of samples	Standard deviation	10th percentile	90th percentile	Water quali classificatic
Nutrients	Oxidised nitrogen	0.076 ± 0.060	0.020	24	0.146	0.006	0.180	moderate
	TKN	0.597 ± 0.142	0.480	24	0.347	0.300	0.914	moderate
	Total phosphorus	0.020 ± 0.005	0.018	24	0.011	0.009	0.035	good
	Soluble phosphorus	0.0052± 0.0004	0.005	23	0.001	0.005	0.005	-
	Dissolved organic carbon	5.3 ± 1.0	4.1	24	2.51	2.9	9.32	good
	Silica	8.8 ± 1.2	9.5	24	2.8	5.0	12.0	-
Physical	pH (pH units)	8.1 ± 0.1	8.1	24	0.13	7.9	8.2	good
	Temperature (deg C)	16.7 ± 2.1	17.0	22	4.8	11.0	23.0	-
	Dissolved oxygen	9.1 ± 1.0	8.9	19	2.2	5.7	11.9	moderate
Clarity	Turbidity (NTU)	4.7 ± 2.5	1.8	24	6.3	0.8	12.2	good
	Colour (Hu)	22 ± 8.7	13	24	21	8	54	moderate
Heavy Metals	Total copper	0.006 ± 0.002	0.005	24	0.006	0.005	0.006	good
	Total lead	0.0010± 0.0001	0.001	24	0.0002	0.001	0.001	good
	Total zinc	0.143 ± 0.037	0.112	24	0.092	0.056	0.252	poor
	Soluble zinc	0.126 ± 0.030	0.096	24	0.074	0.049	0.234	-
	Total iron	0.222 ± 0.102	0.120	24	0.249	0.082	0.503	good
	Total aluminium	0.245 ± 0.143	0.101	24	0.352	0.064	0.543	-
	Soluble aluminium	0.063 ± 0.015	0.056	24	0.037	0.032	0.075	good
Salinity	Conductivity (µS/cm)	8214 ± 1012	9275	24	2480	4258	10100	poor
	Total dissolved solids	4672 ± 581	5250	24	1424	2400	5800	poor
Ions	Chloride	2790 ± 498	2815	24	1219	1398	3222	poor
	Fluoride	0.801 ± 0.051	0.785	24	0.113	0.652	0.916	good
	Sulfate	392 ± 34	417	24	84	228	456	good
	Bicarbonate	397 ± 21	399	24	53	308	456	-
	Calcium	144 ± 10	144	24	26	108	173	-
	Magnesium	232 ± 22	247	24	53	130	277	-
	Potassium	37 ± 4	38	24	9.2	20	46	-
	Sodium	1369 ± 139	1485	24	340	745	1674	poor

Water quality classification based on criteria listed in section 2.1 of this report.

Hill River (near Andrews at GS507500)

The Hill River catchment land uses include sheep and cattle grazing and cropping. Some remnant low woodland remains.

The results (table 16) indicated that the Hill River had generally moderate to poor water quality based on the following:

- Water clarity (colour and turbidity) was poor.
- Salinity and concentrations of some major ions (sodium and chloride) were high.
- Dissolved oxygen concentrations were low at times.
- Copper, zinc and iron concentrations were elevated.
- Concentrations of nutrients (nitrogen and phosphorus) were elevated.

The paucity of data from this site is due to irregular flow. The Hill River only flows briefly after extensive rainfall events.

Table 16 Hill River Water Quality

	Water Quality Characteristics (all values in mg/L unless specified).	Mean ± Confidence Interval	Median	Number of samples	Standard deviation	10th percentile	90th percentile	Water quali classificatic
Nutrients	Oxidised nitrogen	0.177 ± 0.177	0.062	10	0.280	0.009	0.600	moderate
	TKN	1.52 ± 0.48	1.24	10	0.759	0.88	2.19	moderate
	Total phosphorus	0.179 ± 0.102	0.122	10	0.162	0.028	0.400	moderate
	Soluble phosphorus	0.063 ± 0.044	0.038	10	0.069	0.005	0.168	-
	Dissolved organic carbon	13.1 ± 1.9	12.8	10	3.05	7.5	14.5	moderate
	Silica	8.6 ± 2.6	10.0	10	4.1	3	13	-
Physical	pH (pH units)	7.8 ± 0.2	7.7	10	0.3	7.4	7.9	good
	Temperature (deg C)	15.5 ± 2.8	15.0	9	4.2	-	-	-
	Dissolved oxygen	7.2 ± 2.6	7.1	7	2.2	-	-	-
Clarity	Turbidity (NTU)	43 ± 47	8.4	11	78	1.1	58	poor
	Colour (Hu)	79 ± 35	73	11	60	5.4	163	poor
Heavy Metals	Total copper	0.009 ± 0.004	0.005	10	0.007	0.005	0.019	moderate
	Total lead	0.0018 ± 0.0010	0.001	10	0.0016	0.001	0.003	good
	Total zinc	0.050 ± 0.011	0.056	10	0.018	0.024	0.063	poor
	Soluble zinc	0.046 ± 0.090	0.047	10	0.015	0.024	0.059	-
	Total iron	1.74 ± 1.35	0.763	10	2.14	0.08	3.23	moderate
	Total aluminium	1.61 ± 1.40	0.567	10	2.21	0.08	5.08	-
	Soluble aluminium	0.064 ± 0.019	0.058	10	0.030	0.025	0.097	good
Salinity	Conductivity (µS/cm)	2658 ± 1127	2270	10	1782	851	4950	poor
	Total dissolved solids	1469 ± 628	1250	10	993	470	2800	poor
Ions	Chloride	681 ± 321	557	10	508	175	1350	poor
	Fluoride	0.69 ± 0.14	0.685	10	0.225	0.33	0.94	good
	Sulfate	156 ± 68	144	10	107	46	285	good
	Bicarbonate	248± 82	224	10	130	115	442	-
	Calcium	81 ± 33	73	10	52	25	144	-
	Magnesium	80 ± 38	66	10	60	19	164	-
	Potassium	9.8 ± 2.4	9.9	10	3.7	6.7	11.2	-
	Sodium	368 ± 165	307	10	261	104	712	poor

Water quality classification based on criteria listed in section 2.1 of this report.

Kanyaka Creek (Old Kanyaka at GS509503)

The Kanyaka Creek catchment, situated in the north of the State, includes land uses such as sheep and cattle grazing on low woodland and chenopod shrubland.

The results (table 17) indicated that Kanyaka Creek had generally moderate water quality based on the following:

- Salinity and concentrations of some major ions (sulfate, sodium and chloride) were present in very high concentrations.
- Zinc concentrations were high and copper concentrations were slightly elevated but other heavy metals were low.
- Dissolved organic carbon and TKN concentrations were elevated although oxidised nitrogen and phosphorus concentrations were low.
- Colour was moderate and turbidity was good.

Table 17 Kanyaka Creek Water Quality

	Water Quality Characteristics (all values in mg/L unless specified).	Mean ± Confidence Interval	Median	Number of samples	Standard deviation	10th percentile	90th percentile	Water quali classificatic
Nutrients	Oxidised nitrogen	0.020 ± 0.026	0.006	14	0.049	0.005	0.014	good
	TKN	1.03 ± 0.30	0.97	14	0.558	0.398	1.59	moderate
	Total phosphorus	0.033 ± 0.008	0.031	14	0.015	0.013	0.050	good
	Soluble phosphorus	0.006 ± 0.001	0.005	14	0.003	0.005	0.009	-
	Dissolved organic carbon	10.7 ± 3.2	10.3	14	5.96	4.46	15.4	poor
	Silica	12.4 ± 2.0	12.5	14	3.75	5.0	15.8	-
Physical	pH (pH units)	7.8 ± 0.1	7.9	14	0.18	7.5	8.0	good
Clarity	Turbidity (NTU)	3.4 ± 1.3	2.5	14	2.5	0.86	7.2	good
	Colour (Hu)	21 ± 7	16	14	13	10	36	moderate
Heavy Metals	Total copper	0.008 ± 0.004	0.005	14	0.007	0.005	0.011	moderate
	Total lead	0.001	0.001	14	0	0.001	0.001	good
	Total zinc	0.221 ± 0.061	0.218	14	0.114	0.080	0.319	poor
	Soluble zinc	0.216 ± 0.060	0.213	14	0.114	0.077	0.311	-
	Total iron	0.211 ± 0.082	0.187	14	0.154	0..063	0.411	good
	Total aluminium	0.097 ± 0.051	0.066	14	0.095	0.041	0.192	-
	Soluble aluminium	0.052 ± 0.009	0.048	14	0.017	0.031	0.066	good
Salinity	Conductivity (µS/cm)	11867 ± 3113	10500	14	5825	4922	18480	poor
	Total dissolved solids	6928 ± 1947	6000	14	3643	2780	11000	poor
Ions	Chloride	3631 ± 1128	3185	14	2110	1291	6020	poor
	Fluoride	0.956 ± 0.092	0.99	14	0.173	0.582	1.102	good
	Sulfate	1142 ± 291	1033	14	544	444	1788	poor
	Bicarbonate	313 ± 46	296	14	86	196	421	-
	Calcium	285 ± 61	236	14	115	154	453	-
	Magnesium	347 ± 105	295	14	197	123	598	-
	Potassium	29 ± 8	25	14	15.4	13	47	-
	Sodium	1943 ± 546	1735	14	1021	706	3262	poor

Water quality classification based on criteria listed in section 2.1 of this report.

Cooper Creek (Callyamurra waterhole at GS003501)

The Cooper Creek catchment, situated in the far north of the State, has a land use of primarily cattle grazing on low woodland and chenopod shrubland.

The results (table 18) indicated that Cooper Creek had generally moderate water quality based on the following:

- Turbidity was very high and colour was elevated.
- Phosphorus was present in high concentrations and concentrations of oxidised nitrogen and TKN were moderate.
- Lead, copper, iron, zinc and soluble aluminium concentrations were elevated.
- Salinity and concentrations of major ions were low.

High levels of turbidity are probably caused by erosion and runoff from grazing lands and other agricultural regions in Queensland. The suspended matter contributes to the high concentrations of total phosphorus and heavy metals which readily attach to the clay surfaces. Salinity concentrations were very low compared with most other rivers and streams in South Australia.

Table 18 Cooper Creek Water Quality

	Water Quality Characteristics (all values in mg/L unless specified).	Mean ± Confidence Interval	Median	Number of samples	Standard deviation	10th percentile	90th percentile	Water quali classificatic
Nutrients	Oxidised nitrogen	0.282 ± 0.092	0.289	19	0.200	0.039	0.485	moderate
	TKN	1.46 ± 0.37	1.30	19	0.815	0.89	1.86	moderate
	Total phosphorus	0.562 ± 0.150	0.475	19	0.326	0.214	0.924	poor
	Soluble phosphorus	0.090 ± 0.022	0.075	18	0.048	0.041	0.157	-
	Dissolved organic carbon	5.8 ± 0.9	5.3	19	2.00	3.1	8.1	good
	Silica	12.5 ± 2.5	13.0	19	5.4	4.9	19.1	-
Physical	pH (pH units)	7.6 ± 0.1	7.6	19	0.32	7.2	7.9	good
Clarity	Turbidity (NTU)	509 ± 150	470	17	311	80	914	poor
	Colour (Hu)	42 ± 4	39	17	8.8	31	56	moderate
Heavy Metals	Total copper	0.020 ± 0.006	0.016	19	0.014	0.005	0.040	poor
	Total lead	0.006 ± 0.002	0.005	19	0.004	0.002	0.010	poor
	Total zinc	0.061 ± 0.022	0.043	19	0.049	0.013	0.135	moderate
	Soluble zinc	0.023 ± 0.009	0.014	19	0.020	0.005	0.046	-
	Total iron	13.1 ± 5.5	11.4	19	11.9	1.30	26	poor
	Total aluminium	14.6 ± 6.5	12.6	19	14.2	1.23	27	-
	Soluble aluminium	1.5 ± 2.5	0.104	19	5.48	0.021	0.76	poor
Salinity	Conductivity (µS/cm)	159 ± 21	154	19	45	97	212	good
	Total dissolved solids	87± 11	84	19	25	53	120	good
Ions	Chloride	8.1 ± 0.9	8.0	19	1.88	5.9	11	good
	Fluoride	0.154 ± 0.023	0.150	19	0.051	0.08	0.211	good
	Sulfate	11.2 ± 4.2	8.8	19	9.1	6.4	14	good
	Bicarbonate	68 ± 12	60	19	26	37	100	-
	Calcium	10.9 ± 1.9	10.9	19	4.1	4.5	15	-
	Magnesium	4.0 ± 1.2	3.5	19	2.7	1.4	5.4	-
	Potassium	5.2 ± 0.5	5.3	19	1.2	3.5	6.8	-
	Sodium	22 ± 9	17.8	19	21	11	23	good

Water quality classification based on criteria listed in section 2.1 of this report.

4. CONCLUDING REMARKS

The water quality of different South Australian rivers and streams was highly variable over time. First Creek and Rocky River were characterised by generally good water quality and the River Torrens, Bremer, Mosquito Creek and Hill Rivers were characterised by moderate to poor water quality. All other streams and rivers were classified as having moderate water quality.

Those waterbodies classified as having poor or moderate water quality were characterised by:

- high concentrations of dissolved solids (salinity)
- moderate to high levels of nutrients (principally TKN and phosphorus)
- poor or moderate water clarity as measured by turbidity and colour
- periods of depleted dissolved oxygen concentrations
- high concentrations of some heavy metals.

It is unlikely that the high levels of total aluminium recorded in most rivers and streams would cause significant problems. The water was not acidic (the pH is usually greater than 7) and the high aluminium levels were invariably associated with high levels of particulate matter and were subsequently not biologically available. For example, the 90th percentile for total aluminium in the Cooper Creek site is 27 mg/L with a turbidity of over 900 NTU but biologically this arid-zone creek is quite healthy (Goonan pers comm).

Copper concentrations were slightly elevated at all sites compared with the national criteria (ANZECC 1992). This is unlikely to be cause for concern and probably was indicative of higher natural background levels in our waters compared with those in the eastern states.

A number of initiatives currently underway in South Australian catchments should improve water quality over time. These include:

- **Environmental Improvement Programmes** and **Codes of Practice** being established by EPA and agricultural industries (eg dairies, piggeries and wineries) to improve environmental management and reduce pollutant runoff into streams
- development of an **Environment Protection (Water Quality) Policy** to deal with point and diffuse source pollution
- establishment of catchment management boards
- riparian vegetation and erosion mapping of Mt Lofty Ranges catchments
- community education and monitoring programmes.

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6 FURTHER READING

ANZECC. In press. *Environmental quality guidelines for fresh and marine waters. Part 1: Guidelines reference manual*. Australia and New Zealand Environment Protection Council.

ANZECC. In press. *Environmental quality guidelines for fresh and marine waters. Part 2: Detailed discussions, protocols, methods and monitoring and assessment*. Australia and New Zealand Environment and Conservation Council.

ANZECC. 1992. *National Water Quality Management Strategy. Australian water quality guidelines for fresh and marine waters*. Australian and New Zealand Environment and Conservation Council.

Buckney, RT. 1979. *Chemical loadings in a small river, with observatons on the role of suspended matter in the nutrient flux*. Technical paper No. 40. AWRC.

Cugley, J. 1994. *Ambient water quality monitoring for SA—Issues and requirements*. EPA Draft Report.

Chapman, D (Ed). 1996. *Water quality assessments. A guide to the use of biota, sediments and water in environmental monitoring*. 2nd edition. E and FN SPON.

Drikas, M. 1993. Aluminium in drinking water: A current perspective. *Water*. December: 16-19.

EPA. 1997a. *Ambient water quality monitoring of Lake Alexandrina and Lake Albert*. Water *monitoring report No. 1*. Department for Environment, Heritage and Aboriginal Affairs.

EPA. 1997b. *Ambient water quality monitoring of Gulf St Vincent Metropolitan Bathing Waters. Water monitoring report No. 1*. Department for Environment, Heritage and Aboriginal Affairs.

EPA. In press. *Ambient water quality (nitrate) monitoring of Blue Lake and South East groundwater. Water monitoring report No. 1*. Department for Environment, Heritage and Aboriginal Affairs.

Glatz, A. 1985. *Surface water quality data in South Australia: A review of major water resources*. July 1978—June 1983. EWS Ref: 84/34.

Hart, BT. 1982. *Australian water quality criteria for heavy metals*. Technical paper No. 77. AWRC.

Hart, BT and McKelvie, ID. 1986. Chemical limnology in Australia. In: P De Deckker and WD Williams (Eds). *Limnology in Australia*. pp: 3–31. CSIRO Australia.

Haughey, AV. 1972. *Metropolitan watersheds water pollution studies progress report*. EWS.

Kirk, JTO. 1986. Optical limnology—a manifesto. In: P De Deckker and WD Williams (Eds). *Limnology in Australia*. pp: 33–62. CSIRO Australia.

NHMRC. 1990. *Australian guidelines for recreational use of water*. National Health and Medical Research Council.

NHMRC-ARMCANZ. 1996. *National Water Quality Management Strategy: Australian drinking water guidelines—6*. National Health and Medical Research Council.

Norris, RH and Norris KR. 1994. The need for biological assessment of water quality: Australian perspective. *Australian Journal of Ecology*. 20, 1-6.

Norris, RH, Hart, BT and Bell, C. 1993. *Monitoring River Health Initiative. Core indicators for biological assessment of river health*. Report to CEPA.

Taylor, JK. 1987. *Quality assurance of chemical measurements*. Lewis Publishers, pp. 129-146.

Williams, WD. 1980. *Australian Freshwater Life*. 2nd ed. pp 1-10. Macmillan, Australia.

Wood, G. 1986. *The Mt Lofty Ranges watershed: Impact of land use on water quality and implications for reservoir water quality management*. EWS Ref, 86/19.