The Department of
Water, Land and
Biodiversity
Conservation

TREND ANALYSIS

FLOW PROPORTIONAL COMPOSITE SAMPLE

MONITORING SITES

FOR

DEPARTMENT of WATER, LAND and BIODIVERSITY CONSERVATION

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WATER DATA SERVICES

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1 WARNING

The data provided in this report has been collected under the framework of a Quality Management System (WDS – NATA AS / NZS ISO 9001/2000)

The South Australian Government and Water Data Services reserve the right to adjust this data based on new calibration data and/or new information that may become available.

2 DISCLAIMER

Neither the South Australian Government and its employees nor Water Data Services and its employees can be accountable in any way for the use of this data and/or any subsequent interpretation of the data.

3 EXECUTIVE SUMMARY

The Department of Water, Land and Biodiversity Conservation (DWLBC) engaged Water Data Services to statistically analyse flow and water quality data from 8 composite sampling sites in the Mt Lofty Ranges upstream of the Mt Bold and Millbrook Reservoirs. The then Engineering and Water Supply Department originally set up the sites in 1988 as the Nutrient Budget Study (NBS).

The purpose of this report is to provide a summary of the data collected from the NBS sites in terms of water quality: -

- Concentrations
- Trends
- Excursions (comparison with suitable water quality guideline values)

Trend Analysis was done using the software package WQSTAT Plus. The trend analysis provides an indication as to whether water quality is stable, getting better or getting worse.

Trend analysis does not provide an indication as to how ‘good’ or ‘bad’ the water is. To determine this an “Excursion Analysis” was undertaken (using WQSTAT) to compare the mean concentration with the recommended thresholds.

Trend Analysis Summary

The summary has been divided into natural streams and un-natural streams where the un-natural streams are influenced by water pumped from the River Murray.

For the tables below the following symbols apply: -

↓ - Decreasing trend was detected (water quality improving).
↑ - Increasing trend was detected (water quality getting worse)
→- A significant trend was not detected.

Natural Streams

Site	TDS	SS	EC	TP	TN
AW503502 Scott Creek	→	→	→	↑	↑
AW 503506 Echunga Creek	→	↑	→	→	↑
AW 503507 Lenswood Creek	↓	↓	↓	↓	↓
AW 503509 Aldgate Creek	→	↓	→	↓	↓
AW 502526 Cox Creek	→	↓	→	↓	↓
AW 504525 Kersbrook Creek	↓	→	↓	↑	↑

Un-Natural Streams

Site	TDS	SS	EC	TP	TN
AW 503504 Onkaparinga R. at Houlgraves	→	→	→	↑	↑
AW 504508 Milbrook Reservoir Intake	→	→	→	↑	↑

The table shows that TN concentration is increasing in five of the eight catchments.

The increasing trend in SS for Echunga Creek is a concern and requires further work to determine the reason and set in place remedial actions.

Kersbrook Creek has conflicting trends – TDS and EC are improving over time whilst TP and TN are getting worse.

Exceedance Analysis Summary

The proportion of observations each gauge exceeds a guideline threshold value (T in mg/L) with 95% Confidence.

Natural Streams

Site	TP T=0.1mg/L	TN T=1.0mg/L	SS T=20mg/L	TDS T=500mg/L
AW503502 Scott Creek	9.0%	11.4%	30.0%	66.3%
AW503506 Echunga Creek	21.3%	30.5%	27.5%	96.3%
AW503507 Lenswood Creek	29.3%	51.1%	40.0%	6.6%
AW503509 Aldgate Creek	60.4%	59.8%	85.0%	1.1%
AW503526 Cox Creek	98.9%	100%	97.5%	0.0%
AW504525 Kersbrook Creek	34.1%	78.0%	57.9%	87.7

Un-Natural Streams

Site	TP T=0.1mg/L	TN T=1.0mg/L	SS T=20mg/L	TDS T=500mg/L
AW503504 Onkaparinga R Houlgraves	68.5%	48.2%	90.0%	8.4%
AW504508 Milbrook Intake	75.2%	63.5%	92.5%	51.6%

The results indicate that all of the NBS streams, with the possible exception of Scott Creek, are significant contributors of nutrients and suspended solids into the reservoirs.

While many of the catchments are indicating a decreasing trend in many water quality parameters, they are still above guideline values.

Onkaparinga River, Lenswood, Aldgate and Cox creeks have high exceedences for nutrients (TP and TN) and sediments (SS), but conversely not for salinity (TDS). .

We can be 95% confident that Cox Creek did not exceed the threshold for TDS (500 mg/L) however it was the worst of the eight streams in terms of exceeding the thresholds for over 97% of observations for nutrients (TP, TN) and sediment (SS).

Scott, Echunga, Milbrook and Kersbrook creeks have high proportions of exceedences for salinity (TDS).

4 PROJECT BRIEF

To review water quality information from the Mount Lofty Ranges composite samplers in terms of:

- Homogeneity of flow data in relation to a selection of long term rainfall sites
- Statistical trend in sampled water quality parameters over time
- Comparison of water quality parameters over time to water quality thresholds determined by the *Environment Protection (Water Quality) Policy (WQEPP), the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC), and the Australian Water Quality Guidelines (AWQG).*

5 INTRODUCTION

In 1988 the Water Resources Group, Department of Environment and Natural Resources (now Department of Water, Land and Biodiversity Conservation DWLBC) established the Nutrient Budget Study (NBS). The NBS was introduced to assess the nutrient load entering Mount Bold Reservoir and was later extended in 1992 to the Milbrook Reservoir.

Initially, three existing flow-monitoring sites were extended to include volume proportional composite sampling (see Section 5.2). At the time, these sites pioneered the first practical application of automating the volume proportional composite sampling method in Australia. This was possible because of the development of a digital data logger, by a South Australian company (Systems Design Services), which could accumulate flow volumes and at a preset volume increment, would trigger a pump which removed an aliquot of water from the stream.

In 1992 the program was expanded by a further two monitoring stations and in 1994 an additional three sites were established.

The table below lists the eight NBS sites.

Table 1 **- Nutrient Budget Study Composite Sampling Sites**

Site No.	*Description*	*Parameter*	*Period of Record*
AW503502	Scott Creek at Scott Bottom	Water level/flow Rainfall Water Quality	27/03/1969 to 04/07/2002 08/03/1991 to 04/07/2002 23/08/1988 to 12/06/2002
AW503504	Onkaparinga River at Houlgrave	Water level/flow Rainfall Water Quality	17/04/1973 to 04/07/2002 10/12/1991 to 04/07/2002 25/08/1988 to 12/06/2002
AW503506	Echunga Creek upstream of Mt Bold Res.	Water level/flow Water Quality	22/03/1973 to 04/07/2002 26/08/1988 to 12/06/2002
AW503507	Lenswood Creek at Lenswood	Water level/flow Rainfall Water Quality	18/05/1972 to 04/07/2002 05/09/1997 to 04/07/2002 15/11/1994 to 12/06/2002
AW503509	Aldgate Creek at Aldgate Railway Station NB Continuous Rainfall data collected by BOM	Water level/flow Rainfall Water Quality	13/07/1972 to 04/07/2002 Available from BOM 27/09/1994 to 12/06/2002
AW503526	Cox Creek at Uraidla	Water level/flow Water Quality	23/06/1976 to 04/07/2002 18/10/1994 to 12/06/2002
AW504508	Millbrook Reservoir Intake upstream of Millbrook Reservoir	Water level/flow Water Quality	02/12/1943 to 04/07/2002 24/02/1992 to 12/06/2002
AW504525	Kersbrook Creek upstream of Millbrook Reservoir	Water level/flow Water Quality	14/09/1989 to 04/07/2002 08/04/1992 to 12/06/2002

Each of the NBS sites are shown on the map in Appendix 1

Water Quality in the above table refers to the measured determinands: -

- Electrical Conductivity @ 25°C (EC)
- Total Dissolved Solids (TDS)
- Suspended Solids (SS)
- Oxidised Nitrogen (Nox)
- Organic Nitrogen (TKN)
- Total Phosphorus (TP).

Because of the relative longevity (10 years), in terms of continuous water quality monitoring, these sites are now a valuable source of baseline data. The use of the data from these sites is now not just limited to the original purpose of assessing nutrient loads into reservoirs but are also used for catchment studies.

The purpose of this report is to provide a summary of the data collected from the NBS sites in terms of water quality: -

- Concentrations
- Trends
- Excursions

Concentration data was summarised using the HYDSYS software.

Trend Analysis was done using the software package WQSTAT Plus which was developed collaboratively by Colorado State University, USA and the U.S Environmental Protection Agency. The package was designed specifically for flow and water quality analysis and has been adopted by authorities such as the U.S Environmental Protection Agency, National Institute of Water and Atmospheric Research (New Zealand) and the New Zealand EPA.

The trend analysis provides an indication as to whether water quality is stable, getting better or getting worse. The analysis contained within this report does not include 'cause and effect' analysis. That is, the hydrological catchment characteristics for each site have not been analysed and hydrological reasons for any established trend have not been interpreted. The analysis is purely statistical and not hydrological.

Trend analysis does not provide an indication as to how good or bad the water is. To determine this an "Excursion Analysis" was undertaken (using WQSTAT) to compare the mean concentration with the recommended thresholds (Table 10.2).

6 DATA COLLECTION AND STORAGE

6.1 Flow

At each of the NBS sites is a flow control structure that provides stable flow conditions throughout the flow regimes. Refer to Section 7 for a description of the control structure for each weir. Water level is measured continuously in the upstream pool of the control structure. The instrumentation and methods used to measure water level were chosen to achieve an accuracy of ± 5 mm which is the acknowledged standard adopted by the DWLBC.

Flow measurements (gaugings) done at different water levels provide a water level/flow relationship (rating). The accuracy of the rating depends on the number of gaugings done throughout the flow regime.

Therefore, by measuring water level continuously and by applying a rating a continuous time series of flow is obtained. The accuracy of the flow time series depends upon the accuracy of water level measurement, the accuracy of the rating and the sensitivity of the control. The determination of the accuracy of the data collected is beyond the scope of this report.

The continuous time series data is stored in the DWLBC State Water Archive (HYDSYS). Before the final archiving of data it has undergone a process of data validation via a set of DWLBC and WDS Standard Work Procedures (SWP)

6.2 Composite Sampling Method

Water is sampled from the stream using the volume proportional composite sampling method. The method requires that an accurate predetermined calibration of the river flow versus height relationship is available. This relationship is programmed into the data logger. The logger continuously calculated the cumulative flow passing the sampling location from the continuous measure of water level. Programmed into the logger is a predetermined volume increment (eg 0.2 ML). Each time the volume increment is reached the logger triggers a sampler. The sampler then: -

- Purges the sample line by forcing air out to the river.
- The pump then reverses and flushes the sampling line by extracting water from the river over a preset time.
- After flushing, a 500ml aliquot of water is extracted and delivered into an 80 litre high quality PET plastic tub.

The flow volume increment for triggering the collection of each sample was selected to ensure that a maximum number of samples were taken without overtopping the container into which the individual samples were discharged. The increment was changed as necessary based on current flow conditions so as to attempt to achieve the maximum number of samples. Because the actual flow could never be predicted the increment was chosen so as to provide a safety margin to ensure that the tub does not overflow. A logbook was kept on-site documenting the volume increment and the number of aliquots taken between sample collection visits. The number of individual aliquots varied from 0 to 160, depending upon the flow and the volume increment.

Each week, usually Wednesday, the station was visited and the composite tub was stirred vigorously and one representative sample set removed (1 @ 500ml, 1 @ 1.25 litre PET bottles). The tub was then emptied and cleaned.

The determinand sample result represents the *mean flow-weighted concentration* of the flow during the sample period (usually 1 week). By multiplying the mean concentration value by the total flow volume for the sampling period produces a reliable estimate of load for the sample period.

For more detailed information on the composite sampling method, including effects of storage on the determinand concentrations refer to the report ‘Nutrient Loads in the Onkaparinga River System’ (Nicholson B.L., Clark R.D. 1992)

6.3 Sample Delivery and Analysis

Sample analysis was done by the Australian Water Quality Centre (AWQC), which is NATA accredited for chemical testing and has Quality Certification ISO 9001.

The AWQC provided ‘run sheets’ and bar coded labels for each sample bottle and site location. The bar code provided the AWQC with the site details and the type of water analysis required for the site. When the sample was collected WDS would write the date, time and operator name onto the label. When the sample run was completed each bar code was scanned. The sample bottles were delivered to the AWQC on the same day that they were collected and the scanned information uploaded to the AWQC computer. The bar code then provided the AWQC with trace-ability throughout the processing stages of the sample.

The table below describes the method of analysis for each determinand measured

Table 2 – AWQC Analysis Methods

Analyte	Units	Method	Reference	Limit	Instrument
Total Dissolved Solids (TDS)	mg/L	Direct measurement up to Nov 1996 Derived from conductivity after 1996	ALPHA 2520 B	1	WTW auto ranging with temperature correction
Suspended Solids (SS)	mg/L	Total suspended solids dried at 103 – 105 °C	ALPHA 2540 D	2	Drying Oven
Electrical Conductivity (EC) (at 25 °C)	uS/cm	Electrical conductivity	ALPHA 2520 B	1	WTW auto ranging with temperature correction
Phosphorus – total (TP)	mg/L	$H_2SO_4/K_2SO_4/HgO$ digestion followed by automated ascorbic acid colorimetric method	Technicon Method 376-75W, Technicon Method 155-71W, in-house modifications	0.005	Skalar segmented flow analyzer
Nitrogen + Nitrate as N (Nox)	mg/L	Automated colorimetric cadmium reduction method	ALPHA 4500	0.005	Skalar segmented flow analyzer
Nitrogen – total Kjeldahl (TKN)	mg/L	Kjeldahl digestion followed by automated colorimetric method	Based on Technician method 376-75W	0.1	Skalar segmented flow analyzer

TDS was determined by the direct measurement method for the period 1988 to November 1996. From 1996 TDS was then calculated from EC. The reason for this change is not known. For this report the results from both methods were combined to form the one data set 1988 to 2002.

Analysis for suspended solids commenced in 1996 rather than at the commencement of the program. The reason for this is not documented and not known

Nicholson and Clark (1992) found that Nox deteriorated over the period of on-site storage (1 week) and TKN increased. The change in Total Nitrogen (TKN + Nox) was shown to be less than 4% for the period of on-site storage (Nicholson and Clark, 1992). Therefore, Total Nitrogen, rather than TKN and Nox, was used for the purpose of this report. TKN and Nox concentrations for each sample were added together to produce Total Nitrogen (TN).

6.4 Data Storage

Water level is stored as a continuous time series in the hydrological time series data archive HYDSYS TS. The DWLBC are the custodians of the water archive. Flow ratings for each site are stored within the 'Ratings' system of HYDSYS and when combined with the water level data produces a continuous flow time series.

Water Quality results are archived in the water quality specific archive HYDSYS WQ as well as stored as 'mean values in the preceding interval' in HYDSYS TS.

7 NBS SITES SUMMARY

In December 2002 a DWLBC report "Flow Proportional Composite Sample, Data Summary" (Dec 2002, Water Data Services) summarised the water quality Loads for each of the NBS Sites. This content of this Section (6) was taken directly from the above-mentioned report.

At each of the sites the following water quality determinands measured were

- EC
- TDS
- SS
- Nox
- TKN
- TP
- TN

The Australian Water Quality Centre (NATA accredited) analysed each sample and each result represents a flow volume mean weighted concentration.

Any reference to data quality is qualitative only. During the data processing and verification process data is 'tagged' with a quality tag. For example, 1 = good, 3 = fair, 76 = estimated etc. Any number over 150 is considered to be 'bad' data.

The water quality statistics are based on financial years due to the DWLBC's recently adopted policy (Dec 2002) for publishing flow data.

7.1 AW503502 - Scott Creek at Scott Bottom

7.1.1 Data Description and Period of Record

Continuous Water level	27/03/1969 to 04/07/2002 (33 yrs)
Rainfall	08/03/1991 to 04/07/2002 (11 yrs)
Water Quality.	23/08/1988 to 12/06/2002 (14 yrs)

Water level is monitored continuously and is of good quality with 0.0% of bad record.

Rainfall is of good quality (0.0% bad record) measured continuously in 0.2mm increments.

7.1.2 Statistics

Catchment Area	26.8	km^2
Maximum instantaneous flow recorded to date	18.3	m^3/s (Jun 1981)
Mean annual flow volume	3,390	ML
Mean annual rainfall	780	mm
1:5 year Annual Exceedence Probability	11.6	m^3/s
Number of water quality composite samples	602	
Minimum EC	150	$\mu s/cm^2$ @ 25°C
Maximum EC	2,260	$\mu s/cm^2$ @ 25°C

Average Annual Total Catchment Load (tonnes)		
TDS	901	tonnes
SS	120	tonnes
TP	0.4	tonnes
TN (Nox + TKN)	3.5	tonnes

Average Annual Load (tonnes/km^2)		
TDS	33.6	tonnes/km^2
SS	4.6	tonnes/km^2
TP	0.0	tonnes/km^2
TN (Nox + TKN)	0.1	tonnes/km^2

Note - Figures are based on financial year periods.

7.2 AW503504 - Onkaparinga River at Houlgrave weir

7.2.1 Data Description and Period of Record

Continuous Water level	17/04/1973 to 04/07/2002 (29 yrs)
Rainfall	10/12/1991 to 04/07/2002 (10 yrs)
Water Quality.	23/08/1988 to 12/06/2002 (14 yrs)

Water level is monitored continuously and is of good quality with 0.0% of bad record.

Rainfall is of good quality (0.0% bad record) measured continuously in 0.2mm increments.

7.2.2 Statistics

Catchment Area	321	km^2 (natural catchment)
Maximum instantaneous flow recorded to date	432	m^3/s (Jun 1981)
Mean annual flow volume	73,000	ML
Mean annual rainfall	705	mm
1:5 year Annual Exceedence Probability	164	m^3/s
Number of water quality composite samples	662	
Minimum EC	221	$\mu s/cm^2$ @ 25°C
Maximum EC	1,240	$\mu s/cm^2$ @ 25°C

Average Annual Total Catchment Load (tonnes)		
TDS	21,100	tonnes
SS	3,610	tonnes
TP	14.5	tonnes
TN (Nox + TKN)	108	tonnes

Average Annual Load (tonnes/km^2)		
TDS	65.8	tonnes/km^2
SS	11.2	tonnes/km^2
TP	0.0	tonnes/km^2
TN (Nox + TKN)	0.3	tonnes/km^2

Notes - Figures are based on financial year periods.
Load figures include natural catchment runoff and imported River Murray water.

7.3 AW503506 - Echunga Creek upstream of Mt Bold Reservoir

7.3.1 Data Description and Period of Record

Continuous Water level	22/03/1973 to 04/07/2002 (29 yrs)
Water Quality.	18/08/1988 to 12/06/2002 (14 yrs)

Water level is monitored continuously and 96.5% is good quality data.

7.3.2 Statistics

Catchment Area	34.2	km^2
Maximum instantaneous flow recorded to date	44	m^3/s (Aug 1992)
Mean annual flow volume	3,160	ML
Mean annual rainfall	NA	
1:5 year Annual Exceedence Probability	24.4	m^3/s
Number of water quality composite samples	585	
Minimum EC	376	$\mu s/cm^2$ @ 25°C
Maximum EC	4,000	$\mu s/cm^2$ @ 25°C

Average Annual Total Catchment Load (tonnes)		
TDS	1,570	tonnes
SS	110	tonnes
TP	0.7	tonnes
TN (Nox + TKN)	5.7	tonnes

Average Annual Load (tonnes/km^2)		
TDS	45.9	tonnes/km^2
SS	3.1	tonnes/km^2
TP	0.0	tonnes/km^2
TN (Nox + TKN)	0.2	tonnes/km^2

Notes - Figures are based on financial year periods.

7.4 AW503507 - Lenswood Creek at Lenswood

7.4.1 Data Description and Period of Record

Continuous Water level	18/05/1972 to 04/07/2002 (30 yrs)
Continuous Rainfall	05/09/1997 to 04/07/2002 (5 yrs)
Water Quality.	15/11/1994 to 12/06/2002 (8 yrs)

Water level is monitored continuously and 81.9% of good quality data.

The station was closed from July 1990 and reopened in November 1994 for the NBS study.

7.4.2 Statistics

Catchment Area	16.5	km^2
Maximum instantaneous flow recorded to date	48.4	m^3/s (Jun 1981)
Mean annual flow volume	2,700	ML
Mean annual rainfall	794	mm
1:5 year Annual Exceedence Probability	17.5	m^3/s
Number of water quality composite samples	390	
Minimum EC	256	$\mu s/cm^2$ @ 25°C
Maximum EC	1,400	$\mu s/cm^2$ @ 25°C

Average Annual Total Catchment Load (tonnes)		
TDS	577	tonnes
SS	800	tonnes
TP	0.5	tonnes
TN (Nox + TKN)	5.3	tonnes

Average Annual Load (tonnes/km^2)		
TDS	34.9	tonnes/km^2
SS	48.5	tonnes/km^2
TP	0.0	tonnes/km^2
TN (Nox + TKN)	0.3	tonnes/km^2

Note - Figures are based on financial year periods.

7.5 AW503509 - Aldgate Creek upstream of Railway Station

7.5.1 Data Description and Period of Record

Continuous Water level	13/07/1972 to 04/07/2002 (30 yrs)
Continuous Rainfall	28/07/1997 to 01/02/2002 (5 yrs)
Water Quality	15/11/1994 to 12/06/2002 (8 yrs)

Water level is monitored continuously and 82.5% is good quality data.

This station was closed in July 1989 and reopened again in September 1994.

Rainfall is monitored via the Bureau of Meteorology (BOM) ERTS flood alert system. BOM provide regular data updates to the Department of Water, Land and Biodiversity Conservation.

7.5.2 Statistics

Catchment Area	7.8	km^2
Maximum instantaneous flow recorded to date	22.9	m^3/s (Jun 1981)
Mean annual flow volume	2,700	ML
Mean annual rainfall	752	mm
1:5 year Annual Exceedence Probability	10.5	m^3/s
Number of water quality composite samples	381	
Minimum EC	174	µs/cm^2 @ 25°C
Maximum EC	5,750	µs/cm^2 @ 25°C
Average Annual Total Catchment Load (tonnes)		
TDS	261	tonnes
SS	93.1	tonnes
TP	0.3	tonnes
TN (Nox + TKN)	2.4	tonnes
Average Annual Load (tonnes/km^2)		
TDS	33.5	tonnes/km^2
SS	11.9	tonnes/km^2
TP	0.0	tonnes/km^2
TN (Nox + TKN)	0.3	tonnes/km^2

Note - Figures are based on financial year periods.

7.6 AW503526 - Cox Creek near Uraidla

7.6.1 Data Description and Period of Record

Continuous Water level	23/06/1976 to 04/07/2002 (26 yrs)
Water Quality.	18/10/1994 to 12/06/2002 (8 yrs)

Water level is monitored continuously and 79.6% is of good quality data.

7.6.2 Statistics

Catchment Area	4.3	km^2
Maximum instantaneous flow recorded to date	14.5	m^3/s (Sep 1979)
Mean annual flow volume	1,180	ML
Mean annual rainfall	NA	
1:5 year Annual Exceedence Probability	6.2	m^3/s
Number of water quality composite samples	468	
Minimum EC	188	$\mu s/cm^2$ @ 25°C
Maximum EC	1,150	$\mu s/cm^2$ @ 25°C
Average Annual Total Catchment Load (tonnes)		
TDS	234	tonnes
SS	498	tonnes
TP	1.5	tonnes
TN (Nox + TKN)	7.5	tonnes
Average Annual Load (tonnes/km^2)		
TDS	54.4	tonnes/km^2
SS	116	tonnes/km^2
TP	0.3	tonnes/km^2
TN (Nox + TKN)	1.7	tonnes/km^2

Note - Figures are based on financial year periods.

7.7 AW504508 – Milbrook Intake upstream of Milbrook Reservoir

7.7.1 Data Description and Period of Record

Continuous Water level	02/12/1943 to 04/07/2002 (59 yrs)
Water Quality.	24/02/1992 to 12/06/2002 (10 yrs)

Water level is monitored continuously and 86.8% is good quality data.

7.7.2 Statistics

Catchment Area	Not Applicable	(water supply)
Maximum instantaneous flow recorded to date	13.2	m^3/s (Jun 1987)
Mean annual flow volume	18,200	ML
Mean annual rainfall	NA	
1:5 year Annual Exceedence Probability	Not Applicable	(regulated flow)
Number of water quality composite samples	543	
Minimum EC	220	µs/cm^2 @ 25°C
Maximum EC	1,720	µs/cm^2 @ 25°C

Average Annual Total Load (tonnes)		
TDS	7150	tonnes
SS	738	tonnes
TP	3.5	tonnes
TN (Nox + TKN)	25.7	tonnes

Note - Figures are based on financial year periods.
There is no 'natural' catchment for this site. Water supply system only.

7.8 AW504525 - Kersbrook Creek upstream of Milbrook Reservoir

7.8.1 Data Description and Period of Record

Continuous Water level	14/09/1989 to 04/07/2002 (13 yrs)
Water Quality.	08/04/1992 to 12/06/2002 (10 yrs)

Water level is monitored continuously and is of 88.8% of good quality data.

NB. Kersbrook Creek is also often referred to as Chain of Ponds Creek.

7.8.2 Statistics

Catchment Area	23.0	km^2
Maximum instantaneous flow recorded to date	39.2	m^3/s (Aug 1992)
Mean annual flow volume	2,390	ML
Mean annual rainfall	NA	
1:5 year Annual Exceedence Probability	32.9	m^3/s
Number of water quality composite samples	309	
Minimum EC	131	µs/cm^2 @ 25°C
Maximum EC	3,800	µs/cm^2 @ 25°C
Average Annual Total Catchment Load (tonnes)		
TDS	764	tonnes
SS	185	tonnes
TP	0.3	tonnes
TN (Nox + TKN)	4.8	tonnes
Average Annual Load (tonnes/km^2)		
TDS	33.2	tonnes/km^2
SS	8.0	tonnes/km^2
TP	0.0	tonnes/km^2
TN (Nox + TKN)	0.2	tonnes/km^2

Note - Figures are based on financial year periods.

7.9 Water Quality Concentrations Data Summary (all sites)

The following concentration data summary is derived from ‘flow weighted mean concentrations’ composite sample data. The raw data used for the calculation of concentrations summary are provided on the accompanying CD-ROM. Raw data was verified by the AWQC and again checked by WDS. Summary calculations were done using the software HYDSYS WQ - Summary.

EC @ 25 C (uS/cm)

Site	ID	No Samples	Minimum	10th Percentile	Median	90th Percentile	Maximum	Mean	Std Dev
Scott	AW503502	622	150	496	1235	1810	2260	1187	499
Houlgraves	AW503504	642	221	453	694	941	1240	694	189
Echunga	AW503506	601	376	1050	1430	2410	4000	1618	574
Lenswood	AW503507	410	256	412	654	886	1400	655	179
Aldgate	AW503509	401	174	242	360	504	5750	379	286
Cox	AW503526	478	188	348	574	682	1150	547	129
Millbrook	AW504508	563	220	478	875	1400	1720	899	337
Kersbrook	AW503525	329	131	559	1680	3060	3800	1756	924

TDS calculated (mg/L)

Site	ID	No Samples	Minimum	10th Percentile	Median	90th Percentile	Maximum	Mean	Std Dev
Scott	AW503502	367	120	296	720	1000	1200	672	272
Houlgraves	AW503504	367	150	260	370	490	650	371	92
Echunga	AW503506	364	210	633	780	1300	2000	899	309
Lenswood	AW503507	324	140	240	360	490	550	363	92
Aldgate	AW503509	298	95	130	190	280	340	200	53
Cox	AW503526	368	100	200	320	380	630	303	70
Millbrook	AW504508	375	120	250	460	770	950	484	190
Kersbrook	AW503525	198	86	331	855	1700	2100	924	478

TDS measured (mg/L)

Site	ID	No Samples	Minimum	10th Percentile	Median	90th Percentile	Maximum	Mean	Std Dev
Scott	AW503502	254	100	253	645	987	1200	630	272
Houlgraves	AW503504	275	120	234	400	540	680	395	117
Echunga	AW503506	240	260	500	790	1400	2200	885	334
Lenswood	AW503507	86	140	200	340	485	770	347	121
Aldgate	AW503509	103	110	130	200	278	3200	232	300
Cox	AW503526	111	110	190	320	360	420	293	74
Millbrook	AW504508	188	170	297	505	786	950	514	176
Kersbrook	AW503525	131	72	300	1100	1800	2100	1040	561

SS (mg/L)

Site	ID	No Samples	Minimum	10th Percentile	Median	90th Percentile	Maximum	Mean	Std Dev
Scott	AW503502	252	1	2	5	26	179	13	24
Houlgraves	AW503504	253	2	9	27	61	296	39	43
Echunga	AW503506	253	1	3	7	27	184	13	22
Lenswood	AW503507	235	1	2	6	69	2700	41	196
Aldgate	AW503509	214	1	2	23	111	405	40	55
Cox	AW503526	246	4	11	136	643	6310	351	764
Millbrook	AW504508	256	4	16	35	63	1720	49	113
Kersbrook	AW503525	148	1	4	8	60	265	25	43

Nox (mg/L)

Site	ID	No Samples	Minimum	10th Percentile	Median	90th Percentile	Maximum	Mean	Std Dev
Scott	AW503502	605	0.005	0.008	0.029	0.136	0.477	0.054	0.064
Houlgraves	AW503504	624	0.005	0.024	0.158	0.62	1.65	0.251	0.262
Echunga	AW503506	586	0.005	0.005	0.010	0.201	1.04	0.061	0.105
Lenswood	AW503507	394	0.005	0.005	0.104	1.05	2.78	0.361	0.520
Aldgate	AW503509	387	0.005	0.023	0.206	0.452	1.03	0.228	0.184
Cox	AW503526	460	0.218	2.39	4.29	7.08	16.4	4.57	1.93
Millbrook	AW504508	545	0.010	0.041	0.135	0.45	1.94	0.209	0.220
Kersbrook	AW503525	314	0.005	0.010	0.181	0.639	3.66	0.283	0.368

TKN (mg/L)

Site	ID	No Samples	Minimum	10th Percentile	Median	90th Percentile	Maximum	Mean	Std Dev
Scott	AW503502	622	0.015	0.3	0.49	0.949	8.67	0.585	0.460
Houlgraves	AW503504	642	0.28	0.5	0.76	1.30	3.62	0.853	0.406
Echunga	AW503506	605	0.050	0.170	0.560	1.53	4.70	0.715	0.569
Lenswood	AW503507	410	0.130	0.270	0.460	1.10	4.65	0.626	0.529
Aldgate	AW503509	401	0.250	0.430	0.720	1.40	6.40	0.852	0.539
Cox	AW503526	477	0.160	0.486	1.35	3.776	15.8	1.98	2.16
Millbrook	AW504508	562	0.240	0.550	0.860	1.56	12.6	1.00	0.652
Kersbrook	AW503525	328	0.410	0.577	0.950	1.80	2.94	1.08	0.483

TP (mg/L)

Site	ID	No Samples	Minimum	10th Percentile	Median	90th Percentile	Maximum	Mean	Std Dev
Scott	AW503502	622	0.012	0.026	0.045	0.098	0.590	0.058	0.055
Houlgraves	AW503504	652	0.000	0.058	0.120	0.251	0.818	0.142	0.099
Echunga	AW503506	605	0.006	0.015	0.033	0.153	0.950	0.064	0.088
Lenswood	AW503507	410	0.008	0.016	0.034	0.150	1.20	0.067	0.100
Aldgate	AW503509	401	0.015	0.037	0.081	0.220	3.02	0.130	0.237
Cox	AW503526	477	0.000	0.158	0.720	2.66	38.1	1.35	2.40
Millbrook	AW504508	563	0.020	0.064	0.131	0.254	2.76	0.155	0.153
Kersbrook	AW503525	329	0.007	0.022	0.046	0.154	0.620	0.073	0.0171

7.10 Water Quality Loads Data Summary (all sites)

Summary data was extracted from the report "Flow Proportional Composite Sample Data Summary – Part 1"

Detailed data for each NBS site is contained in *PART 2 – Data - NBS Sites*.

The following tables provide a comparison of average annual loads for each NBS site.

Average Annual Total Catchment Load (tonnes)

Site	ID	Catchment Area km^2	TDS	SS	P	Total N
Scott	AW503502	26.8	901	124	0.4	3.5
Houlgraves	AW503504	321.0	21,100	3,610	14.5	108.5
Echunga	AW503506	34.2	1,570	108	0.7	5.7
Lenswood	AW503507	16.5	577	800	0.5	5.3
Aldgate	AW503509	7.8	261	93	0.3	2.4
Cox	AW503526	4.3	234	498	1.5	7.5
Millbrook	AW504508	NA	7,150	738	3.5	25.7
Kersbrook	AW503525	23.0	764	185	0.3	4.8

Average Annual Load (tonnes/km^2)

Site	ID	Catchment Area km^2	TDS	SS	P	Total N
Scott	AW503502	26.8	33.6	4.6	0.0	0.1
Houlgraves	AW503504	321.0	65.8	11.2	0.0	0.3
Echunga	AW503506	34.2	45.9	3.1	0.0	0.2
Lenswood	AW503507	16.5	34.9	48.5	0.0	0.3
Aldgate	AW503509	7.8	33.5	11.9	0.0	0.3
Cox	AW503526	4.3	54.4	115.7	0.3	1.7
Kersbrook	AW503525	23.0	33.2	8.0	0.0	0.2

Ranked Average Annual TDS Load (tonnes/km^2)

Site	ID	TDS
Houlgraves	AW503504	65.8
Cox	AW503526	54.4
Echunga	AW503506	45.9
Lenswood	AW503507	34.9
Scott	AW503502	33.6
Aldgate	AW503509	33.5
Kersbrook	AW503525	33.2

Ranked Average Annual SS Load (tonnes/km^2)

Site	ID	SS
Cox	AW503502	115.7
Lenswood	AW503504	48.5
Aldgate	AW503506	11.9
Houlgraves	AW503507	11.2
Kersbrook	AW503509	8.0
Scott	AW503526	4.6
Echunga	AW503525	3.1

Ranked Average Annual P Load (tonnes/km^2)

Site	ID	P
Cox	AW503504	0.3
Houlgraves	AW503526	0.0
Aldgate	AW503506	0.0
Lenswood	AW503507	0.0
Echunga	AW503502	0.0
Kersbrook	AW503509	0.0
Scott	AW503525	0.0

Ranked Average Annual Total N Load (tonnes/km^2)

Site	ID	Total N
Cox	AW503502	1.7
Houlgraves	AW503504	0.3
Lenswood	AW503506	0.3
Aldgate	AW503507	0.3
Kersbrook	AW503509	0.2
Echunga	AW503526	0.2
Scott	AW503525	0.1

8 TREND ANALYSIS - METHODOLOGY

8.1 Trend Analysis – description of method used

The method used for trend analysis is adopted from the course "Statistical Methods for Water Quality Sampling Programmes" provided by the Water Quality Centre, National Institute of Water and Atmospheric Research (NIWA), New Zealand. The recommended methods outlined in the course are encapsulated within the WQSAT PLUS software package. The Colorado University, USA in conjunction with the U.S. Environmental Pollution Agency, developed WQSTAT PLUS. Appendix 2 provides detailed descriptions of the mathematical procedures adopted by WQSTAT PLUS.

WQSTAT provides the tools to view data in a number of ways and to expose the underlying data characteristics by removing cyclic effects (seasonality) and flow effects. For example, water quality determinands, which are closely related to flow, an apparent trend in quality could be caused by a change in flow characteristics. Similarly a very large flow event may introduce a trend that in water quality concentrations that does not exist.

For many 'parametric' statistical procedures, for example simple linear regression, the distribution of data is important. A Normal distribution requires different considerations to a Log-Normal distribution. However, 'non-parametric' tests do not rely on a certain 'data distribution'.

The non-parametric Seasonal Kendall Test method (Hirsch et al. 1982) was adopted for trend analysis because: -

- It is a commonly recognized non-parametric method of trend analysis and has been adopted by leading agencies such as NIWA, Colorado University and the United States Environmental Protection Agency.
- The detection of a trend is supported by Confidence Levels (95%, 90%, 80%)
- No assumptions are required or made, apart from homogeneity, about the functional form of a trend that may be present.
- It does not depend on an assumption of a particular underlying data distribution.
- Outliers have a lesser effect, compared to parametric tests, because the test considers the ranks of the data rather than the actual values.
- It removes seasonal cycles from the data set prior to trend analysis.
- The method is easily used and provided as a standard test in WQSTAT Plus.

The mathematical procedure for the Seasonal Kendall Test is provided in Appendix 2.

8.2 Seasonal Adjustment

Concentrations can vary for the same flow rate (Nicholson and Clarke, 1992) depending on the season and a seasonal cyclic effect can be observed in the data set. As described in 7.1 the Seasonal Kendall Test removes cyclic seasonal effects from the data set. The seasons were defined in WQSTAT as: -

Autumn:	March to May
Winter:	June to August
Spring:	September to November
Summer:	December to February

Refer to Appendix 2 for the mathematical procedure used to adjust for seasonality.

8.3 Flow Adjustment

Clark and Crawley (1988) found that weak correlations between flow and concentrations for Nox, TKN, TP existed. Van der Wel (1989) found similar relationships for TDS and Nicholson and Clark (1992) confirmed these relationships.

For water quality concentrations, which are related to flow, an apparent trend in quality could be caused by a change in flow. By flow adjusting before trend analysis, flow effects can be removed and the magnitude and statistical significance of trends, which are not explained by flow. The WQStat Plus method of flow adjusting assumes that a log-log relationship between flow and water quality and can only be considered as a first approximation. Trend analysis was done using un-adjusted and flow-adjusted data. It was found that the flow-adjusted trends were very similar to the un-adjusted data. Therefore this report provides the trend analysis details without flow adjustments.

Refer to Appendix 2 for the mathematical procedure used to adjust for flow.

8.4 Homogeneity

As discussed in 7.1, the non-parametric procedure requires that no assumptions are required or made, apart from homogeneity. The dataset is required to be homogeneous. That is, each result is a part of the one data set. Step – trends can occur in the dataset due to changes in the catchment hydrology, hydrological cycle, landuse and changes in data collection methods. Any of these could produce a change in the trend and so therefore they need to be isolated and the data partitioned appropriately. Trend analysis can then be done on each homogeneous data partition.

Double Mass Curve Analysis (DMCA) was used to carry out a broad test of homogeneity and requires plotting the cumulative value from the test or primary station against a control station(s). The determinand used for the test station was flow volume (ML) and rainfall (mm) was used for each control station. The DMCA is used to detect changes in the catchment over time, not trends, and therefore flow volume and rainfall provides adequate testing for homogeneity within the catchment without having to also test each water quality determinand. Observed uniform cyclic ups and downs between each year are due to seasonal changes within each year. As the data for each site has been previously verified (see Section 5.1) it is assumed that changes in the slope represent some hydrological change rather than a change in data collection methods or bad data.

The hydrological data package, HYDSYS TS, was used to carry out the double mass curve analysis. HYDSYS allows up to 5 control stations to be used and tested against the 'Test' station.

The selection of the Control Stations was based on several requirements: -

- Continuous rainfall monitoring, rather than flow. Rainfall is more independent of changes in catchment characteristics than flow.
- Readily available long-term, good quality data collected to specified standards (DWLBC and WDS documented working procedures, see 5.1).

Note that the selected control sites do not have to be in the same catchments nor neighbouring catchments, as long as the control site is stable over time. By averaging the data from several control sites there is a better chance of smoothing out any localised variations in the reference stations.

The following rainfall sites were chosen as control stations: -

- Scott Creek at Scott Bottom (AW503502)
- Onkaparinga River at Houlgraves (AW503504)
- Torrens River at Mount Pleasant (AW504512)
- First Creek Catchment at Mount Lofty (AW504552)
- Echunga Creek Catchment (AW503533)
- Sixth Creek Catchment (AW504559)

If the DMCA indicated a change in homogeneity over time then another additional test was used to determine if the change is statistically significant. The WQSTAT "Non-parametric analysis of variance (ANOVA)" test was used to compare the different data partitions. This test compares the data before and after the suspected change(s) and determines if the difference between the medians is statistically significant. If this test showed a significant difference then the data set was partitioned and trend analysis was done on each partition.

9 TREND ANALYSIS - RESULTS

9.1 Homogeneity Results

The HYDSYS program HYMASS was used to produce double mass curves for each NBS site.

If there were indicators of temporal shifts then a further statistical test was done (ANOVA,.refer to 7.4 and Appendix 2). The data was partitioned according to the suspected shifts and the ANOVA test was used to compare the partitions in terms of statistical significant differences.

Tests were done for flow only, as it was assumed that any changes in the flow regime, over time, would also produce changes in the water quality regime. For example, if an area of land were cleared of vegetation and housing development occurred then the rainfall/runoff relationship would change. More surface runoff would occur for the same amount of rainfall because there would be little plant interception and very little percolation. Similarly the water quality concentrations for various determinands would change due to the changed land use. SS may decrease and pollutants such as metals may increase.

Appendix 3 contains the homogeneity analysis plots and ANOVA tests.

9.1.1 AW503502 – Scott Creek

The DMCA indicates that the data is homogeneous with a slight possible change in 1997. Because of this suspected change WQSTAT was used to compare the means before and after 1997 to test for significantly different means. The result of the ANOVA test indicates *No Difference* between the medians prior to 1997 and after 1997.

Conclusion: Data is homogeneous and data partitioning is not required.

9.1.2 AW503504 – Onkaparinga River at Houlgraves

The DMCA indicates that there is a slight possible change in 1997. Because of this suspected change WQSTAT was used to compare the means before and after 1997 to test for significantly different means. The result of the ANOVA test indicates *No Difference* between the medians prior to 1997 and after 1997.

Conclusion: Data is homogeneous and data partitioning is not required.

9.1.3 AW503506 – Echunga Creek upstream of Mt Bold Res.

The DMCA indicates that there is a possible change in 1997 as shown by the change in slope. Because of this suspected change WQSTAT was used to compare the means before and after 1997 to test for significantly different means. The result of the ANOVA test indicates *No Difference* between the medians prior to 1997 and after 1997.

Conclusion: Data is homogeneous and data partitioning is not required.

9.1.4 AW503507 Lenswood Creek at Lenswood

The DMCA indicates that there is a possible change in 1997 as shown by the change in slope. Because of this suspected change WQSTAT was used to compare the means before and after 1997 to test for significantly different means. The result of the ANOVA test indicates *No Difference* between the medians prior to 1997 and after 1997.

Conclusion: Data is homogeneous and data partitioning is not required.

9.1.5 AW503509 Aldgate Creek near Aldgate Railway Station

The DMCA shows that the data is homogeneous for the period of record and therefore the ANOVA test is not required.

Conclusion: Data is homogeneous and data partitioning is not required.

9.1.6 AW503526 Cox Creek at Uraidla

The DMCA shows that the data is homogeneous for the period of record and therefore the ANOVA test is not required.

Conclusion: Data is homogeneous and data partitioning is not required.

9.1.7 AW504508 Milbrook Reservoir Intake Channel

The DMCA indicates that there is a possible change in 1995 as shown by the change in slope. Because of this suspected change WQSTAT was used to compare the means before and after 1997 to test for significantly different means. The result of the ANOVA test indicates *No Difference* between the medians prior to 1995 and after 1995.

Conclusion: Data is homogeneous and data partitioning is not required.

9.1.8 AW504525 Kersbrook Creek upstream of Milbrook Reservoir

The DMCA shows a change of slope from 1997. Prior to 1997 the Double Mass Curve shows a different cyclic pattern. Kersbrook Creek stops flowing each year and generally commences flowing again later than most streams in surrounding catchments. The Period 1993 to the middle of 1995 was a dry period. WQSTAT was used to compare the means before and after 1997 to test for significantly different means. The result of the ANOVA test indicates *No Difference* between the medians prior to 1997 and after 1997.

Conclusion: Data is homogeneous and data partitioning is not required.

9.1.9 Homogeneity Summary

For the purpose of trend analysis the data sets for each of the NBS sites can be considered as homogeneous. Therefore analysis will be done for the period of record for each site.

9.2 Trend Analysis – Summary of Results

Refer to Appendix 4 for the Trend Graphs and associated tables.

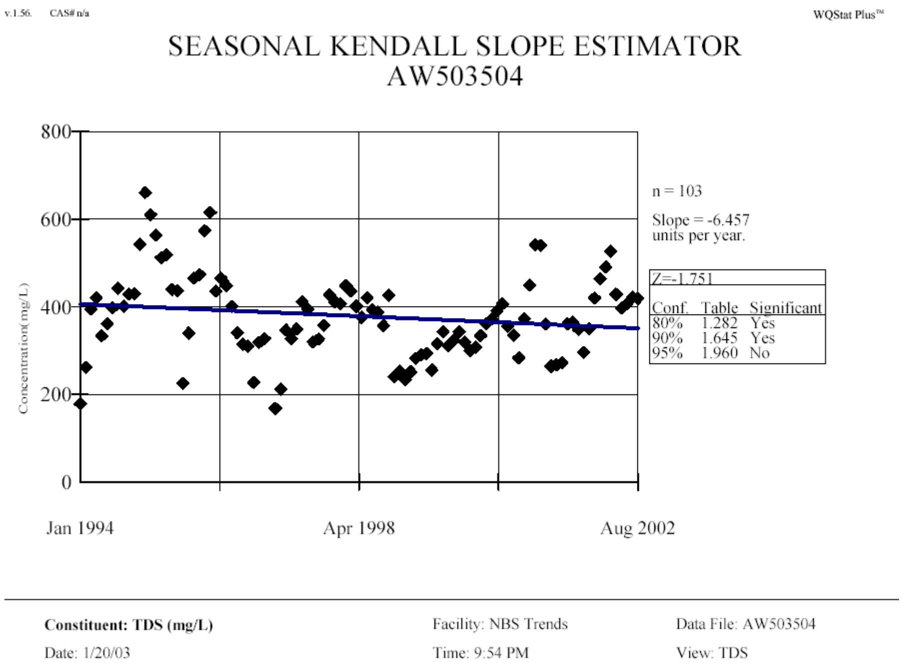
9.2.1 Interpretation of results

For each site and determinand the Seasonal Kendall Test for trends was used. The trend analysis procedure used monthly mean concentration values that were extracted from HYDSYS and imported into WQSTAT Plus.

The Seasonal Kendal Test is an extension of the Mann-Kendall test but it also includes the removal of seasonality (See Appendix 2). This method is not greatly affected by gross data errors or outliers. You will observe that in some of the trend plots there appears to be significant outliers. These values have been checked and are legitimate extreme values and so have not been removed from the data set. Although not presented in this report, outliers were removed to see what affect they had on the final result. The tests showed only minor changes in the derived trend slopes.

<u>Example - Interpretation</u>

WQStat provides a graphical and tabular output of the trend result eg



The graph displays each monthly mean concentration as a scatter plot over time and the derived trend line. The information and table to the right of each graph is as follows: -

Symbol	Description
n	n=103 103 monthly mean concentration values
slope	Slope = -6.457 units per year. For this report the Kendall Slope (Appendix 2) is derived. To calculate the Kendall Slope, the slopes are estimated for all seasons. The slopes are then ordered and the median of these slopes is the Seasonal Kendall slope estimator and is the slope of the derived trend line. In this case there is a downward trend of –6.457 mg/L per year.
Z	Z= -1.751. Z is the derived Test Statistic (see Appendix 2)
Conf	80%, 90% and 95% Confidence Level
Table	The 'Table' refers to 'Table of Distribution' and in this case represents a table of statistical values calculated for each Confident Level (80, 90 & 95%) and is derived from the Mann-Kendall Statistic for each season. (See Appendix 2)
Significant	Yes or No. The Z value is compared to the confidence levels of 80%, 90% and 95%. If the absolute value of Z is larger than these levels, the null hypothesis of no trend is rejected, and a trend exists.

In the above example WQStat has computed a test statistic, Z, of –1.751 from a data set. The test value is then compared with critical values (Table) of three confidence levels.

The comparison at the 95% level indicates that the absolute value of Z is less than the critical value (1.960). Therefore the test statistic is *not significant* and the *null hypothesis* (the null hypothesis is 'trend does not exist') should be accepted. At this confidence level there is a 5% chance of rejecting the null hypothesis when it is true (Concluding that the test statistic is significant when it is not.)

At the 90% level, absolute Z is greater than the critical value (1.645) and therefore the null hypothesis is rejected and a trend exists.

The same for the 80% level.

The test, in this case, is therefore most powerful or able to detect significant differences at the 90% level. However, there is also a 10% chance that a trend does not exist.

9.2.2 AW503502 – Trend Analysis – Summary of Results

Data: Flow un-adjusted

Determinand	Number of observations (monthly mean concentrations)	Kendall Slope Estimate (mg/L per year)	Is the Trend Significant?	Confident Level
TDS	166	+2.405	No	-
SS	40	-1.615	No	-
EC	167	+4.683	No	-
TP	167	+0.001	Yes	95%
TN	167	+0.012	Yes	95%

Flow adjustment had little effect on the results.

Trends could not be confidently detected for TDS, SS and EC.

It is 95% Confident that TP and TN concentrations are increasing.

9.2.3 AW503504 – Trend Analysis – Summary of Results

Data: Flow un-adjusted

Determinand	Number of observations (monthly mean concentrations)	Kendall Slope Estimate (mg/L per year)	Is the Trend Significant?	Confident Level
TDS	167	+0.254	No	-
SS	40	-1.893	No	-
EC	168	+0.601	No	-
TP	168	+0.004	Yes	95%
TN	168	+0.020	Yes	95%

Flow adjustment had little effect on the results.

Trends could not be confidently detected for TDS, SS and EC.

It is 95% Confident that TP and TN concentrations are increasing. It is not known whether the increase in TP and TN is caused by natural catchment inputs or influences from the River Murray.

9.2.4 AW503506 – Trend Analysis - Summary of Results

Data: Flow un-adjusted

Determinand	Number of observations (monthly mean concentrations)	Kendall Slope Estimate (mg/L per year)	Is the Trend Significant?	Confident Level
TDS	163	-1.061	No	-
SS	40	+2.377	Yes	95%
EC	167	-1.598	No	-
TP	167	+0.000	No	-
TN	167	+0.013	Yes	95%

Flow adjustment had little effect on the results.

Trends could not be confidently detected for TDS, EC and TP.

It is 95% Confident that SS and TN concentrations are increasing.

Further hydrological and landuse studies are required to determine the reasons for this increase. The author, BL Nicholson, has visually observed signs of increases in TN during field visits. He has carried out data collection runs since 1996 and for the first time, summer of 2002 (Jan/Feb), noticed the stream was a bloom of green alga ***Cladophora*** and ***Spirogyra.*** This was a visual indicator that nutrient concentrations had increased. After approximately 1 month the algae disappeared.

9.2.5 AW503507 – Trend Analysis - Summary of Results

Data: Flow un-adjusted

Determinand	Number of observations (monthly mean concentrations)	Kendall Slope Estimate (mg/L per year)	Is the Trend Significant?	Confident Level
TDS	91	-11.16	Yes	95%
SS	40	-1.834	Yes	80%
EC	92	-18.7	Yes	95%
TP	167	-0.003	Yes	80%
TN	167	-0.064	Yes	95%

Flow adjustment had no effect on the results.

TDS concentration is decreasing at approximately 11 mg/L per year.

It is likely (80% confident) that SS concentration is decreasing approximately 1.9 mg/L per year.

EC concentrations are decreasing at approximately 18.7 mg/L.

It is likely (80% confident) that TP is decreasing at approximately 0.003 mg/L.

TN concentration is decreasing at 0.06 mg/L per year.

The trend analysis indicates that the quality of water is improving. For all determinands measured decreasing trends were detected.

9.2.6 AW503509 – Trend Analysis - Summary of Results

Data: Flow un-adjusted

Determinand	Number of observations (monthly mean concentrations)	Kendall Slope Estimate (mg/L per year)	Is the Trend Significant?	Confident Level
TDS	93	-1.042	No	-
SS	40	-8.514	Yes	95%
EC	93	-0.968	No	-
TP	91	-0.004	Yes	80%
TN	94	-0.016	Yes	80%

Flow adjustment had no effect on the results.

A trend was not detected for TDS

SS concentration is decreasing approximately 8.5 mg/L per year.

A trend was not detected for EC.

TP concentration is most likely decreasing (80% confident) at 0.004 mg/L per year.

TN concentration is likely (80% confident) to be decreasing at 0.014 mg/L per year.

9.2.7 AW503526 – Trend Analysis - Summary of Results

Data: Flow un-adjusted

Determinand	Number of observations (monthly mean concentrations)	Kendall Slope Estimate (mg/L per year)	Is the Trend Significant?	Confident Level
TDS	92	-0.968	No	-
SS	40	-86.09	Yes	95%
EC	93	-4.146	No	-
TP	93	-0.041	Yes	80%
TN	93	-0.191	Yes	95%

Flow adjustment had little effect on the results.

A TDS trend was not detected

SS concentration is decreasing approximately 86 mg/L per year.

An EC trend was not detected.

TP concentration is likely to be decreasing (80% confident) at 0.04 mg/L per year.

TN concentration is decreasing at 0.19 mg/L per year.

9.2.8 AW504508 – Trend Analysis - Summary of Results

Data: Flow un-adjusted

Determinand	Number of observations (monthly mean concentrations)	Kendall Slope Estimate (mg/L per year)	Is the Trend Significant?	Confident Level
TDS	124	-1.975	No	-
SS	40	+0.116	No	-
EC	125	-4.271	No	-
TP	125	+0.005	Yes	95%
TN	125	+0.031	Yes	95%

Flow adjustment had no effect on the results.

A trend could be detected for TDS, SS and EC.

It is 95% confident that TP concentration is increasing at 0.005 mg/L per year and TN is increasing at 0.031 mg/L per year.

It is not known whether the increase in TP and TN is due to catchment inputs or influenced by the River Murray

9.2.9 AW504525 – Trend Analysis - Summary of Results

Data: Flow un-adjusted

Determinand	Number of observations (monthly mean concentrations)	Kendall Slope Estimate (mg/L per year)	Is the Trend Significant?	Confidence Level
TDS	122	-41.14	Yes	95%
SS	38	2.138	No	-
EC	123	-68.66	Yes	95%
TP	123	+0.005	Yes	95%
TN	123	+0.036	Yes	95%

TDS concentration is decreasing at approximately 41 mg/L per year.

A SS trend was not detected.

EC concentration is decreasing at approximately 69 µs/cm^2.

TP concentration is increasing at 0.005 mg/L per year.

TN concentration is increasing at 0.036 mg/L per year.

9.3 Trend Analysis Summary

The summary has been divided into natural streams and un-natural streams where the un-natural streams are influenced by water pumped from the River Murray.

For the tables below the following symbols apply: -

↓ - Decreasing trend was detected (water quality improving).
↑ - Increasing trend was detected (water quality getting worse)
→- A significant trend was not detected.

Natural Streams

Site	TDS	SS	EC	TP	TN
AW503502 Scott Creek	→	→	→	↑	↑
AW 503506 Echunga Creek	→	↑	→	→	↑
AW 503507 Lenswood Creek	↓	↓	↓	↓	↓
AW 503509 Aldgate Creek	→	↓	→	↓	↓
AW 502526 Cox Creek	→	↓	→	↓	↓
AW 504525 Kersbrook Creek	↓	→	↓	↑	↑

Un-Natural Streams

Site	TDS	SS	EC	TP	TN
AW 503504 Onkaparinga R. at Houlgraves	→	→	→	↑	↑
AW 504508 Milbrook Reservoir Intake	→	→	→	↑	↑

The table shows that TN concentration is increasing in 5 of the eight catchments.

The increasing trend in SS for Echunga Creek is a concern and requires further work to determine the reason and set in place remedial actions.

Kersbrook Creek has conflicting trends – TDS and EC are improving over time whilst TP and TN are getting worse.

10 EXCURSION ANALYSIS

A requirement of the Project Brief was to provide an assessment of exceedences over Threshold values as defined by the Brief. The Brief stipulated the following Threshold values were to be used for the 'Environmental Value of Freshwater Aquatic Ecosystems': -

Table 10.1 Water Quality environmental values and threshold limits

Determinand	**Threshold mg/L**	**Environmental** Value	**Source of** Threshold value
TP	0.1	Lowland river South Aust.	ANZECC 2000 Table 3.3.8
TN	1.0	Lowland river South Aust	ANZECC 2000 Table 3.3.8
SS	20	Freshwater aquatic ecosystem	WQEPP
TDS	500	Raw water supply	Aust Drinking Water Guidelines Aesthetic Value

Excursion Analysis was carried out using WQSTAT. The 'Proportion Estimate' method (Refer to Appendix 2) was used to assess the proportion of observations in the data set that exceed the excursion limit (threshold).

10.1 Interpretation of Results

The Proportion Estimate test computes the proportion (P) of observations in the record that exceed a stated Excursion Limit also known as the Threshold (see Table 10.1 above) and computes a Confidence Limit for this proportion (P). The test provides P for all data and then for each Season. The seasons are listed as Month/Day: -

3/1 March (Autumn)
6/1 June (Winter)
9/1 September (Spring)
12/1 December (Summer)

An example of the tabular output for TP where the Threshold is 0.5 mg/L is shown below: -

Confidence	**N**	**Proportion %**
95%	167	9

The table above depicts that at the 95% Confidence Level (CL) 9% of observations exceeded the threshold. The best result is 0% Proportion (P) exceeds the threshold at the 95% CL and the worst case is a P = 100 where all observations exceed the EL.

10.2 Excursion Analysis – Summary of Results

Appendix 5 provides the excursion analysis data from which Table 10.2 was derived.

Table 10.2 shows the Proportion of exceedence over the threshold value (T in mg/L, value of T from Table 10.1) at the 95% Confidence Limit. As can be seen from the table we can be 95% confident that Cox Creek did not exceed the threshold for TDS (500 mg/L) however it was the worst of the eight streams in terms of exceeding the thresholds for over 97% of observations for TP, TN and SS.

Table 10.2 Proportion of exceedence

Site	**TP T=0.1**	**TN T=1.0**	**SS T=20**	**TDS T=500**
AW503502 Scott Creek	9.0%	11.4%	30.0%	66.3%
AW503504 Onkaparinga R Houlgraves	68.5%	48.2%	90.0%	8.4%
AW503506 Echunga Creek	21.3%	30.5%	27.5%	96.3%
AW503507 Lenswood Creek	29.3%	51.1%	40.0%	6.6%
AW503509 Aldgate Creek	60.4%	59.8%	85.0%	1.1%
AW503526 Cox Creek	98.9%	100%	97.5%	0.0%
AW504508 Milbrook Intake	75.2%	63.5%	92.5%	51.6%
AW504525 Kersbrook Creek	34.1%	78.0%	57.9%	87.7

The trend analysis showed that Cox Creek's SS, TP and TN concentrations are reducing but it will take some 26 years at the current trend to reach conformance for TN.

All of the NBS streams are significant contributors of nutrients and suspended solids into the reservoirs. Scott, Echunga, Milbrook and Kersbrook creeks have high proportions of exceedences for TDS. Onkaparinga River, Lenswood, Aldgate and Cox creeks have high exceedences for all of the determinands analysed except for TDS, which are particularly low.

11 CONCLUSIONS

11.1 AW503502 Scott Creek

The data set is homogeneous for the period of record.
Trend analysis showed that TP and TN concentrations are increasing.
Excursion analysis showed that TP exceeded the threshold for 9% of all observations, TN 11.4%, SS 30% and TDS 66.3%.

11.2 AW503504 Onkaparinga River at Houlgraves

The data set is homogeneous for the period of record.
Trend analysis showed that TDS and EC concentrations are decreasing and TP and TN concentrations are increasing.
Excursion analysis showed that TP exceeded the threshold 68.5% of observations, TN for 48.2% of the observations, SS for 90% of the observations and TDS for 8.4%.

11.3 AW503506 Echunga Creek

The data set is homogeneous for the period of record.
Trend analysis showed that SS and TN concentrations are increasing. The analysis showed that suspended solids concentrations are increasing at approximately 2.5 mg/L per year. At this rate, SS will be consistently above the Threshold (Table 10.1) within 15 years. Consideration should be given to identifying the reason for this increase and remedial action taken. Excursion analysis showed that each of the determinands significantly exceeded the threshold values where TDS was the worst with 96% of all observations exceeding the threshold.

11.4 AW503507 Lenswood Creek

The data set is homogeneous for the period of record.
Trend analysis showed that TP, TN, TDS, SS and EC concentrations are all decreasing.
Excursion analysis showed that each of the determinands, apart from TDS, significantly exceeded the threshold. TDS exceeded the threshold for 6.6% of observations.

11.5 AW503509 Aldgate Creek

The data set is homogeneous for the period of record.
Trend analysis showed that TP, TN and SS concentrations are decreasing.
Excursion analysis showed that each of the determinands, apart from TDS, significantly exceeded the threshold. TDS exceeded the threshold for only 1% of observations.

11.6 AW503526 Cox Creek

The data set is homogeneous for the period of record.
Trend analysis showed that TP, TN and SS concentrations are all decreasing.
Excursion analysis showed that TP exceeded the DWLBC recommended threshold for 98.9% of the observations. TN exceeded the threshold for 100% of the observations and SS for 97.5% of the observations. TDS did not exceed the threshold limit.

11.7 AW504508 Milbrook Reservoir Intake

The data set is homogeneous for the period of record.
Trend analysis showed that TP and TN concentrations are increasing.
Excursion analysis showed that each of the determinands significantly exceeded the threshold.

11.8 AW504525 Kersbrook Creek

The data set is homogeneous for the period of record.
Trend analysis showed that TDS, and EC are decreasing. TP and TN concentrations are increasing.
Excursion analysis showed that each of the determinands, significantly exceeded the threshold.

11.9 General Discussion

All streams, except Scott Creek have high concentrations of Total Nitrogen and Suspended Solids that are entering the Mt Bold and Milbrook Reservoirs. It follows that the increasing trend for Total Nitrogen would also exist in the receiving waters (Reservoirs) and that the occurrence of toxic algal blooms would be increasing. Each chemical dosing of a reservoir, to destroy an algal bloom, costs SA Water more than the annual cost of maintaining and operating the NBS monitoring program (approx $70,000).

Total Nitrogen and Suspended Solids are significantly greater than the adopted Threshold for all of the NBS streams (Section 10). Cox Creek was identified as improving but it also consistently and significantly exceeds the adopted thresholds.

This report has provided conclusive, statistically supported, evidence of trends and excursions. This information would not be possible without a continuous long-term data collection program.

In the early 1970's the Federal Government recognized the need for long term flow monitoring stations to provide baseline information for the future economic, sustainable development of the States water resources. The National Assessment Program was established (NAP) and funding was provided to all States for the construction and on-going operation of key flow monitoring stations. In 1988 the Federal government transposed the responsibility of NAP to the States. A similar assessment program should be adopted for water quality so that long-term baseline data is gathered for future benchmarking. The continuation of the NBS program will ensure that the value of the already irreplaceable data will continue to grow in terms of a measuring stick to be used for the economic and sustainable development of water resources in the Mount Lofty Ranges.

This report has identified the water quality trends within the eight catchments studied and compared the water quality to key threshold values. It has shown that the streams are not healthy in terms of Nutrients and Suspended Solids but there are signs of water quality improvements.

The report does not identify hydrological reasons for the established trends nor does it provide hydrological interpretation. However, State Government departments such as the EPA, DWLBC, SA Water, PIRSA and the catchment boards can grasp the information within this report and use the data to provide a benchmark for future improvements in water quality. This cannot be done if the monitoring program ceases.

The cost of the annual operation of the NBS program can be recovered by preventing one algal bloom in Mt Bold or Milbrook Reservoirs per year. Remedial actions for the reduction of nutrients will provide the State with immediate and long term economic savings with the reduction of algal blooms. It is **recommended** that the eight NBS sites become an integral part of a water quality 'baseline' monitoring program with secure, permanent and adequate funding. By doing this, water resource managers will have an accurate and long-term 'water quality gauge' to assess the effectiveness of catchment management strategies within the Mount Lofty Ranges.

Both Milbrook Reservoir Intake and Onkaparinga River receive waters from the River Murray for Adelaide's domestic water supply. This report 'lumped' natural and imported water together and so the identified trends could not be related to the natural catchment or the River Murray. It is **recommended** that further work be done to isolate the natural flow from the imported River Murray waters and determine the relative contribution of Total Nitrogen and Suspended Solids.

Changes in trends can potentially be related to changes in the environment caused by management strategies (or lack of management). The trends identified in this report and future identified trends could be considered in relation to catchment management strategies. Investigations into the land use and land management may give a reason for trends that could then be related to 'cause and effect' and catchment hydrology.

A regular review of the data may allow the assessment of the effectiveness of catchment management strategies put in place since the release of this report. For this review the trend analysis could partition the data so that data after the release of this report is able to be compared to the results of this report.