Water Monitoring Report

October 1995 - December 1997

Ambient Water Quality Monitoring of Lake Alexandrina and Lake Albert

Report No 1

Environment Protection Agency
Government of South Australia

Cover photograph: Yachts on Lake Alexandrina, Milang (photo H. Smyth)

September 1998

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ISSN 1328 - 9918

Printed on recycled paper

SUMMARY

The water quality of Lakes Alexandrina and Albert is poor, according to findings of the ambient water quality monitoring programme of the lakes.

These findings are based on samples taken at five sites on Lakes Alexandrina and three sites on Lake Albert between October 1995 and December 1997.

Samples are collected monthly and analysed for nutrients, heavy metals and major ions, and for water clarity and salinity.

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.

The water quality of the lakes is described as poor because of:

- high turbidity in Lake Alexandrina
- moderate nitrogen and phosphorus concentrations
- concentrations of heavy metals exceeding national guidelines for the protection of aquatic ecosystems at some sites
- salinity exceeding the guidelines for good quality drinking water at some sites.

Lake Albert is more saline but less turbid than Lake Alexandrina and has higher concentrations of some dissolved salts. Lake Alexandrina had higher concentrations of some heavy metals and of total phosphorus.

Future surveys will measure chlorophyll and algal concentrations to assess the frequency of cyanobacterial blooms.

Initiatives to reduce the level of pollutants entering the River Murray and Lake Alexandrina include:

- an **Environment Protection (Water Quality) Policy** that aims to prevent point source effluent discharge and reduce diffuse agricultural sources such as runoff and soil erosion
- **Codes of Practice** for specific industries, such as dairies, that address management methods of reducing runoff, and for urban areas to reduce point source pollution from streets and industrial site runoff
- initiatives by the Murray–Darling Basin Commission to reduce nutrient and salt inputs from the catchment
- a water catchment management board for the River Murray with measures to improve water quality.

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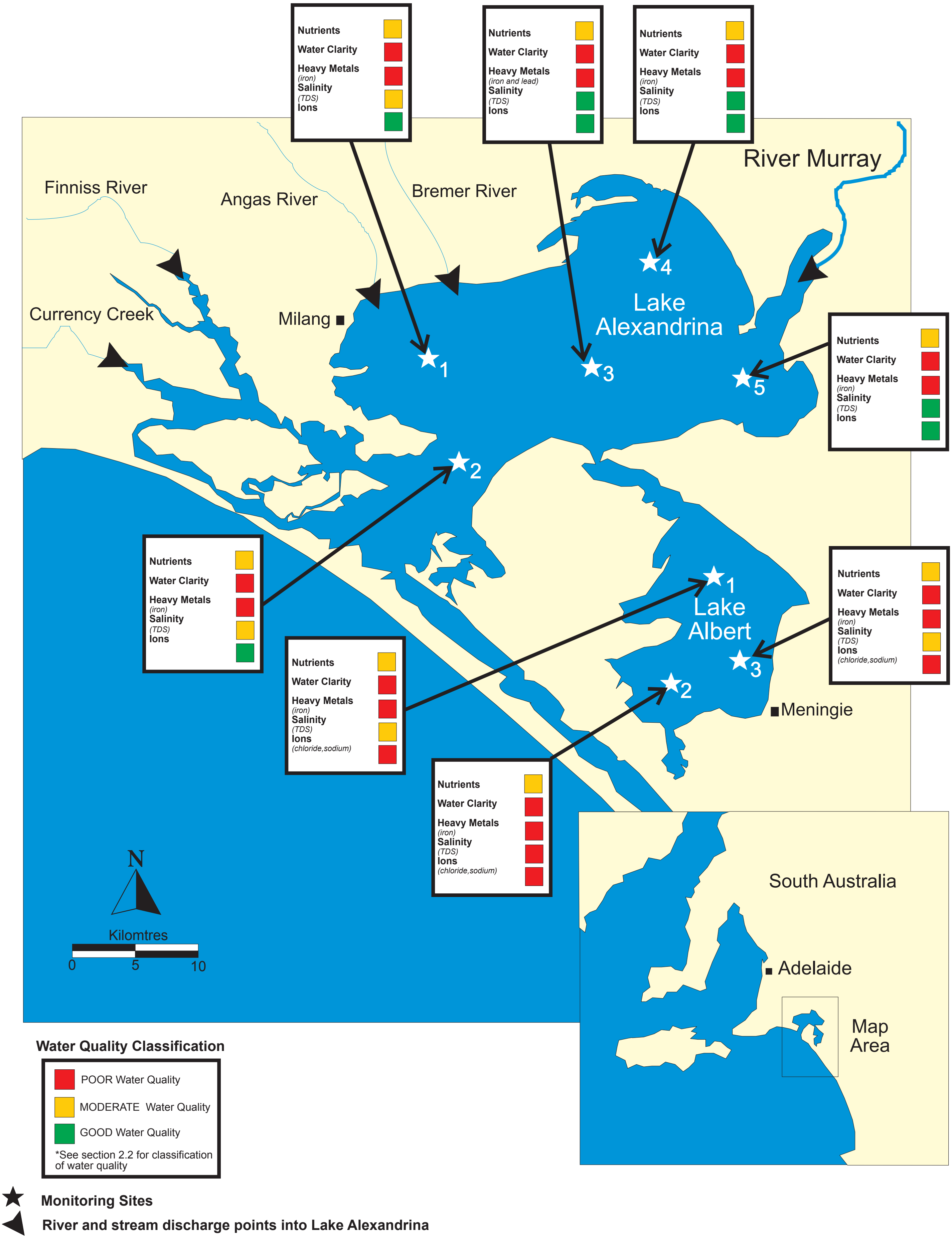
Figure 1

Ambient Water Quality Monitoring Sites
Lake Alexandrina and Lake Albert



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 Lake Alexandrina and Lake Albert.

The programme began in October 1995, and each month samples are taken and analysed from eight sites; five on Lake Alexandrina and three on Lake Albert. The sites and characteristics chosen are based on environmental issues for the lakes. This report summarises the preliminary results of the programme.

The objectives of the ambient monitoring programme are to:

- provide a qualitative and quantitative assessment of water quality in Lake Alexandrina and Lake Albert
- determine statistically significant changes or trends in the key characteristics of water quality
- provide data to assess the long term ecologically sustainable development of the two lakes.

1.1 AMBIENT WATER QUALITY

Ambient water quality refers to the overall quality of waterbodies and indicates the quality of water when all the effects that may impact upon quality are considered rather than just the effects of particular discharges. The results in this report are indicative of water quality over the period from October 1995 to December 1997.

1.2 LAKE ALEXANDRINA AND LAKE ALBERT

Lake Alexandrina (figure 1) is the largest reservoir of freshwater in South Australia and is important from ecological, recreational, agricultural and economic viewpoints. Agricultural industry and townships based along the lakes' edges extract water for a wide variety of purposes.

The lakes were formally an estuarine system but since the construction of barrages at the River Murray mouth in 1940, seawater has been excluded and the lakes now receive water and sediment primarily from the Murray (Geddes 1988).

Both lakes, and particularly Lake Alexandrina, are shallow, well mixed by prevailing winds, and are relatively turbid and saline. Under favourable conditions, nutrient inputs promote blooms of non-toxic algae *Planctonema lauterbornei* and microcrustaceans such as *Daphnia* species (Geddes 1984a,b).

Blooms of toxic *Nodularia* and *Anabaena* species (cyanobacteria) occur regularly on the lake for substantial periods and the water is often unusable during this time. Blooms are linked to the availability of nutrients, particularly nitrogen and phosphorus, and favourable weather conditions. Blooms and their toxic effects were first described in the late nineteenth century (Francis 1878) and have continued to be commonly reported (Codd et al 1994). Algal blooms probably occurred before European settlement but their frequency and severity may be increasing because of the effects of human activities.

At times the salinity of the lake increases substantially due to flow and high salinity conditions in the River Murray, evaporation from the lake and intrusion of seawater in the vicinity of the barrages. High salinity can diminish the beneficial uses of the lake water, including its use as a potable water supply.

The River Murray has the greatest effect on water quality in the lakes and provides the biggest contribution to sediment, nutrients and salt loads. The Bremer, Angas, Currency and Finniss rivers all discharge into the lake but their influence away from the point of discharge is probably minor.

The environmental values for the lakes are therefore protection of water quality:

- to support the aquatic ecosystem
- for recreation and aesthetic uses
- for potable and agricultural uses of the water.

1.3 WHAT IS MONITORED

Water quality monitoring is carried out regularly by SA Water at the intake to the Milang water supply for algal numbers and physical and chemical characteristics. This is the only other routine monitoring currently being carried out on the lake, however data from earlier studies (Mackay et al 1988 and Steffenson 1995) are available.

Characteristics monitored in the programme are:

- nutrients (total Kjeldahl nitrogen (TKN), total phosphorus, ammonia, oxidised nitrogen and silica)
- heavy metals (lead, zinc, copper, mercury, cadmium, iron and aluminium)
- water clarity (turbidity) and salinity (total dissolved solids and conductivity)
- major ions (chloride, fluoride, sulfate, calcium, magnesium, potassium, sodium and bicarbonate).

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

2 ASSESSMENT METHODS

2.1 STATISTICAL METHODS

The purpose of a 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.

2.2 WATER QUALITY CLASSIFICATION

It is useful to broadly classify the water quality at each site as 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 national guidelines — Australian Water Quality Guidelines for Fresh and Marine Waters (ANZECC 1992), or the Australian Drinking Water Guidelines (NHMRC and ARMCANZ 1996) — or 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. Heavy Metals and Major Ions

- GOOD: 90th percentile is less than or equal to a criterion.
  (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 the criterion then the water quality would not be classified as good).
- MODERATE: 90th percentile greater than a criterion but median is less than this criterion.
- POOR: Median is greater than or equal to a criterion **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).

B. Nutrients and Water Clarity

There are no specific national guidelines for nutrients in freshwaters, only range concentrations indicative of freshwaters (ANZECC 1992). Table 1 describes a broad classification for nutrients in Lake Alexandrina and Albert based on:

- Criteria used in the ambient water quality monitoring of Port River and metropolitan bathing waters (Environment Protection Authority 1997a,b)
- range criteria for freshwaters (ANZECC 1992).

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

Table 1 Criteria used to broadly classify water quality for nutrients and turbidity.

	TKN-N (mg/L)	**Oxidised nitrogen** (mg/L)	**Total phosphorus** (mg/L)	**TDS** (mg/L) (NHMRC 1992)	**Suspended Solids** (mg/L) (ANZECC 1997)	**Turbidity** (NTU)
• GOOD:	<1.0	<0.1	<0.1	<500	<5	<20
• MODERATE:	1.0-10.0	0.1-1.0	0.1-1.0	500-1000	5-30	20-50
• POOR:	>10.0	>1.0	>1.0	>1000	>30	>50

2.3 DIFFERENCES BETWEEN SITES

It is important to determine whether there are statistically significant differences between monitoring sites. The variation in some data can be substantial but may not be significant from a statistical viewpoint. One-way analysis of variance and the post hoc Tukeys pairwise comparison were used to test for differences at the 5% level of significance (P=0.05). At this level there is a probability of only 1 in 20 that a difference in means could have arisen by chance.

3 ASSESSMENT OF THE DATA

Figure 1 shows the location of monitoring sites and summarises the water quality conditions in the two lakes.

3.1 NUTRIENTS

Nutrients, such as oxidised nitrogen, phosphorus and silica are essential for plant growth. In excess however, they can encourage nuisance growths of algae, and on occasions, toxic cyanobacteria.

TKN is a measure of the organically bound nitrogen and includes both dissolved and particulate forms. Oxidised nitrogen is a soluble form of nitrogen. Total phosphorus includes both dissolved and particulate forms of phosphorus. Silica is of particular importance to diatoms (a class of algae) which use silica to build siliceous cases around themselves.

Sources

The major natural source of nitrogen and phosphorus into the lakes is runoff of nutrients from catchments into streams that eventually discharge into the lakes. Other sources include agricultural land runoff containing soil and fertilisers, urban stormwater and wastewater, and irrigation drainage.

Impacts

Excessive nutrients, combined with favourable weather conditions, can cause algal blooms. Cyanobacterial blooms can produce toxins and odours that render waters unfit for use by humans and animals. *Nodularia spumigena*, for instance, produces hepatotoxins which can cause damage to the liver. *Anabaena circinalis* may release neurotoxins, which can cause a number of effects including muscular tremor, and in extreme cases, convulsions and respiratory failure.

A cyanobacterial bloom is often characterised by a thick green paint like scum that forms on the water surface at the lake edge. Some toxins bio-degrade after three or four weeks; others persist for months. Although people are rarely poisoned by these blooms, stock losses have been substantial from stock drinking lake water containing toxins (Codd et al 1994, 1989; Carmichael 1994; Hallegraeff 1993; Cullen 1986).

Oxidised nitrogen (nitrate plus nitrite as nitrogen)

The data for most nutrients, including oxidised nitrogen, show that the distributions of measured concentrations are slightly skewed towards low values with means higher than the median. Nitrite concentrations in well-oxygenated ecosystems are normally negligible.

The results (table 2) indicated that all sites had good water quality relative to the criteria described in section 2.2B for the protection of the lake ecosystem.

Table 2 Oxidised nitrogen in Lake Alexandrina and Lake Albert

Statistics (mg/L) *Location*	Mean ± confidence interval	Median	Number of samples	Standard deviation	10^{th} percentile	90^{th} percentile	Water quality classification
Alex 1	0.007 ± 0.003	0.01	16	0.005	0.005	0.014	good
Alex 2	0.010 ± 0.008	0.01	16	0.016	0.005	0.027	good
Alex 3	0.016 ± 0.009	0.01	15	0.018	0.006	0.032	good
Alex 4	0.009 ± 0.007	0.01	16	0.014	0.005	0.024	good
Alex 5	0.017 ± 0.014	0.01	17	0.029	0.005	0.075	good
Albert 1	0.006 ± 0.001	0.01	17	0.002	0.005	0.010	good
Albert 2	0.006 ± 0.001	0.01	17	0.002	0.005	0.009	good
Albert 3	0.006 ± 0.001	0.01	17	0.002	0.005	0.009	good

Classification based on 90^{th} percentile as follows: good: <0.1 mg/L; moderate: 0.1-1 mg/L; poor >1 mg/L
Note: No significant difference between sites, P>0.05

Total Kjeldahl Nitrogen (TKN as nitrogen)

The results (table 3) indicated that all sites had moderate water quality relative to the criteria for the protection of the lake ecosystem described in section 2.2B. This is a similar pattern to that observed for total phosphorus.

Table 3 TKN in Lake Alexandrina and Lake Albert

Statistics (mg/L) *Location*	Mean ± Confidence interval	Median	Number of samples	Standard deviation	10^{th} percentile	90^{th} percentile	Water quality classification
Alex 1	0.942 ± 0.180	0.99	27	0.468	0.160	1.328	moderate
Alex 2	0.916 ± 0.168	0.92	27	0.435	0.200	1.360	moderate
Alex 3	1.442 ± 0.321	1.40	27	0.833	0.200	2.314	moderate
Alex 4	0.833 ± 0.181	0.90	27	0.469	0.160	1.166	moderate
Alex 5	0.784 ± 0.163	0.83	28	0.431	0.170	1.089	moderate
Albert 1	1.195 ± 0.200	1.15	28	0.529	0.666	1.695	moderate
Albert 2	1.239 ± 0.326	1.09	28	0.862	0.480	1.595	moderate
Albert 3	1.080 ± 0.188	1.15	28	0.496	0.200	1.578	moderate

Classification based on 90^{th} percentile as follows: good: <1 mg/L; moderate: 1-10 mg/L; poor: >10 mg/L
Note: No significant difference between sites, P>0.05

Phosphorus (total phosphorus)

The results (table 4) indicated that all sites had moderate water quality relative to the criteria for the protection of the lake ecosystem described in section 2.2B. Phosphorus concentrations in Lake Albert are generally lower than Lake Alexandrina but the difference is not statistically significant.

Table 4 Phosphorus in Lake Alexandrina and Lake Albert

Statistics (mg/L) *Location*	Mean ± Confidence interval	Median	Number of samples	Standard deviation	10th percentile	90th percentile	Water quality classification
Alex 1	0.182 ± 0.065	0.131	25	0.163	0.063	0.422	moderate
Alex 2	0.165 ± 0.058	0.127	25	0.145	0.066	0.464	moderate
Alex 3	0.168 ± 0.042	0.138	25	0.134	0.093	0.232	moderate
Alex 4	0.176 ± 0.086	0.107	25	0.214	0.064	0.410	moderate
Alex 5	0.155 ± 0.058	0.111	26	0.148	0.058	0.427	moderate
Albert 1	0.126 ± 0.043	0.093	26	0.109	0.064	0.287	moderate
Albert 2	0.115 ± 0.035	0.089	26	0.089	0.053	0.265	moderate
Albert 3	0.122 ± 0.044	0.092	26	0.112	0.056	0.220	moderate

Classification based on 90th percentile as follows: good: <0.1 mg/L; moderate: 0.1-1 mg/L; poor: >1 mg/L

Note: Alex 3 significantly different to Albert 1,2 and 3, P<0.05

Silica

The results for silica shown in table 5 are not assessed for water quality because there are no criteria available for the protection of the lake ecosystem. Concentrations of silica in fresh water in other parts of the world can vary between 1-30 mg/L although higher concentrations up to 100 mg/L are not unusual (APHA 1992).

Table 5 Silica in Lake Alexandrina and Lake Albert

Statistics (mg/L) *Location*	Mean ± Confidence interval	Median	Number of samples	Standard deviation	10th percentile	90th percentile
Alex 1	1.97 ± 0.87	1.0	25	2.17	0.70	3.64
Alex 2	2.07 ± 1.34	1.0	24	3.28	1.00	3.00
Alex 3	4.20 ± 1.71	2.1	24	4.18	0.85	9.40
Alex 4	2.31 ± 0.94	1.6	24	2.30	1.00	4.00
Alex 5	2.37 ± 0.84	1.6	24	2.07	0.86	5.40
Albert 1	1.12 ± 0.44	1.0	25	1.10	0.32	1.12
Albert 2	1.14 ± 0.47	1.0	25	1.18	0.52	1.12
Albert 3	2.95 ± 1.35	2.1	24	3.30	0.85	5.35

No guideline available

Note: Alex 3 significantly different to Alex 1 and Albert 1, 2 and 3, P<0.05

3.2 WATER CLARITY

Suspended matter influences the turbidity and transparency of water, and may include silt, clay, particles of inorganic and organic matter, plankton and other micro-organisms. Turbidity (measured in Nephelometric Turbidity Units or NTU) is a measure of the amount of scattering of light and can be approximately related to visibility as follows:

2NTU	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 corresponds to a visibility of about 1.2 metres depth which is the water clarity requirement for primary contact recreational use of water (NHMRC 1990).

Turbidity

The results (table 6) indicated that all sites had poor water quality relative to the criteria described in section 2.2B. Median and mean concentrations were substantially different indicating a skewed data set. Turbidity concentrations in Lake Alexandrina were generally higher than Lake Albert but the difference was not statistically significant.

Table 6 Turbidity in Lake Alexandrina and Lake Albert

Statistics (NTU) / *Location*	Mean ± Confidence interval	Median	Number of samples	Standard deviation	10th percentile	90th percentile	Water quality claification
Alex 1	119.3 ± 53.68	68.0	25	134.2	16.4	400.0	poor
Alex 2	111.2 ± 52.04	60.0	25	130.1	15.6	372.0	poor
Alex 3	132.7 ± 62.10	72.0	25	155.3	25.8	455.0	poor
Alex 4	114.6 ± 57.16	60.0	25	142.9	13.8	442.0	poor
Alex 5	94.67 ± 43.92	52.5	26	112.0	15.7	329.0	poor
Albert 1	73.19 ± 30.15	47.0	26	76.9	10.7	220.5	poor
Albert 2	66.02 ± 27.20	47.5	26	69.4	13.9	176.5	poor
Albert 3	63.69 ± 28.04	48.0	26	71.5	14.9	134.0	poor

Classification based on 90th percentile as follows: good: <20 NTU; moderate: 20-50 NTU; poor: >50 NTU
Note: No significant difference between sites, P>0.05

Suspended Solids

The results (table 7) indicated that water quality in both lakes were poor relative to the criteria for fresh waters of 30 mg/L (adapted from ANZECC in press). This criteria however, may not be appropriate for Lake Alexandrina and Albert due to the natural high background concentrations in both lakes.

Suspended solids may arise from industrial and sewage discharges but is mainly derived from diffuse sources such as soil and stream erosion or re-suspension of solids in the lakes. Levels of suspended solids in Lake Alexandrina and Albert would be expected to be high due to the shallowness of the lakes and the influence of wind driven turbulence that may re-suspend sediment. The major source of suspended solids is from the River Murray.

Figure 2 describes a highly significant relationship between turbidity and suspended solids in Lakes Alexandrina and Albert. Only data from August 1996 to February 1997 were used. More data for suspended solids will be needed over many years and climatic conditions to determine the true relationship between the two characteristics. Regressions were forced through the origin as it is assumed zero turbidity equates to zero suspended solids.

Table 7 Suspended Solids in Lake Alexandrina and Lake Albert

Statistics (NTU) *Location*	Mean ± Confidence interval	Median	Number of samples	Standard deviation	10th percentile	90th percentile	Water quality clarification
Alex 1	83.9 ± 18.5	78.0	25	46.3	28.2	150.8	poor
Alex 2	72.5 ± 16.9	57.0	25	42.2	27.2	138.0	poor
Alex 3	85.1 ± 23.4	67.5	25	58.5	36.7	174.4	poor
Alex 4	78.9 ± 24.2	55.0	25	60.6	29.4	187.2	poor
Alex 5	41.9 ± 11.1	32.0	26	28.4	20.1	93.3	poor
Albert 1	81.7 ± 18.0	77.0	26	45.8	36.7	127.6	poor
Albert 2	70.4 ± 14.4	70.0	25	36.1	30.4	119.6	poor
Albert 3	63.9 ± 12.3	54.0	25	30.7	28.2	108.4	poor

Classification based on 90th percentile as follows: good: <20 mg/L; moderate: 20-50 mg/L; poor: >50 mg/L
Note: No significant difference between sites, P>0.05

(A) Lake Alexandrina (B) Lake Albert

y = 0.676 (±0.082)x R^2 = 0.635 P<0.001 y = 1.507 (±0.103)x R^2 = 0.834 P<0.001

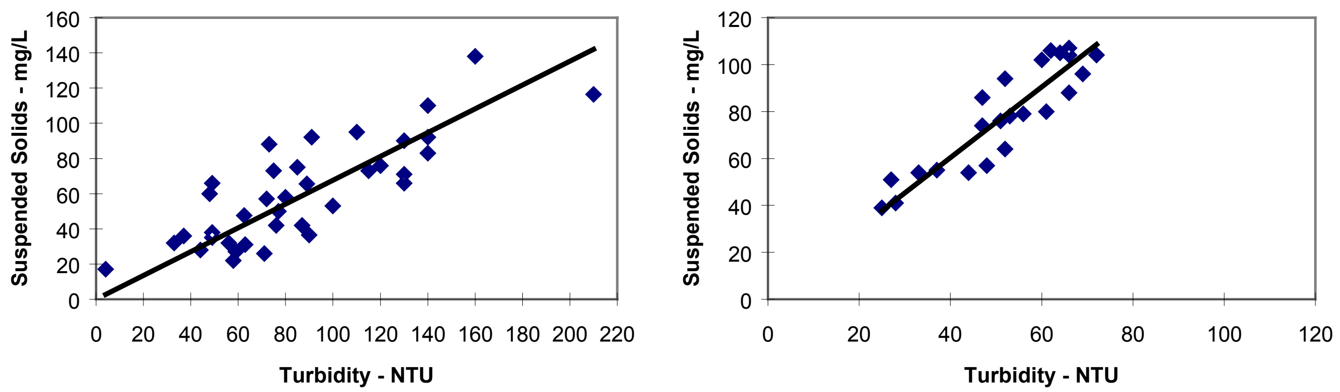


Figure 2. Relationship between suspended solids and turbidity in (a) Lake Alexandrina and (b) Lake Albert

As some nutrients, heavy metals and bacterial indicator organisms can be absorbed onto clay particles, turbidity and suspended solid concentrations can often correlate well with some other water quality charateristics. For example, Figure 3 describes the highly significant relationship between turbidity and total phosphorus for both lakes.

(A) Lake Alexandrina (B) Lake Albert

y = 895.284 (±206.78)x - 45.39 R^2 = 0.667 P<0.001 y = 469.37 (±194.12)x + 5.309 R^2=0.670 P<0.001

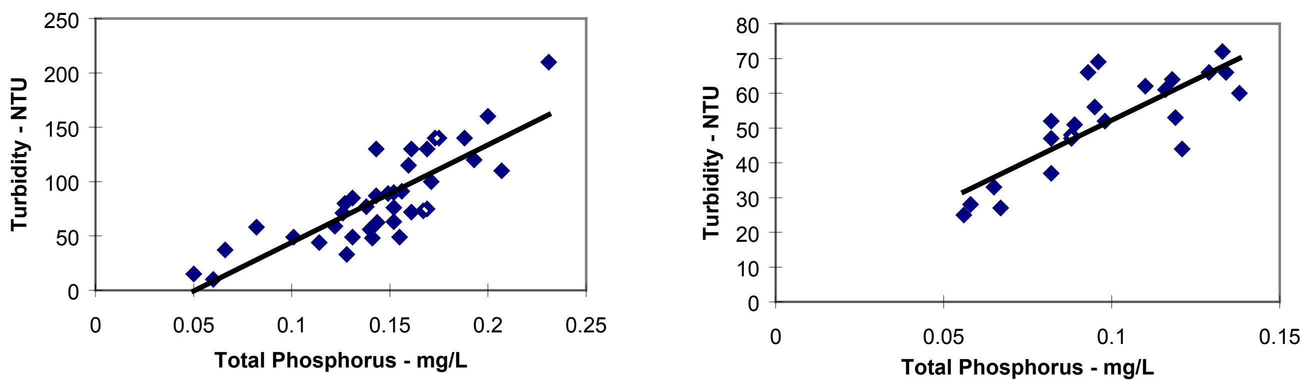


Figure 3. Relationship between turbidity and total phosphorus in (a) Lake Alexandrina and (b) Lake Albert

3.3 HEAVY METALS

Heavy metals are found in dissolved and particulate forms and have the potential to be toxic to organisms above certain concentrations.

Sources

Heavy metal contamination in Lakes Alexandrina and Albert may occur from natural sources, agricultural practices, industry, wastewater discharge and urban runoff into the River Murray. Other sources include fungicides (copper) and motor powered boats (lead).

Impacts

Heavy metals will readily accumulate in sediment and are absorbed on the surface of clay particles. As a result, higher turbidity levels are often associated with higher iron concentrations. Some heavy metals can bio-accumulate, and thereby move up the food chain and be ultimately consumed by humans.

Note: At all sites mercury and cadmium were measured below detection limits of 0.0002 and 0.0001 mg/L respectively and are not represented in the summary tables.

Aluminium (total aluminium)

Results (table 8) indicated that all sites had poor water quality relative to the criteria described in section 2.2A for the protection of freshwater ecosystems in waters with a pH greater than 6.5 (ANZECC 1992) as the 90th percentile and median values were greater than 0.1 mg/L for all sites. This classification is misleading, however, as the toxicity is due primarily to a particular soluble form of aluminium (ANZECC 1992) whereas it can be seen by reference to table 9 that most aluminium was in a particulate or insoluble form. For this reason total aluminium has not been classified.

Table 8 Aluminium in Lake Alexandrina and Lake Albert

Statistics (mg/L) *Location*	Mean ± Confidence interval	Median	Number of samples	Standard deviation	10th percentile	90th percentile
Alex 1	3.211 ± 0.930	2.50	25	2.326	0.634	6.430
Alex 2	2.974 ± 0.984	2.44	25	2.459	0.362	6.768
Alex 3	3.963 ± 1.932	2.97	25	4.829	0.764	7.192
Alex 4	3.435 ± 1.615	2.41	25	4.038	0.504	7.740
Alex 5	2.348 ± 0.606	2.11	26	1.544	0.3510	4.800
Albert 1	2.362 ± 0.741	1.75	26	1.888	0.557	5.494
Albert 2	1.809 ± 0.444	1.59	26	1.131	0.384	3.160
Albert 3	1.775 ± 0.440	1.59	26	1.121	0.314	3.187

Note: No significant difference between sites, $P>0.05$

Soluble aluminium

The results of soluble aluminium monitoring are given in table 9. Soluble aluminium concentrations were substantially less than total aluminium concentrations. This was due principally to the influence of suspended material which was included in the total aluminium results but not in the soluble aluminium results. It is known that aluminium toxicity is associated with soluble forms of aluminium, not particulate forms. For this reason the classification has been applied to the soluble aluminium results.

Table 9 Soluble aluminium in Lake Alexandrina and Lake Albert

Statistics (mg/L) / *Location*	Mean ± Confidence interval	Median	Number of samples	Standard deviation	10th percentile	90th percentile	Water quality classification
Alex 1	0.326 ± 0.266	0.037	25	0.664	0.007	1.780	moderate
Alex 2	0.309 ± 0.235	0.035	25	0.587	0.004	1.620	moderate
Alex 3	0.349 ± 0.296	0.038	25	0.740	0.013	1.760	moderate
Alex 4	0.369 ± 0.296	0.044	25	0.739	0.006	2.020	moderate
Alex 5	0.274 ± 0.188	0.042	25	0.469	0.009	1.300	moderate
Albert 1	0.197 ± 0.150	0.037	26	0.383	0.009	0.920	moderate
Albert 2	0.169 ± 0.138	0.035	26	0.351	0.003	0.748	moderate
Albert 3	0.176 ± 0.161	0.035	26	0.411	0.003	0.726	moderate

Classification: good: 90th percentile ≤ 0.1 mg/L
moderate: 90th percentile > 0.1 mg/L but median <0.1 mg/L
poor: median ≥ 0.1 mg/L

Note: No significant difference between sites, P>0.05

Copper (total copper)

The results (table 10) indicated that all sites had moderate water quality relative to the criteria described in section 2.2A for the protection of freshwater ecosystems. The national guidelines for the protection of aquatic ecosystems specify a guideline of 0.005 mg/L for copper (ANZECC 1992). This value is the same as the analytical detection limit for freshwaters. This causes problems for assessment as measurements reported at the detection limit fail to meet the national guideline. The criteria used has therefore been set at 0.01 mg/L to overcome these problems.

Table 10 Copper in Lake Alexandrina and Lake Albert

Statistics (mg/L) / *Location*	Mean ± Confidence interval	Median	Number of samples	Standard deviation	10th percentile	90th percentile	Water quality classification
Alex 1	0.010 ± 0.003	0.007	25	0.006	0.005	0.022	moderate
Alex 2	0.010 ± 0.003	0.007	25	0.007	0.005	0.018	moderate
Alex 3	0.011 ± 0.003	0.007	25	0.007	0.005	0.017	moderate
Alex 4	0.011 ± 0.004	0.008	25	0.009	0.005	0.021	moderate
Alex 5	0.009 ± 0.004	0.005	26	0.010	0.004	0.020	moderate
Albert 1	0.008 ± 0.002	0.005	26	0.006	0.005	0.018	moderate
Albert 2	0.009 ± 0.003	0.005	26	0.008	0.004	0.017	moderate
Albert 3	0.008 ± 0.004	0.005	26	0.009	0.005	0.014	moderate

Classification: good: 90th percentile ≤ 0.01 mg/L
moderate: 90th percentile > 0.01 mg/L but median <0.01 mg/L
poor: median ≥ 0.01 mg/L

Note: No significant difference between sites, P>0.05

Iron (total iron)

The results (table 11) indicated that all Lake Alexandrina and Lake Albert sites had poor water quality relative to the criteria described in section 2.2A for the protection of freshwater ecosystems (ANZECC 1992).

Table 11 Iron in Lake Alexandrina and Lake Albert

Statistics (mg/L) / *Location*	Mean ± Confidence interval	Median	Number of samples	Standard deviation	10th percentile	90th percentile	Water quality classification
Alex 1	3.352 ± 0.740	2.920	25	1.851	1.426	5.348	poor
Alex 2	3.101 ± 0.789	2.800	25	1.973	1.109	5.652	poor
Alex 3	5.405 ± 1.406	5.150	25	3.510	1.500	8.604	poor
Alex 4	3.550 ± 1.273	2.410	25	3.182	1.298	7.420	poor
Alex 5	2.498 ± 0.564	2.165	26	1.438	0.934	4.550	poor
Albert 1	2.390 ± 0.597	1.865	26	1.523	1.040	4.495	poor
Albert 2	1.791 ± 0.358	1.660	26	0.912	0.928	3.135	poor
Albert 3	1.740 ± 0.379	1.510	26	0.965	0.784	3.450	poor

Classification: good: 90th percentile ≤ 1.0 mg/L
moderate: 90th percentile > 1.0 mg/L but median <1.0 mg/L
poor: median ≥ 0.1 mg/L

Note: Alex 3 significantly different to Alex 5 and Albert 1,2 and 3, P<0.05

Lead (total lead)

The results (table 12) indicated that one Lake Alexandrina site had poor water quality and all other sites had moderate or good water quality relative to the criteria described in section 2.2A for the protection of freshwater ecosystems (ANZECC 1992). Elevated lead concentrations are of concern due to their potential for bioaccumulation.

Table 12 Lead in Lake Alexandrina and Lake Albert

Statistics (mg/L) / *Location*	Mean ± Confidence interval	Median	Number of samples	Standard deviation	10th percentile	90th percentile	Water quality classification
Alex 1	0.004 ± 0.001	0.003	25	0.003	0.002	0.009	moderate
Alex 2	0.006 ± 0.005	0.003	25	0.013	0.002	0.006	moderate
Alex 3	0.005 ± 0.001	0.005	25	0.003	0.002	0.009	poor
Alex 4	0.003 ± 0.001	0.003	25	0.002	0.001	0.005	good
Alex 5	0.003 ± 0.001	0.002	25	0.004	0.001	0.005	good
Albert 1	0.003 ± 0.001	0.002	26	0.003	0.001	0.006	moderate
Albert 2	0.003 ± 0.001	0.002	26	0.002	0.001	0.004	good
Albert 3	0.003 ± 0.001	0.002	26	0.003	0.001	0.004	good

Classification: good: 90th percentile ≤ 0.005 mg/L
moderate: 90th percentile > 0.005 mg/L but median <0.005 mg/L
poor: median ≥ 0.005 mg/L

Note: No significant difference between sites, P>0.05.

Zinc (total zinc)

The results (table 13) indicated that four Lake Alexandrina sites and one Lake Albert site had moderate water quality relative to the criteria described in section 2.2A for the protection of freshwater ecosystems. However, 90th percentiles were only marginally above the guideline for the protection of the aquatic ecosystem (ANZECC 1992).

Table 13 Zinc in Lake Alexandrina and Lake Albert

Statistics (mg/L)	Mean ± Confidence interval	Median	Number of samples	Standard deviation	10th percentile	90th percentile	Water quality classification
Location							
Alex 1	0.028 ± 0.008	0.023	25	0.019	0.008	0.054	moderate
Alex 2	0.024 ± 0.007	0.021	25	0.017	0.005	0.044	good
Alex 3	0.038 ± 0.011	0.030	25	0.029	0.008	0.077	moderate
Alex 4	0.026 ± 0.008	0.020	25	0.020	0.007	0.057	moderate
Alex 5	0.024 ± 0.007	0.020	26	0.018	0.005	0.052	moderate
Albert 1	0.028 ± 0.006	0.027	26	0.015	0.007	0.048	good
Albert 2	0.029 ± 0.008	0.026	26	0.020	0.006	0.047	good
Albert 3	0.034 ± 0.013	0.026	26	0.034	0.006	0.056	moderate

Classification: good: 90th percentile ≤ 0.05 mg/L
moderate: 90th percentile > 0.05 mg/L but median <0.05 mg/L
poor: median ≥ 0.05 mg/L

Note: No significant difference between sites, P>0.05

Soluble zinc

The results shown in table 14 cannot be given a water quality classification because there are no guidelines available. Soluble zinc were included because it is likely that soluble forms are more toxic than particulate forms.

Table 14 Soluble zinc in Lake Alexandrina and Lake Albert

Statistics (mg/L)	Mean ± Confidence interval	Median	Number of samples	Standard deviation	10th percentile	90th percentile
Location						
Alex 1	0.019 ± 0.007	0.013	25	0.017	0.005	0.046
Alex 2	0.015 ± 0.006	0.010	25	0.015	0.004	0.028
Alex 3	0.021 ± 0.008	0.014	25	0.019	0.002	0.047
Alex 4	0.015 ± 0.004	0.015	25	0.011	0.004	0.029
Alex 5	0.017 ± 0.005	0.019	26	0.013	0.005	0.032
Albert 1	0.022 ± 0.005	0.021	26	0.014	0.006	0.038
Albert 2	0.021 ± 0.006	0.019	26	0.014	0.005	0.038
Albert 3	0.020 ± 0.006	0.019	26	0.015	0.004	0.044

No guideline available

Note: No significant difference between sites, P>0.05

3.4 SALINITY AND MAJOR IONS

Concentrations of salinity and major ions can vary due to local geology, climate and geography.

Sources and impacts

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

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 aquatic invertebrates and bones of vertebrates.

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

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

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

Potassium salts are widely used in industry and in agricultural fertilisers and enter from discharges and runoff from agricultural land. Potassium salts are highly soluble and readily accumulated by aquatic biota as an essential element.

Sodium is highly soluble in water and a very abundant element. Concentrations may be increased by sewage and industrial effluents or seawater intrusion. The Australian Drinking Water Guidelines set a criteria of 180 mg/L based on aesthetic considerations. High sodium levels in water are undesirable for drinking and damage soil structure when used for irrigation.

Sulfate occurs naturally and can arise from atmospheric deposition from oceanic aerosols and the leaching of sulphur compounds. Industrial discharge and atmospheric precipitation are other sources. Concentrations greater than 500 mg/L may make water unpleasant to drink and can cause purgative effects.

A. SALINITY

Conductivity (at 25°C)

Specific conductance, or conductivity, is a measure of the water's ability to conduct an electrical current and is dependent on the concentration of dissolved solids such as mineral salts.

The results in table 15 show Lake Albert's salinity was significantly higher than that of Lake Alexandrina.

Table 15 Conductivity (at 25°C) in Lake Alexandrina and Lake Albert

Statistics (µS/cm) *Location*	Mean ± Confidence interval	Median	Number of samples	Standard deviation	10th percentile	90th percentile
Alex 1	575.7 ± 75.1	568	25	187.7	337.6	830.4
Alex 2	597.5 ± 98.7	570	25	246.8	309.4	974.0
Alex 3	529.1 ± 67.1	542	25	167.8	322.0	745.6
Alex 4	550.7 ± 65.2	552	25	163.1	307.6	768.0
Alex 5	543.3 ± 69.2	570	26	176.4	287.4	761.8
Albert 1	1253.0 ± 89.1	1280	26	227.1	933.8	1500.0
Albert 2	1300.0 ± 112.5	1360	26	286.9	952.1	1619.0
Albert 3	1300.8 ± 65.7	1280	26	167.5	1084.0	1553.0

Note: Albert 1 significantly different to Alex 1, 2, 3, 4 and 5, P<0.05
Albert 2 significantly different to Alex 1, 2, 3, 4 and 5, P<0.05
Albert 3 significantly different to Alex 1, 2, 3, 4 and 5, P<0.05

Total dissolved solids (TDS)

Total dissolved solids is derived from conductivity measurements. The results (table 16) indicated that one Lake Albert site had poor water quality relative to the criteria described in section 2.2A. Four sites had moderate water quality and three sites had good water quality, however, 90th percentiles were only marginally less than the drinking water guideline. TDS in Lake Albert was significantly higher than Lake Alexandrina.

Table 16 Total dissolved solids in Lake Alexandrina and Lake Albert

Statistics (mg/L) *Location*	Mean ± Confidence interval	Median	Number of samples	Standard deviation	10th percentile	90th percentile	Water quality classification
Alex 1	336.6 ± 48.8	320.0	25	121.9	186.0	530.0	moderate
Alex 2	347.8 ± 59.4	320.0	25	148.4	185.4	582.4	moderate
Alex 3	301.3 ± 46.0	300.0	25	115.03	176.0	477.4	good
Alex 4	321.7 ± 43.9	329.0	25	109.8	170.0	491.8	good
Alex 5	315.7 ± 46.0	310.0	26	117.3	157.0	487.4	good
Albert 1	730.8 ± 65.4	705.0	26	166.7	545.0	963.0	moderate
Albert 2	757.7 ± 80.7	745.0	26	205.8	521.0	1036.0	poor
Albert 3	757.0 ± 58.5	705.0	26	149.1	597.0	992.4	moderate

Classification based on 90th percentile as follows: good: <500 mg/L; moderate:500-1000 mg/L; poor: >1000 mg/L
Note: Albert 1 significantly different to Alex 1, 2, 3, 4 and 5, P<0.05
Albert 2 significantly different to Alex 1, 2, 3, 4 and 5, P<0.05
Albert 3 significantly different to Alex 1, 2, 3, 4 and 5, P<0.05

B. MAJOR IONS

Bicarbonate

As shown in table 17, bicarbonate concentrations in Lake Albert were significantly higher than Lake Alexandrina.

Table 17 Bicarbonate in Lake Alexandrina and Lake Albert

Statistics (mg/L) *Location*	Mean ± Confidence interval	Median	Number of samples	Standard deviation	10^{th} percentile	90^{th} percentile
Alex 1	62.4 ± 6.5	64.0	7	8.7	53.4	70.8
Alex 2	62.9 ± 6.7	64.0	7	8.9	53.8	72.8
Alex 3	58.9 ± 3.6	58.0	7	4.8	54.8	63.8
Alex 4	62.0 ± 8.7	62.0	7	11.5	51.2	74.8
Alex 5	61.6 ± 8.1	60.5	8	11.4	47.7	75.3
Albert 1	137.6 ± 4.9	137.0	8	7.0	130.5	145.3
Albert 2	140.1 ± 2.8	140.0	8	3.9	136.5	145.0
Albert 3	133.5 ± 5.7	133.5	8	7.9	124.7	141.8

No guideline available

Note: Albert 1 significantly different to Alex 1, 2, 3, 4 and 5, $P<0.05$
Albert 2 significantly different to Alex 1, 2, 3, 4 and 5, $P<0.05$
Albert 3 significantly different to Alex 1, 2, 3, 4 and 5, $P<0.05$

Calcium

As shown in table 18, calcium concentrations in Lake Albert were significantly higher than Lake Alexandrina.

Table 18 Calcium in Lake Alexandrina and Lake Albert

Statistics (mg/L) *Location*	Mean ± Confidence interval	Median	Number of samples	Standard deviation	10^{th} percentile	90^{th} percentile
Alex 1	15.82 ± 1.93	15.60	19	4.21	10.70	22.20
Alex 2	16.60 ± 2.89	15.30	19	6.29	10.50	25.10
Alex 3	14.66 ± 2.23	13.20	19	4.85	9.91	21.60
Alex 4	15.56 ± 1.89	15.50	19	4.12	9.70	21.70
Alex 5	15.20 ± 1.92	15.80	20	4.29	9.76	20.97
Albert 1	33.52 ± 3.10	36.30	20	6.94	26.16	44.59
Albert 2	37.54 ± 3.06	37.80	20	6.84	30.14	44.72
Albert 3	36.95 ± 2.32	36.60	20	5.18	29.97	43.27

No guideline available

Note: Albert 1 significantly different to Alex 1, 2, 3, 4 and 5, $P<0.05$
Albert 2 significantly different to Alex 1, 2, 3, 4 and 5, $P<0.05$
Albert 3 significantly different to Alex 1, 2, 3, 4 and 5, $P<0.05$

Chloride

The results (table 19) indicated that all Lake Albert sites had poor water quality and all Lake Alexandrina sites had good water quality relative to the criteria described in section 2.2A for the protection of drinking water. Chloride concentrations in Lake Albert are significantly higher than Lake Alexandrina.

Table 19 Chloride in Lake Alexandrina and Lake Albert

Statistics (mg/L) *Location*	Mean ± Confidence interval	Median	Number of samples	Standard deviation	10^{th} percentile	90^{th} percentile	Water quality classification
Alex 1	111.3 ± 22.0	113.0	19	47.9	55.0	183.6	good
Alex 2	117.4 ± 27.7	113.0	19	60.4	54.2	188.4	good
Alex 3	130.3 ± 18.0	135.0	21	41.2	92.0	177.0	good
Alex 4	108.7 ± 21.4	104.0	19	46.6	52.8	166.4	good
Alex 5	104.5 ± 21.0	95.5	20	46.9	49.9	161.1	good
Albert 1	312.1 ± 20.7	312.0	20	46.3	270.1	354.6	poor
Albert 2	315.1 ± 29.3	321.5	20	65.4	279.6	371.1	poor
Albert 3	315.9 ± 21.0	316.5	20	46.9	255.0	362.9	poor

Classification: good: 90^{th} percentile ≤ 250 mg/L (based on aesthetics)
moderate: 90^{th} percentile > 250 mg/L but median < 250 mg/L
poor: median ≥ 250 mg/L

Note: Albert 1 significantly different to Alex 1, 2, 3, 4 and 5, $P<0.05$
Albert 2 significantly different to Alex 1, 2, 3, 4 and 5, $P<0.05$
Albert 3 significantly different to Alex 1, 2, 3, 4 and 5, $P<0.05$

Fluoride

The results (table 20) indicated that all sites had good water quality relative to the criteria described in section 2.2A for the protection of drinking water. Fluoride concentrations in Lake Albert are significantly higher than Lake Alexandrina.

Table 20 Fluoride in Lake Alexandrina and Lake Albert

Statistics (mg/L) *Location*	Mean ± Confidence interval	Median	Number of samples	Standard deviation	10^{th} percentile	90^{th} percentile	Water quality classifcation
Alex 1	0.18 ± 0.02	0.2	25	0.06	0.11	0.24	good
Alex 2	0.17 ± 0.02	0.2	25	0.04	0.11	0.23	good
Alex 3	0.18 ± 0.04	0.2	25	0.09	0.10	0.26	good
Alex 4	0.16 ± 0.02	0.2	25	0.05	0.10	0.20	good
Alex 5	0.16 ± 0.02	0.2	26	0.05	0.10	0.20	good
Albert 1	0.25 ± 0.04	0.3	26	0.09	0.19	0.30	good
Albert 2	0.29 ± 0.05	0.3	26	0.14	0.20	0.36	good
Albert 3	0.29 ± 0.05	0.3	26	0.13	0.23	0.39	good

Classification: good: 90^{th} percentile ≤ 1.5 mg/L
moderate: 90^{th} percentile > 1.5 mg/L but median <1.5 mg/L
poor: median ≥ 1.5 mg/L

Note: Albert 1 significantly different to Alex 1, 2, 3, 4 and 5, $P<0.05$
Albert 2 significantly different to Alex 1, 2, 3, 4 and 5, $P<0.05$
Albert 3 significantly different to Alex 2, 3, 4 and 5, $P<0.05$

Magnesium

As shown in table 21, magnesium concentrations in Lake Albert were significantly higher than Lake Alexandrina.

Table 21 Magnesium in Lake Alexandrina and Lake Albert

Statistics (mg/L) *Location*	Mean ± Confidence interval	Median	Number of samples	Standard deviation	10th percentile	90th percentile
Alex 1	14.27 ± 2.55	12.80	19	5.55	8.20	23.00
Alex 2	14.58 ± 2.94	12.80	19	6.41	8.30	24.00
Alex 3	12.03 ± 2.55	11.00	19	5.56	8.14	21.78
Alex 4	13.97 ± 2.44	12.80	19	5.31	7.20	22.90
Alex 5	13.47 ± 2.40	12.40	20	5.37	7.13	22.71
Albert 1	33.52 ± 3.10	30.50	20	6.94	26.16	44.81
Albert 2	34.76 ± 4.20	31.40	20	9.40	25.95	47.00
Albert 3	34.14 ± 3.56	31.00	20	7.97	25.45	45.93

No guideline available

Note: Albert 1 significantly different to Alex 1, 2, 3, 4 and 5, $P<0.05$
Albert 2 significantly different to Alex 1, 2, 3, 4 and 5, $P<0.05$
Albert 3 significantly different to Alex 1, 2, 3, 4 and 5, $P<0.05$

Potassium

As shown in table 22, potassium concentrations in Lake Albert were significantly higher than Lake Alexandrina.

Table 22 Potassium in Lake Alexandrina and Lake Albert

Statistics (mg/L) *Location*	Mean ± Confidence interval	Median	Number of samples	Standard deviation	10th percentile	90th percentile
Alex 1	4.5 ± 0.5	4.5	19	1.1	3.0	6.4
Alex 2	4.6 ± 0.7	4.6	19	1.7	2.2	6.4
Alex 3	4.3 ± 0.5	4.2	19	1.2	3.2	5.6
Alex 4	4.3 ± 0.6	4.5	19	1.2	2.2	5.9
Alex 5	4.1 ± 0.4	4.1	19	0.9	2.9	5.5
Albert 1	9.3 ± 0.5	9.3	20	1.1	8.2	11.0
Albert 2	9.6 ± 0.7	9.6	20	1.6	7.9	11.4
Albert 3	9.4 ± 0.4	9.2	20	1.0	8.2	11.0

No guideline available

Note: Albert 1 significantly different to Alex 1, 2, 3, 4 and 5, $P<0.05$
Albert 2 significantly different to Alex 1, 2, 3, 4 and 5, $P<0.05$
Albert 3 significantly different to Alex 1, 2, 3, 4 and 5, $P<0.05$

Sodium

The results (table 23) indicated that all Lake Albert sites hade poor water quality and all Lake Alexandrina sites had good water quality relative to the criteria described in section 2.2A for the protection of drinking water. Sodium concentrations in Lake Albert were significantly higher than Lake Alexandrina.

Table 23 Sodium in Lake Alexandrina and Lake Albert

Statistics (mg/L) *Location*	Mean ± Confidence interval	Median	Number of samples	Standard deviation	10th percentile	90th percentile	Water quality classification
Alex 1	72.5 ± 13.7	69.0	19	29.8	39.3	120.0	good
Alex 2	75.8 ± 17.2	68.0	19	37.5	35.2	134.0	good
Alex 3	65.2 ± 12.9	59.0	19	28.1	35.3	111.0	good
Alex 4	70.7 ± 12.8	72.0	19	28.0	34.3	112.0	good
Alex 5	68.0 ± 13.2	63.0	20	29.6	28.5	118.8	good
Albert 1	186.8 ± 13.9	182.0	20	31.3	153.8	238.9	poor
Albert 2	191.2 ± 18.8	191.0	20	42.0	152.5	239.5	poor
Albert 3	190.0 ± 15.0	188.0	20	33.6	148.3	243.0	poor

Classification: good: 90th percentile ≤ 180 mg/L
moderate: 90th percentile > 180 mg/L but median < 180 mg/L
poor: median ≥ 180 mg/L

Note: Albert 1 significantly different to Alex 1, 2, 3, 4 and 5, $P<0.05$
Albert 2 significantly different to Alex 1, 2, 3, 4 and 5, $P<0.05$
Albert 3 significantly different to Alex 1, 2, 3, 4 and 5, $P<0.05$

Sulfate

The results (table 24) indicated that all sites had good water quality relative to the criteria described in section 2.2A for the protection of drinking water. Sulfate concentrations in Lake Albert were significantly higher than Lake Alexandrina.

Table 24 Sulfate in Lake Alexandrina and Lake Albert

Statistics (mg/L) *Location*	Mean ± Confidence interval	Median	Number of samples	Standard deviation	10th percentile	90th percentile	Water qulaity classification
Alex 1	25.7 ± 5.2	26.0	19	11.3	13.2	42.2	good
Alex 2	26.4 ± 6.1	25.0	19	13.3	13.18	44.3	good
Alex 3	30.5 ± 4.4	32.0	21	10.1	20.3	42.2	good
Alex 4	25.1 ± 5.0	25.1	19	10.9	12.6	38.6	good
Alex 5	24.1 ± 4.9	21.5	20	10.9	11.7	38.4	good
Albert 1	62.0 ± 4.2	63.8	20	9.5	50.8	72.6	good
Albert 2	63.6 ± 6.0	67.3	20	13.5	52.4	74.8	good
Albert 3	62.7 ± 4.3	64.4	20	9.6	50.0	73.2	good

Classification: good: 90th percentile ≤ 500 mg/L
moderate: 90th percentile > 500 mg/L but median < 500 mg/L
poor: median ≥ 500 mg/L

Note: Albert 1 significantly different to Alex 1, 2, 3, 4 and 5, $P<0.05$
Albert 2 significantly different to Alex 1, 2, 3, 4 and 5, $P<0.05$
Albert 3 significantly different to Alex 1, 2, 3, 4 and 5, $P<0.05$

4 CONCLUDING REMARKS

Based on the preliminary findings of the ambient water quality monitoring programme the water quality of Lakes Alexandrina and Albert would be described as poor for the following reasons:

1. Turbidity was high with mean concentrations exceeding 100 NTU in Lake Alexandrina. Lake Albert had marginally lower turbidity than Lake Alexandrina.
2. Concentrations of TKN and phosphorus were moderate in both lakes, however oxidised nitrogen concentrations were low.
3. Concentrations of iron exceeded national guidelines for the protection of the aquatic ecosystem. Concentrations of lead and zinc exceeded these guidelines at some sites. Concentrations of copper were elevated at all sites.
4. Salinity (TDS), chloride and sodium exceeded the guideline for good quality drinking water at some sites.

The primary source of poor quality water is from the River Murray which derives its water from the catchments of the Murray—Darling Basin. The turbidity and nutrient status of the lake is comparable to observations made by Geddes (1984a, 1988), Mackay et al (1988) and Steffensen (1995).

Differences in the concentrations of salinity and major ions highlighted the physico-chemical differences between the two lakes. For instance:

1. Lake Albert was more saline than Lake Alexandrina with significantly higher concentrations of total dissolved solids.
2. Lake Albert had significantly higher concentrations of chloride, fluoride, sulfate, bicarbonate, calcium, potassium and sodium than Lake Alexandrina.
3. Lake Alexandrina was generally more turbid than Lake Albert but the difference was not statistically significant.
4. For iron and aluminium, Lake Alexandrina had marginally higher concentrations than Lake Albert.

The differences are primarily due to the concentration of salts in Lake Albert owing to evaporation and poorer flushing, and the direct influence of the River Murray discharging into Lake Alexandrina.

An important consideration for Lakes Alexandrina and Albert is the potential for cyanobacterial blooms. Although oxidised nitrogen was very low, concentrations of other forms of nitrogen (eg. TKN) and phosphorus were moderate in both lakes. Human activities have probably increased the incidence of cyanobacterial blooms. High turbidity and hence reduced light availability, is probably an important factor that prevents blooms from occurring more frequently. Future surveys will include measurements of chlorophyll and algae so that changes in the frequency of algal blooms can be assessed.

Initiatives throughout the Murray and Lake Alexandrina catchments to reduce nutrient inputs include:

1. The development of a **Water Quality Policy** that aims to:
   - prevent point sources of municipal and industrial effluent discharge
   - reduce diffuse agricultural sources such as runoff and soil erosion.

2. **Codes of Practice** for specific industries, such as dairies, that address management methods for reducing agricultural runoff into waterways. Codes of Practice will also aim to reduce urban source pollution from streets and industrial site runoff.
3. Initiatives by the Murray Darling Basin Commission to reduce nutrient and salt inputs throughout the catchment.
4. The establishment of a Catchment Management Board for the River Murray and measures that they will be taking to improve water quality.

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