Report 16, to end of June 2010

Lower Lakes and Tributaries

Water Quality Report

Ambient and Response Monitoring

Environment Protection Authority

EPA South Australia

Observations at a Glance

- ***Areas of localised acidity in Boggy Lake have been dosed with limestone on the 28th May to the 2nd June and 22nd to the 24th June, as a result alkalinity has improved and acidity has been reduced at all sites.***
- ***pH and alkalinity remains satisfactory at all sites within the main water bodies of Lake Alexandrina and Lake Albert whilst salinity and nutrient levels remain very high at all sites.***
- ***Previously acidic sites on the western margin of Lake Albert were found to have neutralised during June (pH 6-8.5). The eastern margin of Lake Albert is yet to be screened for water quality, this is scheduled to be undertaken in July.***
- ***Alkalinity in Upper Currency Creek has continued to increase to between 46-55 mg/L as $CaCO_3$, however is still considered a high risk site of acidification and continues to be monitored bi-weekly.***
- ***The previously acidic water body at Loveday Bay has been neutralised as a result of the connection with high alkaline water from Lake Alexandrina.***

Background

The Environment Protection Authority (EPA), Department of Environment and Natural Resources (DENR), and the Department for Water (DFW) are monitoring to assess potential water quality impacts associated with water level decline and the oxidation of acid sulfate soils in the Lower Lakes. Ambient water quality sampling is undertaken fortnightly at 19 sites in Lake Alexandrina (including the Goolwa Channel, Currency Creek and Finniss River tributary regions), and Lake Albert (Figure 1). Response water quality sampling is also undertaken in selected regions that have experienced acidification or are at risk of acidification (Figure 1). Previous reports are contained on the EPA website[1].

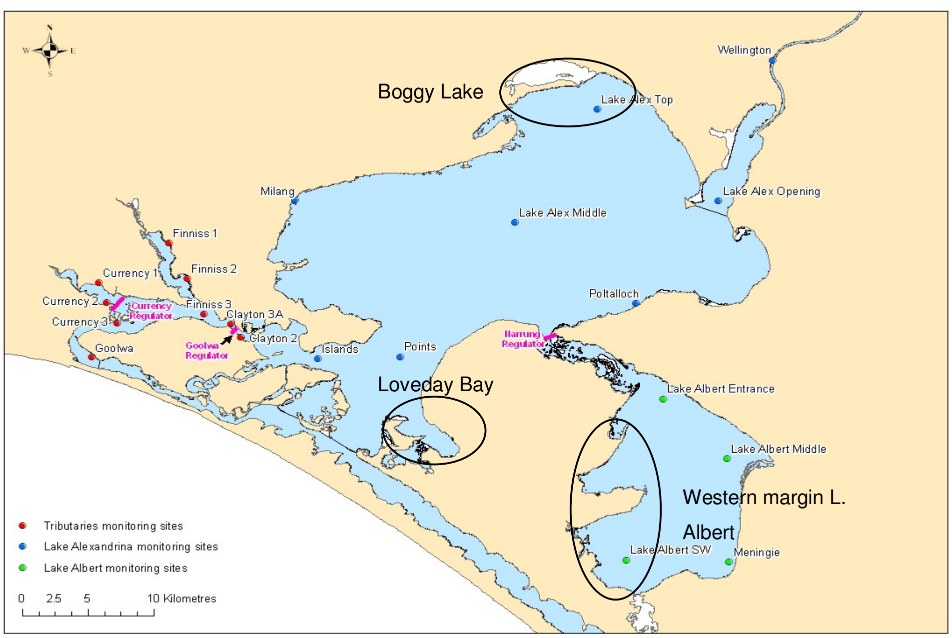

Figure 1 – Map of the ambient (points) and response (black ovals) monitoring sites

[1] See http://www.epa.sa.gov.au/environmental_info/water_quality/monitoring_programs_and_assessments/lower_lakes

Water Quality Parameters

A wide range of water quality parameters are monitored within the Lower Lakes with key parameters reported herein being pH, alkalinity, salinity, sulfate:chloride ratio, turbidity, nutrients and chlorophyll. A brief description of these parameters and typical historical (pre-drought) levels are provided below:

***pH** is an indicator of acidity or alkalinity. Neutral water has a pH of 7, acidic solutions have lower values and alkaline solutions have higher values. Prior to the current drought, the pH in the region was typically between 8.3 and 8.5.*

***Alkalinity** is a measure of the buffering capacity of water, or the capacity of the water to neutralise acids and resist pH change. Alkalinity within water bodies is consumed as acid is released from acid sulfate soils. Adding limestone contributes alkalinity to waters, helping to neutralise any acid released from the sediments. Historically, alkalinity levels within this region have been between 80 and 250 mg/L as* $CaCO_3$.

***Salinity** is a measure of the amount of dissolved salts in the water. Saline water conducts electricity more readily than freshwater, so electrical conductivity (EC) is routinely used to measure salinity. As salinity increases, it may become toxic to native freshwater organisms. Prior to drought conditions, salinity was on average less than 700 µS/cm (EC) in Lake Alexandrina (at Milang) and less than 1600 EC in Lake Albert (at Meningie).*

***Turbidity** is a measure of the cloudiness or haziness in water caused by suspended solids (e.g. sediment, algae). Turbidity is expressed in Nephelometric Turbidity Units (NTU) and is measured using a relationship of light reflected from a given sample. Turbidity is very variable in the Lower Lakes and influenced primarily by wind events. Prior to drought conditions, turbidity was on average about 60 NTU in Lake Alexandrina (at Milang).*

***Sulfate:chloride ratio** is used to give an indication of any sulfate inputs from acid sulfate soils. Chloride concentration is largely determined by evaporation and dilution. An increase in the ratio of sulfate:chloride indicates possible external sulfate inputs from acid sulfate soils. Prior to the drought, this ratio was about 0.06 (*SO_4*: Cl).*

***Nutrients - Total nitrogen (TN) and total phosphorus (TP)** are the total amount of nitrogen and phosphorus present in the water body. Nitrogen can be present in different forms (e.g. organic nitrogen in plant material, ammonia, nitrate and nitrite). Phosphorus can also be present in different forms (e.g. organic phosphorus, phosphate). High concentrations of phosphorus and nitrogen can result in excessive growth of aquatic plants such as phytoplankton, cyanobacteria, macrophytes and filamentous algae. Prior to drought conditions, TN was on average about 1.2mg/L in Lake Alexandrina (at Milang) and 1.6mg/L in Lake Albert (at Meningie) with TP on average about 0.15 mg/L in Lake Alexandrina (at Milang).*

***Chlorophyll a** is the main photosynthetic pigment in green algae. The concentration of chlorophyll gives an indication of the volume of aquatic plants present in the water column. Levels in excess of 15 µg/L are considered very high ("hyper-eutrophic") and nuisance algae and plant growth can occur. Prior to drought conditions, chlorophyll was on average about 24 µg/L in Lake Alexandrina (at Milang) and 35 µg/L in Lake Albert (at Meningie).*

Lake Alexandrina

Ambient water quality monitoring results are discussed below for selected sites and parameters in Lake Alexandrina.

pH

- pH levels remain relatively stable and within ANZECC guideline levels (pH 6.5-9.5) at all sites in the main Lake Alexandrina water body (Figure 2).

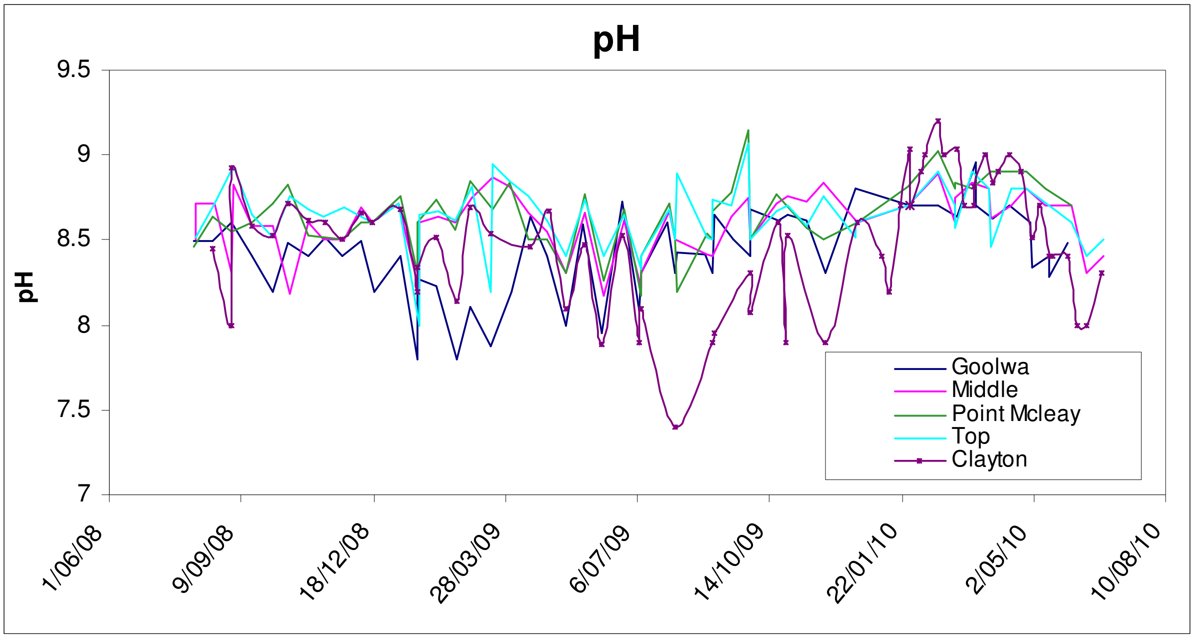

Figure 2 – pH at the Lake Alexandrina ambient monitoring sites

Alkalinity

- Alkalinity remains stable and satisfactory for all sites in the main areas of Lake Alexandrina (Figure 3).

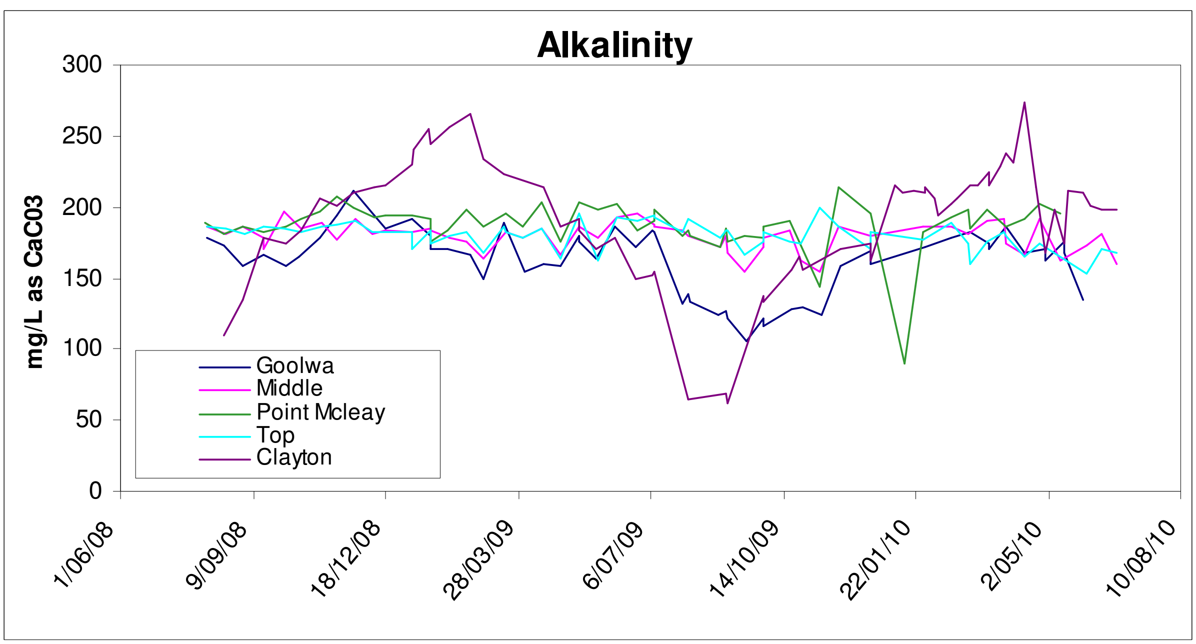

Figure 3 – Alkalinity at the Lake Alexandrina ambient monitoring sites

Salinity (EC)

Salinity (as measured by electrical conductivity) has slightly decreased at most sites during June (Figure 4). Autumn rainfall, increased River Murray Basin inflows, and cooler autumn weather have contributed to this decline. Despite these minor decreases, salinity thresholds for freshwater species to live healthily in the Lower Lakes have been exceeded in the entire Lower Lakes[2]. A current EPA macro-invertebrate survey of the Lower Lakes is confirming this assessment, with no or very few freshwater species remaining and very limited re-colonisation of brackish-estuarine species. Salinity at the Goolwa site is very high and continues to increase, possibly due to low regional inflows and continued concentration of salts.

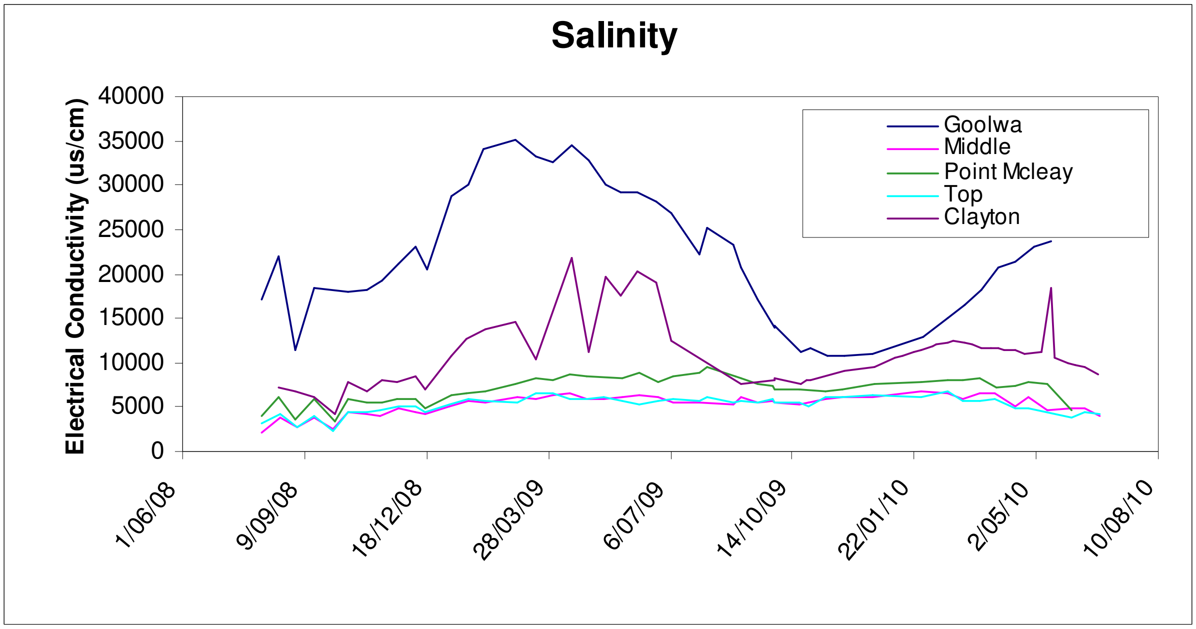

Figure 4 – Salinity at the Lake Alexandrina ambient monitoring sites

[2] Few freshwater species are predicted to remain above 8000 EC, but the diversity of freshwater ecosystems decrease rapidly above 5,000 EC. See Nielsen et al. (2008), *Marine and Freshwater Research*, 59, 549-559.

Sulfate:chloride ratio

- The sulfate:chloride ratio continues to show some variability, but is not showing a clear trend that would suggest widespread acid sulfate soil influences (Figure 5). Some increases were seen at the Goolwa and Clayton sites, most likely as a result of localised acid flux in the Currency-Finniss region during the winter re wetting of 2009.

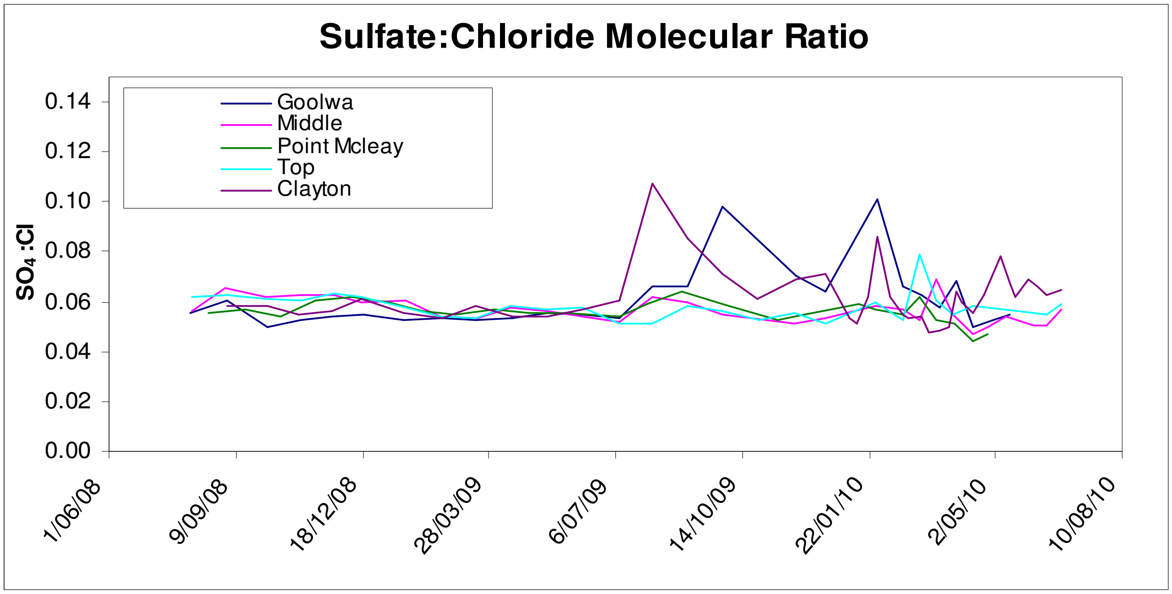

Figure 5 – Sulfate:chloride ratio at the Lake Alexandrina ambient monitoring sites

Turbidity

- Turbidity is variable in Lake Alexandrina and influenced primarily by wind events (Figure 6). The sites at Goolwa and near Clayton appear to have much lower turbidity than the other sites at present. This is likely to be due to less current and wind-driven re suspension of sediment as a consequence of the Clayton regulator being in place. The aggregation and settling of suspended particles is also likely to be increased by the high salinities at these two sites (Figure 4).

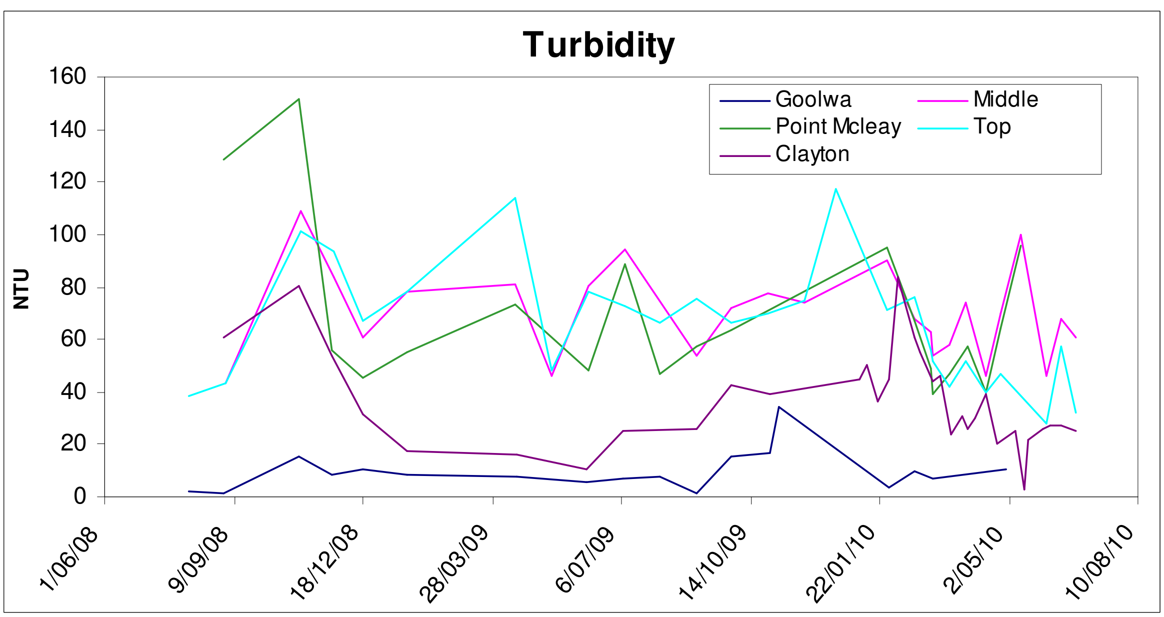

Figure 6 – Turbidity at the Lake Alexandrina ambient monitoring sites

Nutrients (total nitrogen and phosphorus)

- Total nitrogen and total phosphorus remain at very high levels in Lake Alexandrina (see Milang data in Figures 7 and 8). These levels are well in excess of the ANZECC guidelines (<1mg/L TN, <0.025 mg/L TP) and high compared to historical levels. A declining trend of both total nitrogen and total phosphorous has been observed since the spring of 2009 which could be attributed to the increased presence and re establishment of aquatic plants over this time. This is supported by high levels of Chlorophyll *a observed at the same site (Figure 9).*

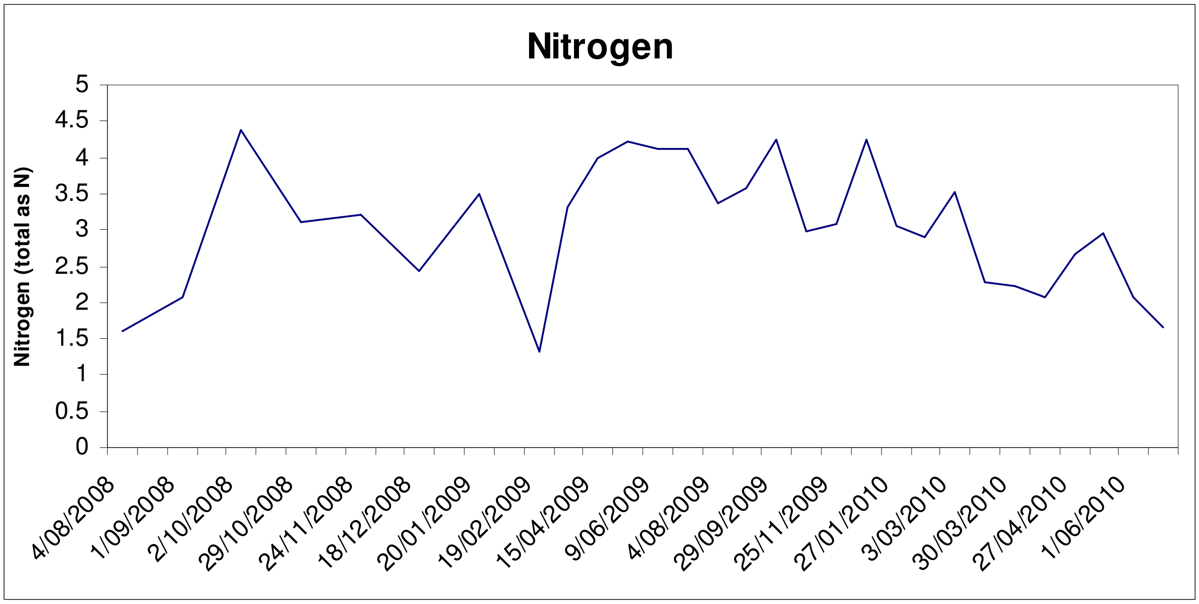

Figure 7 – Total Nitrogen at Milang

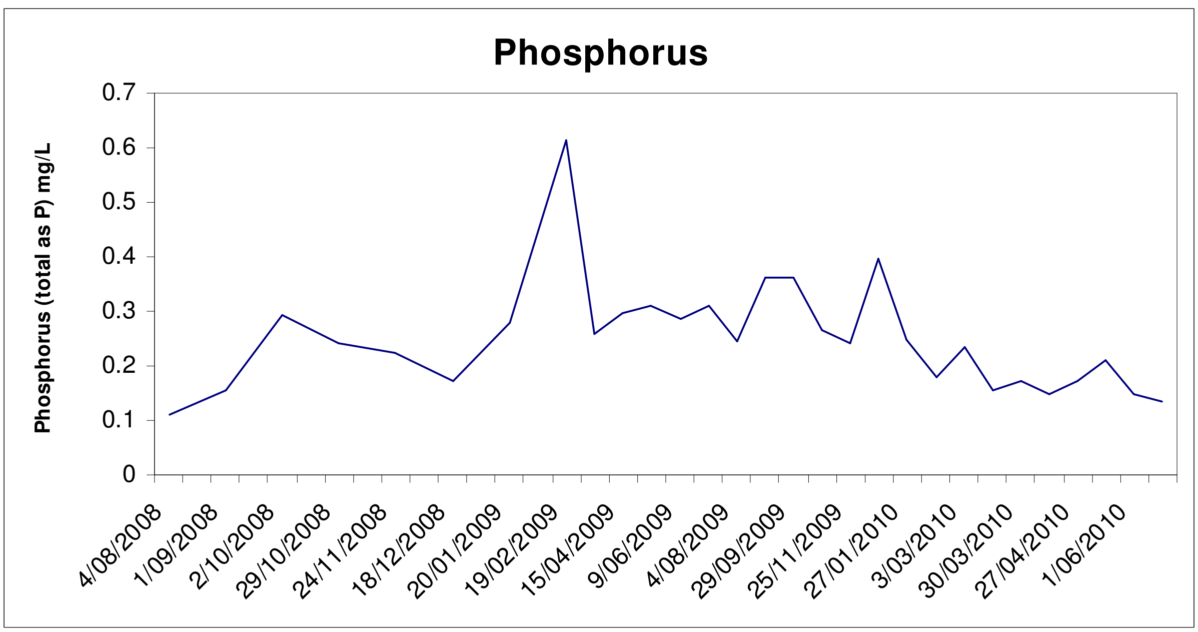

Figure 8 – Total Phosphorus at Milang

Chlorophyll and blue-green algae

- Chlorophyll *a* is also at very high levels in Lake Alexandrina (see Milang data in Figure 9). These levels are well in excess of historical values and ANZECC guidelines (<15 µg/L) indicating a highly nutrient enriched (hyper-eutrophic) system. While the chlorophyll levels in Lake Alexandrina are very high, no potentially toxic blue-green algal blooms are currently present.

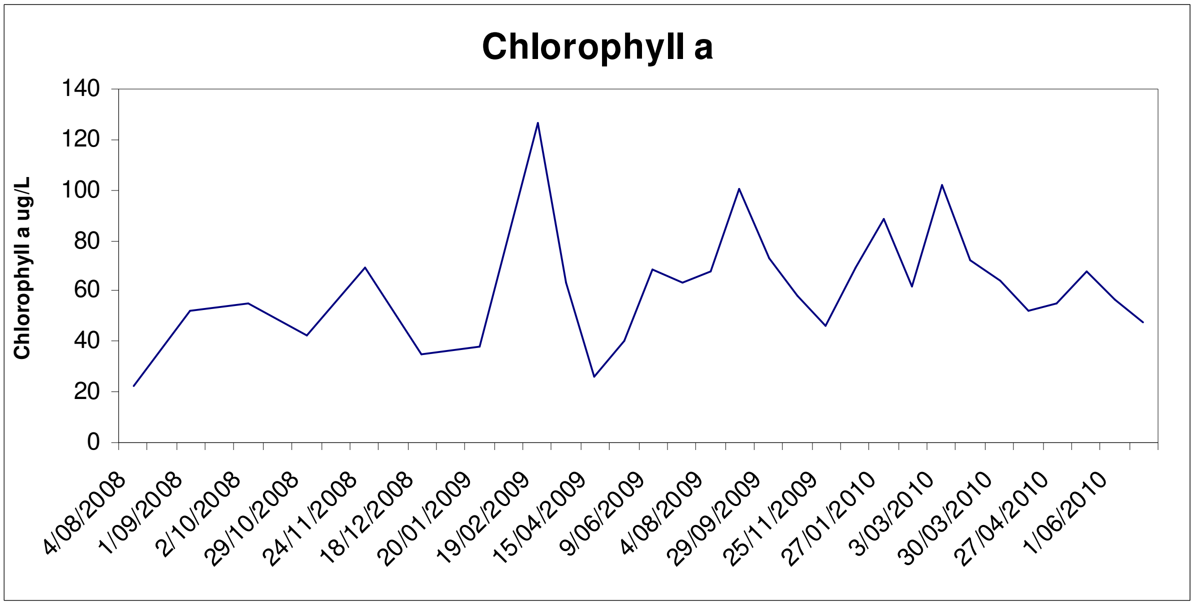

Figure 9 – Chlorophyll at Milang

Lake Albert Water Quality

Ambient water quality monitoring results are discussed below for selected sites and parameters in Lake Albert.

pH

- pH levels are stable and within ANZECC guideline levels (pH 6.5-9.0) at all sites in the main Lake Albert water body (Figure 10).

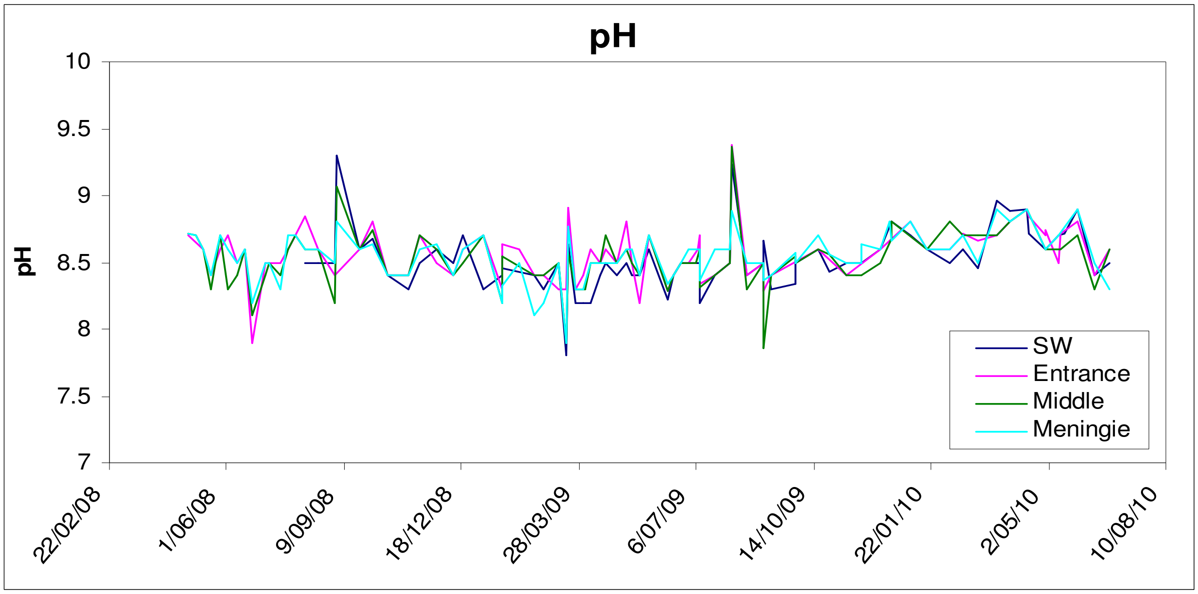

Figure 10 – pH at the Lake Albert ambient monitoring sites

Alkalinity

- Lake Albert alkalinity remains high and rapid increases were seen in January (270 - 310 mg/L as $CaCO_3$, Figure 11). The reason for this increase is unclear and the alkalinity levels now greatly exceed those in Lake Alexandrina. Alkalinity has been decreasing over the last month at all sites. This is presumably due to the increasing dilution from lower alkalinity water pumped from Lake Alexandrina with the entrance site recording the largest alkalinity decline.

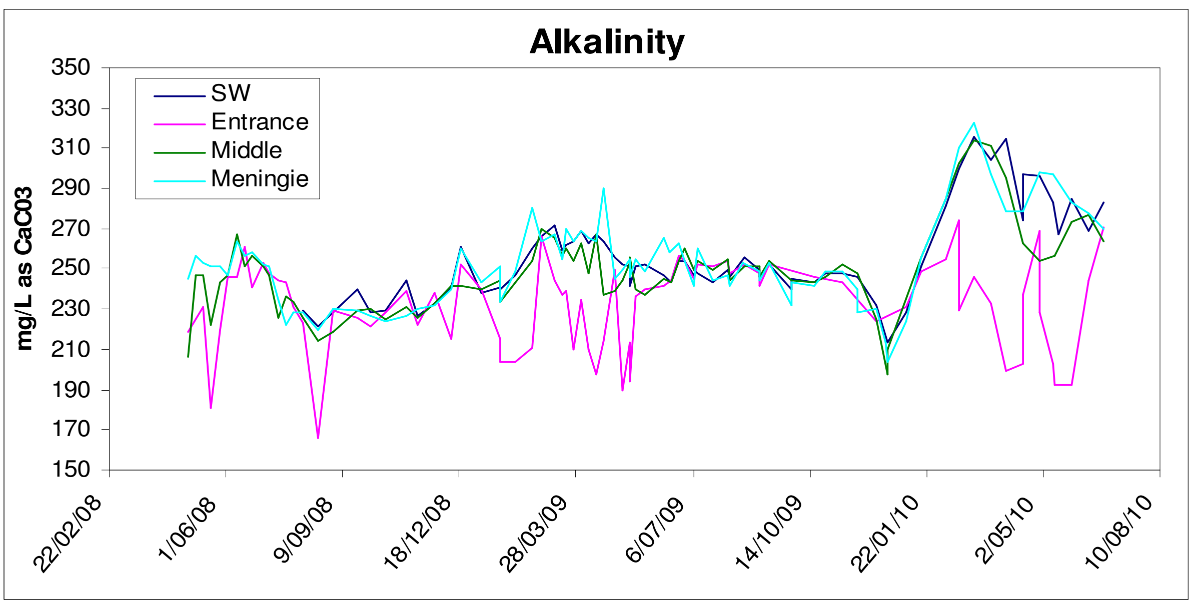

Figure 11 – Alkalinity at the Lake Albert ambient monitoring sites

Salinity (EC)

- Salinity remains very high compared to historical levels but has recently decreased at all sites with the exception of the Entrance site. This site has experienced an increase in salinity due to the completion of pumping and mixing with more saline waters within the lake (Figure 12).

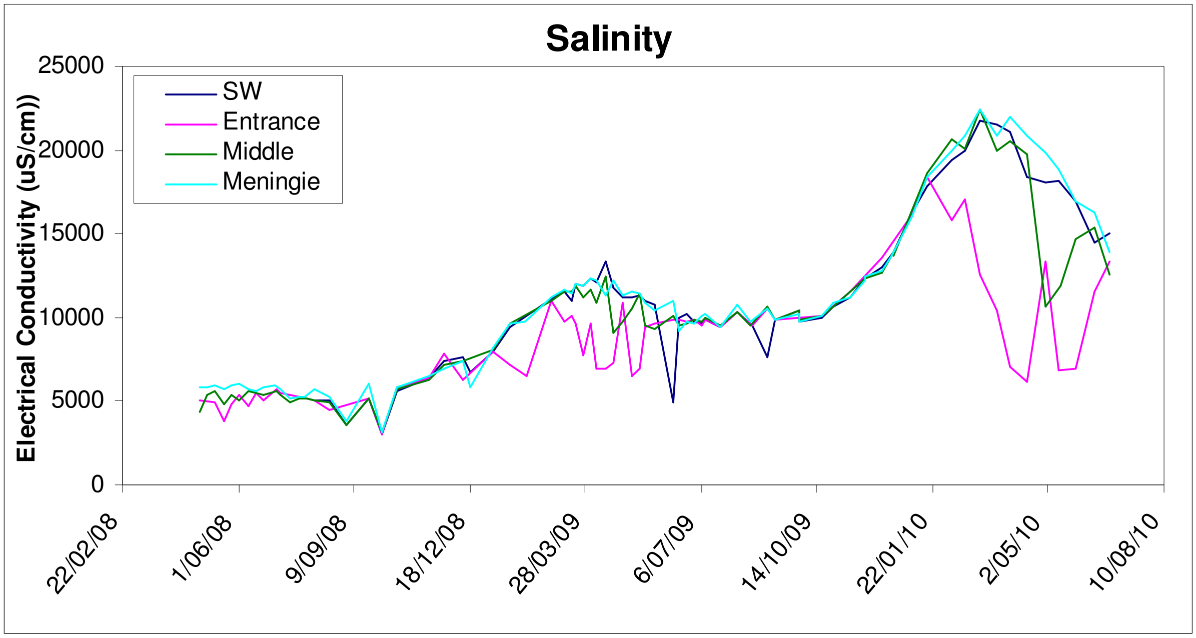

Figure 12 – Salinity at the Lake Albert ambient monitoring sites

Sulfate:chloride ratio

- The sulfate:chloride ratio has continued to decrease over the last few months (Figure 13). This may be related to the dilution from Lake Alexandrina water pumped in (ratio is now similar to that in Lake Alexandrina, see Figure 5).

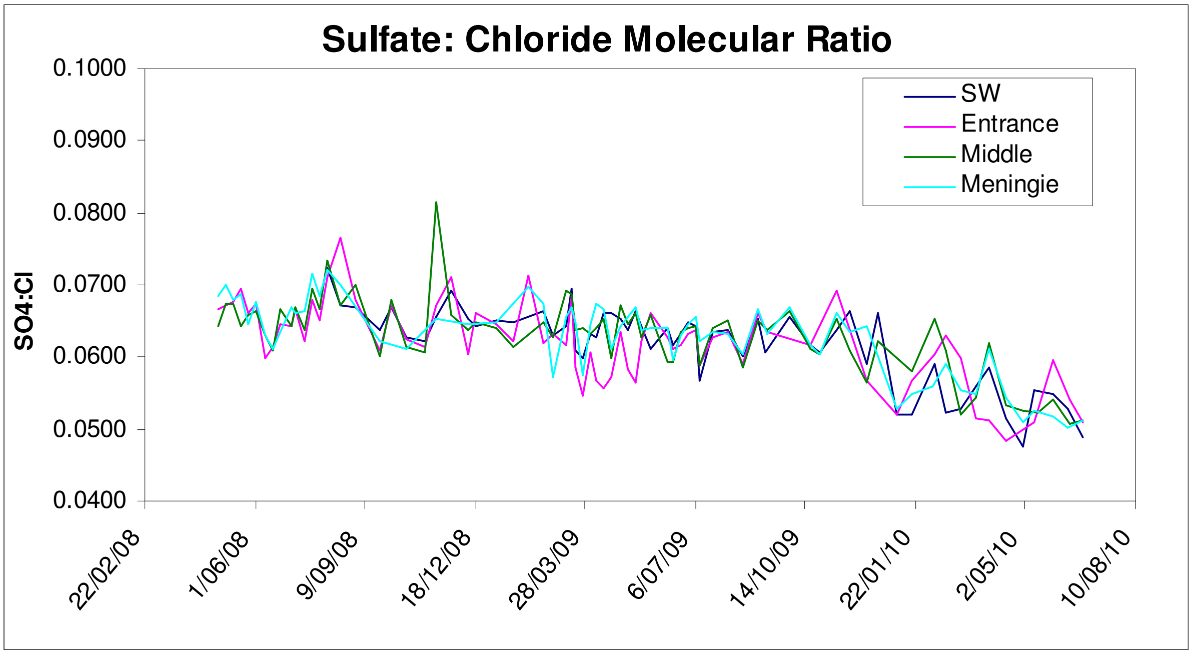

Figure 13 – Sulfate:chloride ratio at the Lake Albert ambient monitoring sites

Turbidity

- Turbidity in Lake Albert currently appears relatively low in comparison to levels in the last 2 years (Figure 14).

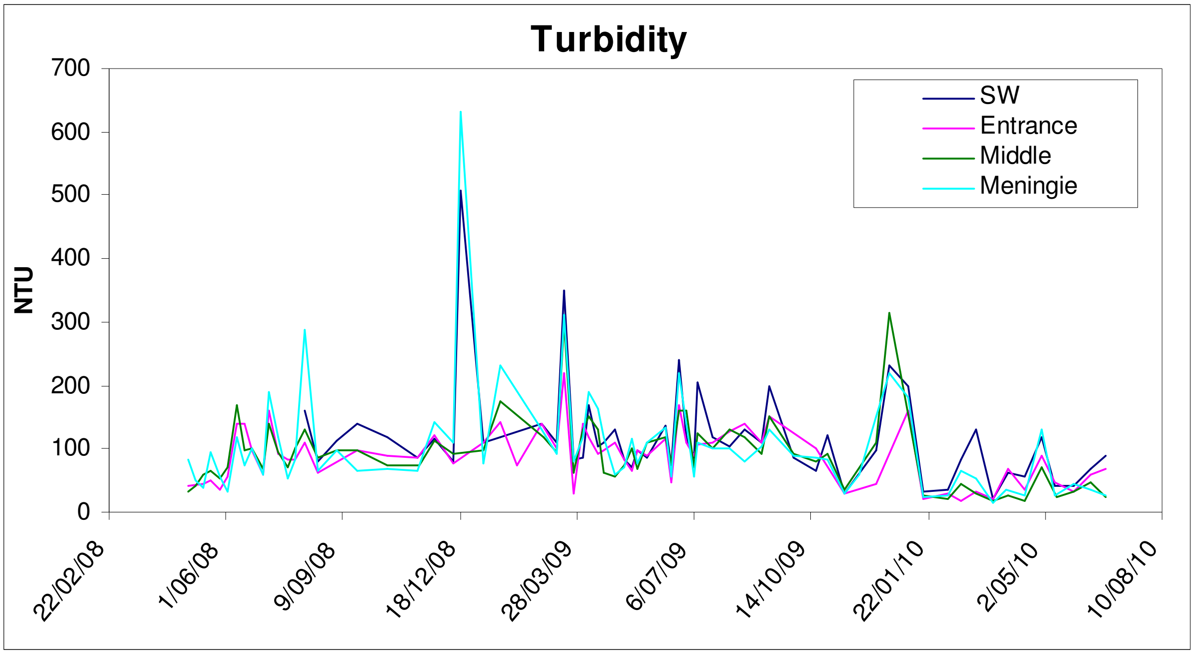

Figure 14 – Turbidity at the Lake Albert ambient monitoring sites

Nutrients (total nitrogen and phosphorus)

- Total nitrogen and total phosphorus are now at very high levels in Lake Albert (see Meningie data in Figures 15 and 16).). These levels are well in excess of the ANZECC guidelines (<1mg/L TN, <0.025 mg/L TP- indicated by the red dashed line on the graphs) and high compared to historical levels.

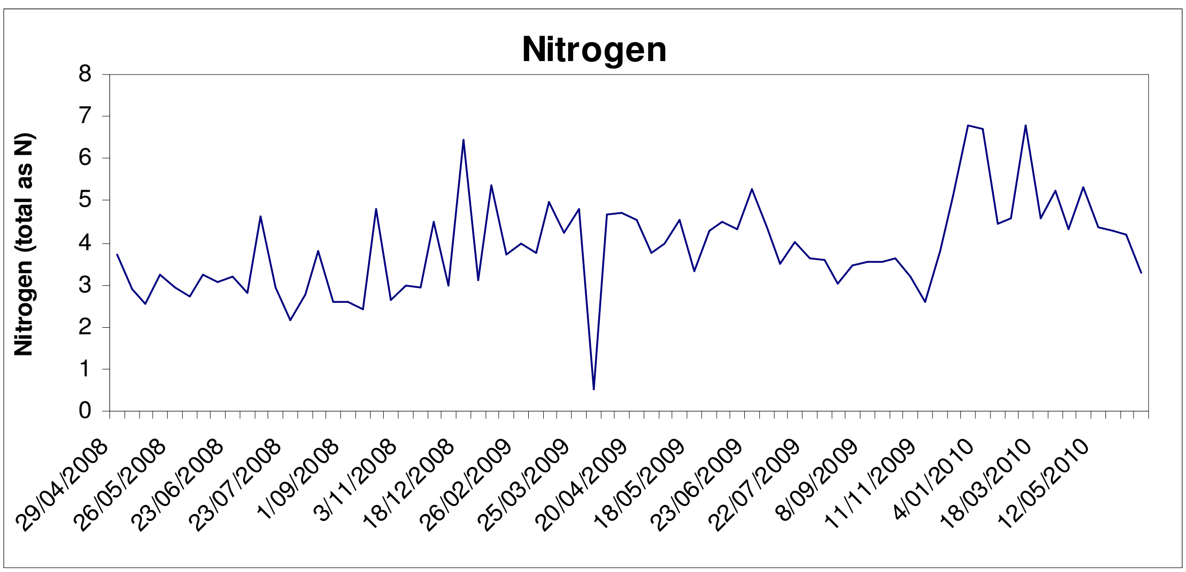

Figure 15 – Total Nitrogen at Meningie

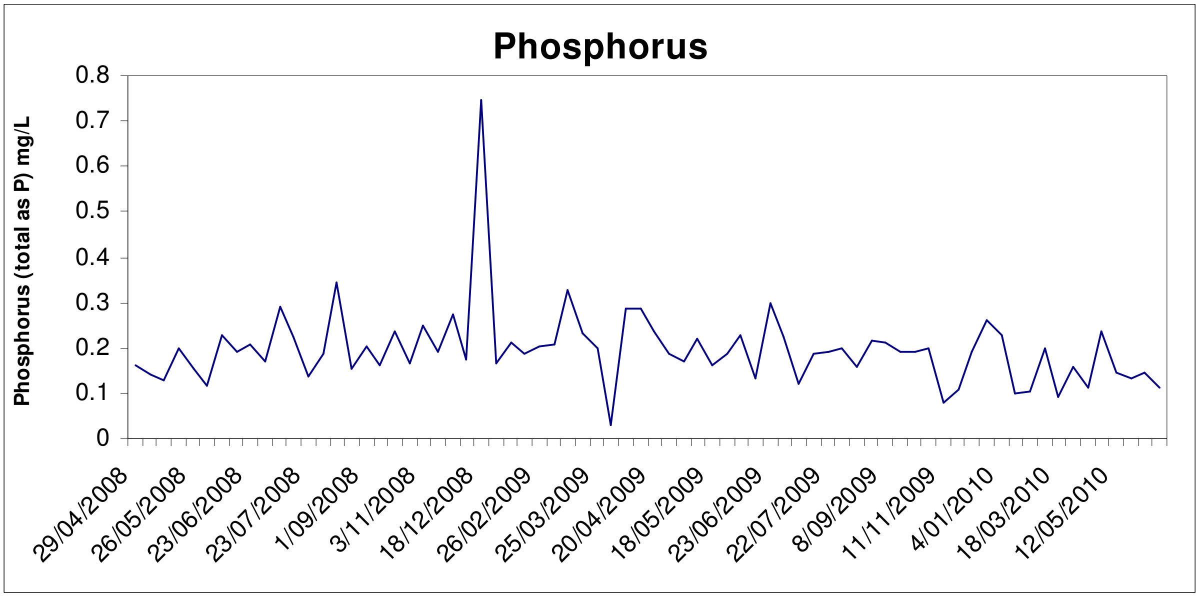

Figure 16 – Total phosphorus at Meningie

Chlorophyll and blue-green algae

- Chlorophyll *a* is variable but remains at very high levels in Lake Albert (see Meningie data in Figure 17). These levels are well in excess of the ANZECC guidelines (<15 µg/L- indicated by the red dashed line on the graphs) and indicate a very nutrient enriched system. No toxic blue-green algal issues are apparent at present, although this will be monitored closely over coming months as a large *Nodularia* (potentially toxic blue-green algae) bloom formed in the winter of 2009.

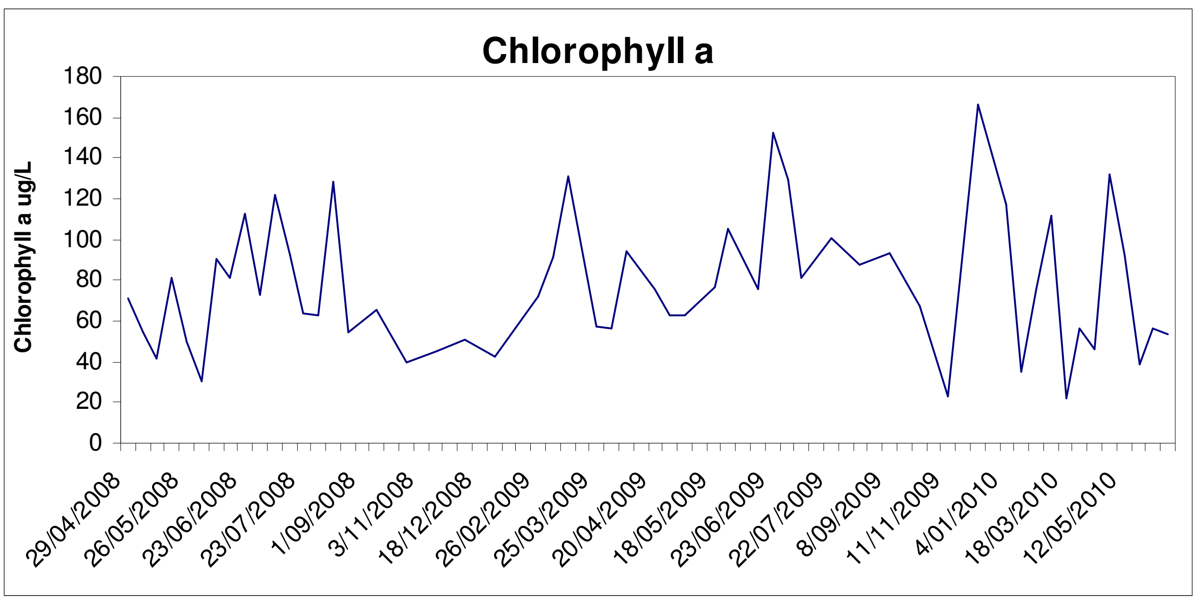

Figure 17 – Chlorophyll at Meningie

Tributaries Water Quality

Ambient water quality monitoring results are discussed below for selected sites and parameters in the Currency-Finniss tributaries region. See Figure 1 for sample site locations.

pH

- pH levels are stable and within ANZECC guideline levels (pH 6.5-9.5) at all sites in the tributaries (Figure 18).

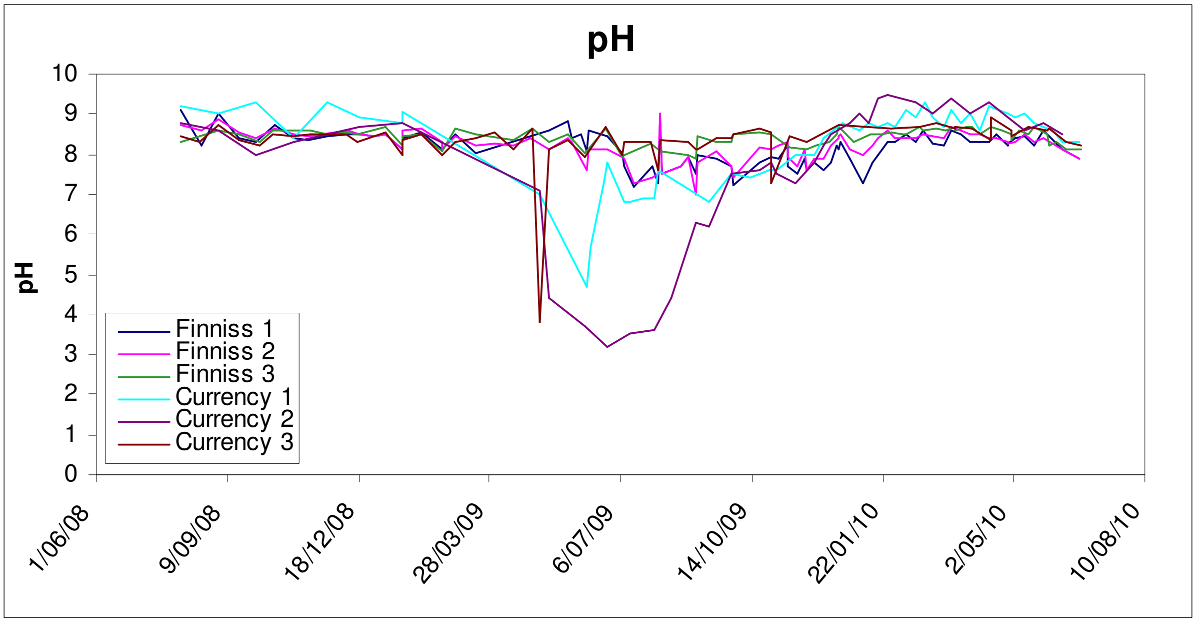

Figure 18 – pH at the Tributary ambient monitoring sites

Alkalinity

- Alkalinity at most of the tributary sites is satisfactory (Figure 19). The upper Currency Creek region has shown some alkalinity declines and the upper Currency pool still displaying low alkalinity (see acidification response section).

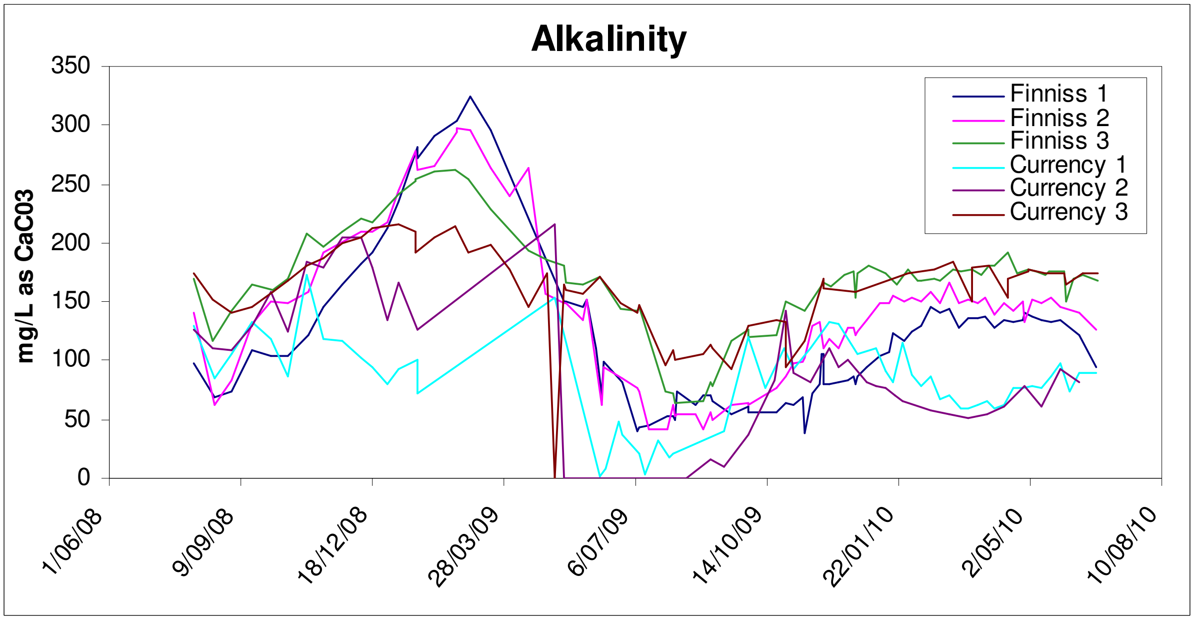

Figure 19 – Alkalinity at the Tributary ambient monitoring sites

Salinity (EC)

- Salinity is still increasing at all sites due to concentration by evaporation (Figure 20). This area is not receiving any dilution from the recent increased river inflows to Lake Alexandrina due to the physical restriction of the Goolwa Regulator.

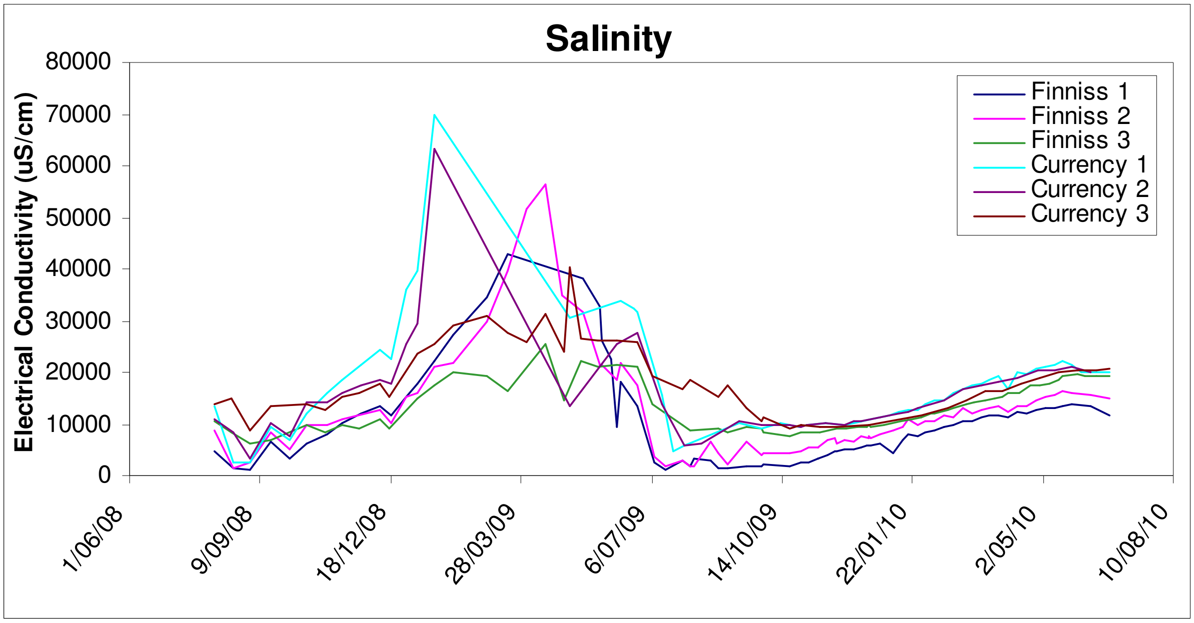

Figure 20 – Salinity at the Tributary ambient monitoring sites

Sulfate:chloride ratio

- The sulfate:chloride ratio shows some variability but is not showing any clear increasing trends that would suggest widespread acid sulfate soil inputs (Figure 21). Previously, during the winter of 2009, there were large increases in this ratio when the Currency region acidified.

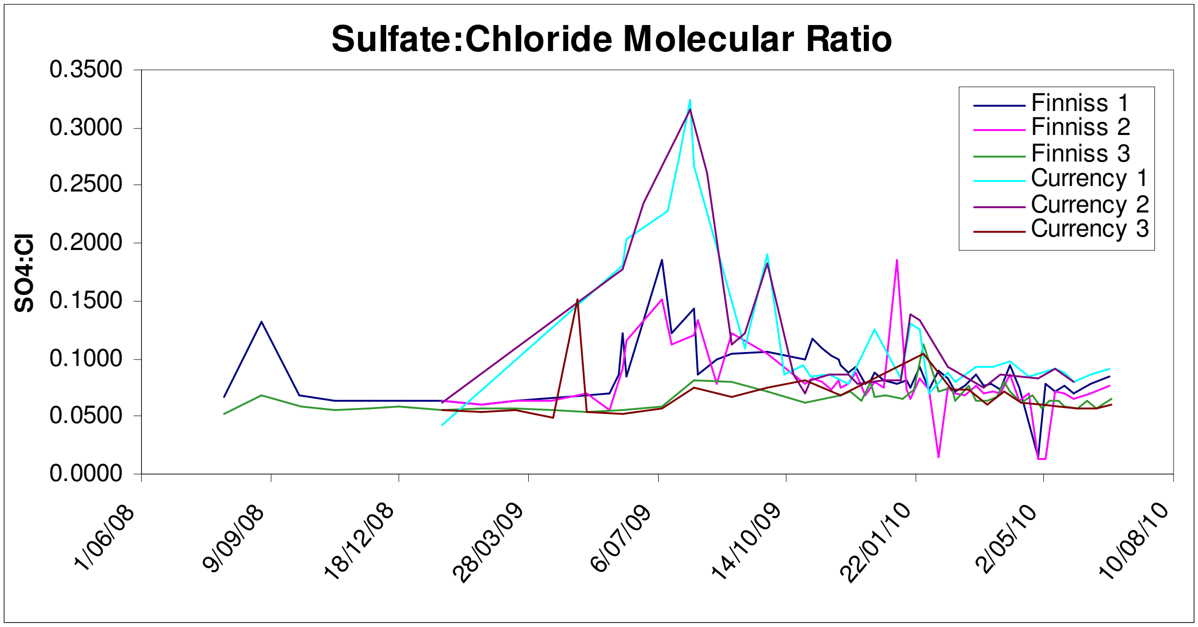

Figure 21 – Sulfate:chloride molecular ratio at the Tributary ambient monitoring sites

Turbidity

- Since pumping into the Goolwa Channel concluded, the turbidity at all the tributary sites within the Clayton regulator has decreased markedly (Figure 22) and are at very low levels (<7NTU) in comparison to other sites in Lake Alexandrina, the exception is the Currency 1 site where the turbidity remains variable and influenced by seasonal tributary inflows (see Figure 6). The very low turbidity in this region is likely due to increased particle settling and reduced particle resuspension due to a reduction in wind-driven current flows following construction of the Clayton regulator. Salt-induced coagulation and settling of fine clay particles (colloids) is another likely reason for this outcome.

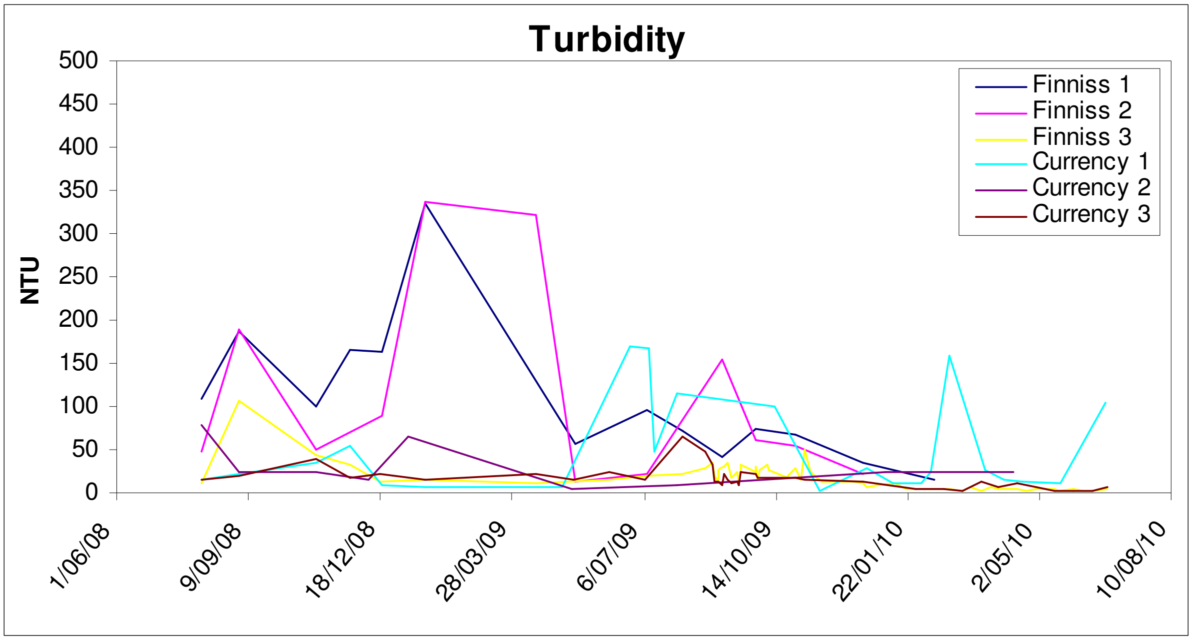

Figure 22 – Turbidity at the Tributary ambient monitoring sites

Nutrients (total nitrogen and phosphorus)

- Total nitrogen and phosphorus are at high levels in the tributaries, although levels are presently much lower than during last winter (Figures 23 and 24).

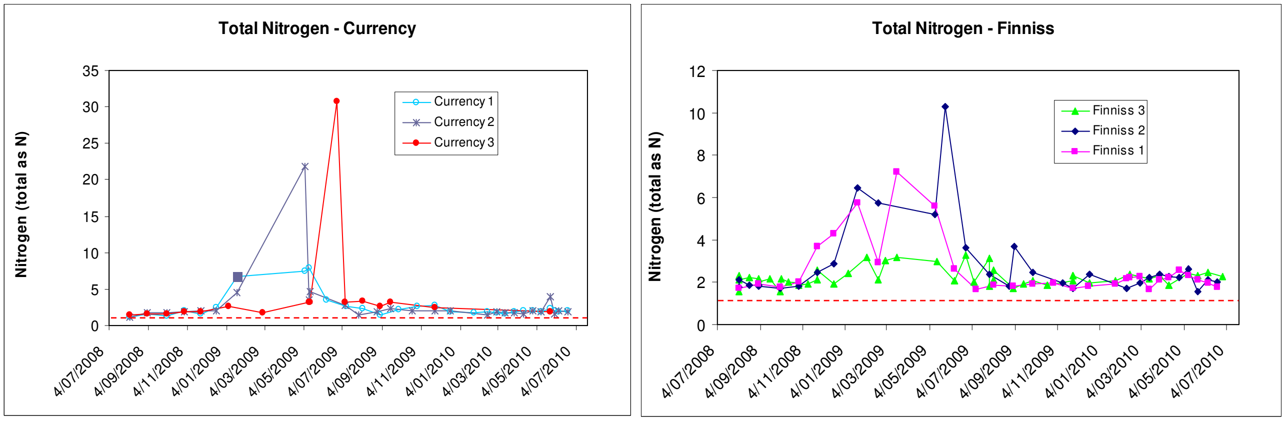

Figure 23 – Total Nitrogen at the Tributary ambient monitoring sites

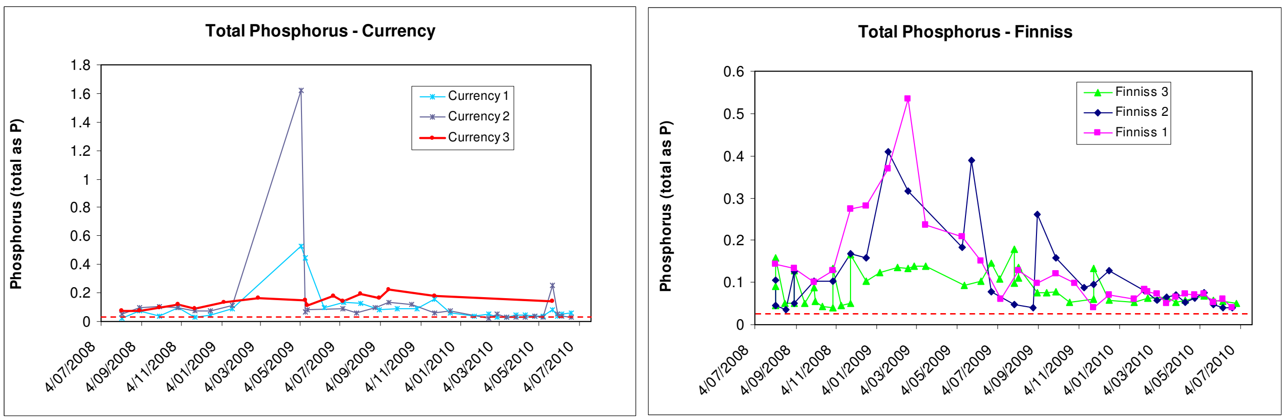

Figure 24 – Total phosphorus at the Tributary ambient monitoring sites

Chlorophyll and blue-green algae

- Chlorophyll *a* is at very high levels at the lower tributary sites (Figure 25). These levels are well in excess of the ANZECC guidelines (<15 µg/L) and indicate a very nutrient enriched system. No toxic blue-green algal issues are apparent at present. A large increase in filamentous (*Cladophora sp.)* and macro-algal growth (*Stuckenia pectinata*) was observed in this region over the summer of 2009/10, presumably as a result of the greater water clarity allowing more light to stimulate algal growth.

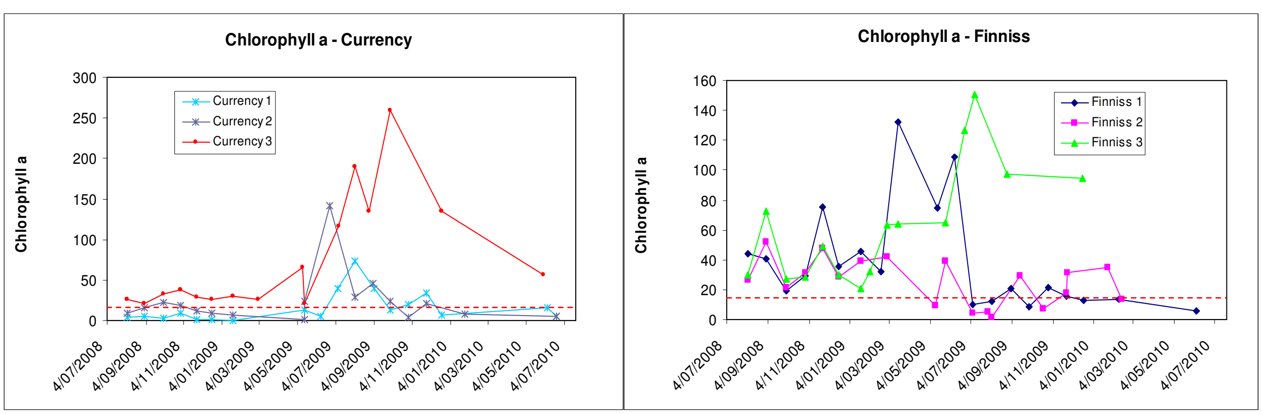

Figure 25 – Chlorophyll *a* at the Tributary ambient monitoring sites

Acidification response monitoring

Response water quality monitoring is being undertaken on an “as needs basis” to assess if any localised acidification is present. See Figure 1 for general sample site locations. The selection of sites was based upon perceived acid sulfate soil risk, in accordance with available data on the concentration and distribution of sulfidic and sulfuric materials. Each site was screened to identify the extent of acidity and frequency of monitoring was determined from these results. The information informs the need for management actions, such as limestone dosing, which has the capacity to reduce the acidity hazard and mitigate further metal release.

Boggy Lake

Figure 26 – Acidified surface water (pH 2-3) overlying cracked clay soils

Figure 27 shows a map of pH levels at 10 sites in Boggy Lake sampled on 28/6/2010. During June, there was a decrease in the acidity and increase in pH at several sites along the northern margin of Boggy Lake, which is mostly likely a result of the addition of limestone. However, acidity is still present at most sites (90-164 mg/L as $CaCO_3$) and pH is still well below ANZECC guidelines, and notably low in the western and southern sections (3-4, red dots on figure) The waters in Boggy Lake increase in pH as they mix with the alkaline waters of Lake Alexandrina. Continued evaluation of the monitoring data will determine whether further limestone addition is needed in Boggy Lake.

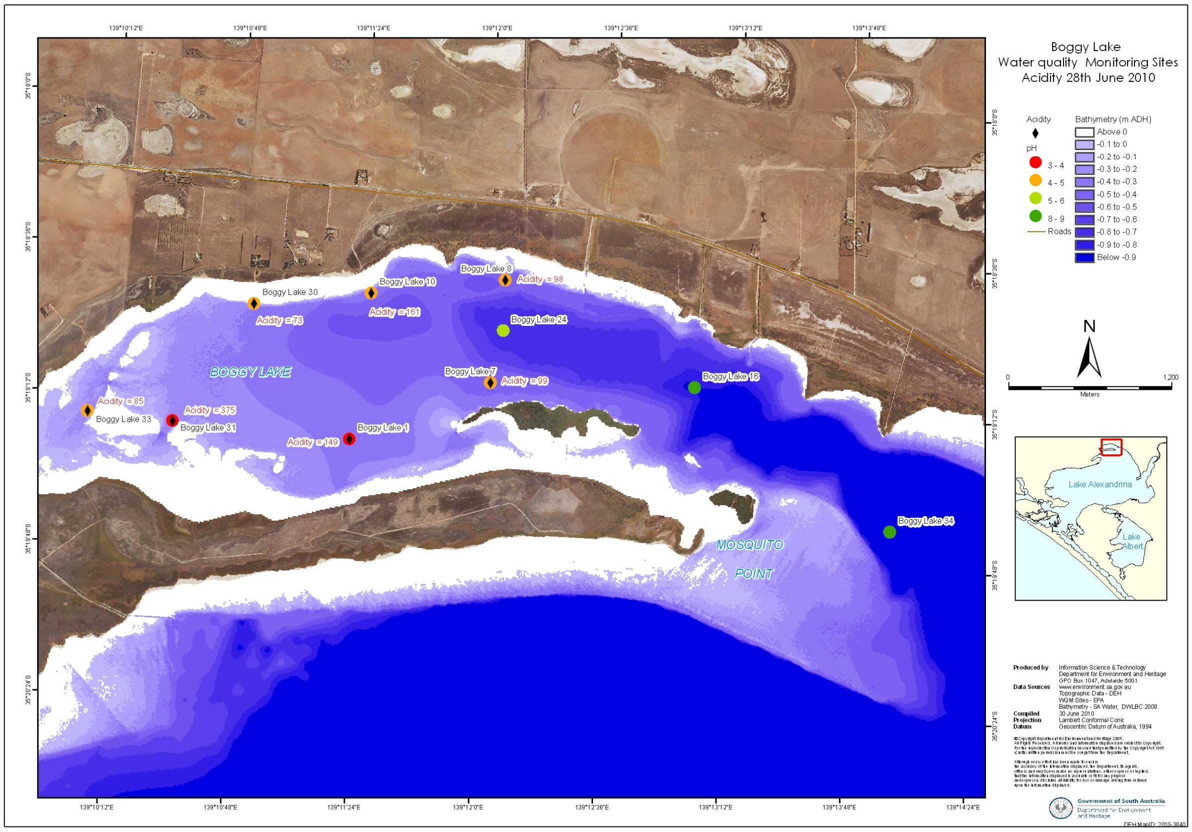

Figure 27 – Map of Boggy Lake pH levels on 18/5/2010

Western margin of Lake Albert

The water quality of Lake Albert's western shoreline was examined again on the21st of June 2010 to follow up on sites screened in April and May 2010 which displayed low pH values and high acidity readings (see May 2010 monthly report). Of the 13 sites examined on the 21st of June, all illustrated increases in pH and alkalinity (pH within ANZECC guidelines for all sites), as well as a reduction in acidity at all sites. Currently, it seems that the water of Lake Albert is providing sufficient alkalinity to neutralise the acidity mobilised from the sediment. Given the high potential acidity load of the sediment in this area, the western margin of Lake Albert will be examined again during July 2010.

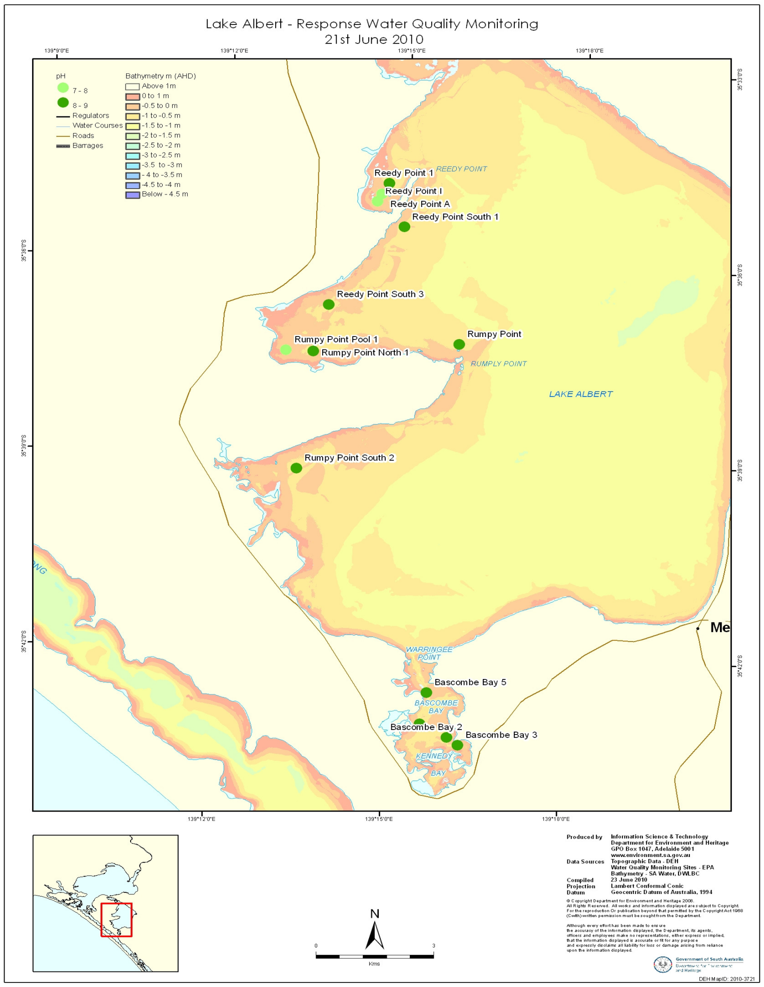

Figure 28 – Map of western Lake Albert pH levels in June 2010

Loveday Bay

Loveday Bay is a shallow lagoon located at the south eastern shore of Lake Alexandrina (Figure 1 and 33).

Figure 29: EPA monitoring sites - Loveday Bay

Figure 30 shows the difference in water quality on either side of the sandbar. The sites on the Lake Alexandrina side of the sandbar (LB 7, LB8, LB 9 and LB 10) remained at neutral pH levels throughout the monitoring period. The sites on the SE of the sandbar (LB 1, LB 5 and LB 6) indicated low pH levels up to the point of complete desiccation (drying out period). Initial rewetting in these sites resulted in low pH levels until connection and therefore mixing became apparent (early May 2010) Recent samples indicate the water body is now neutral pH after a second winter rainfall rewetting and connection to Lake Alexandrina. Monitoring will schduled to continue.

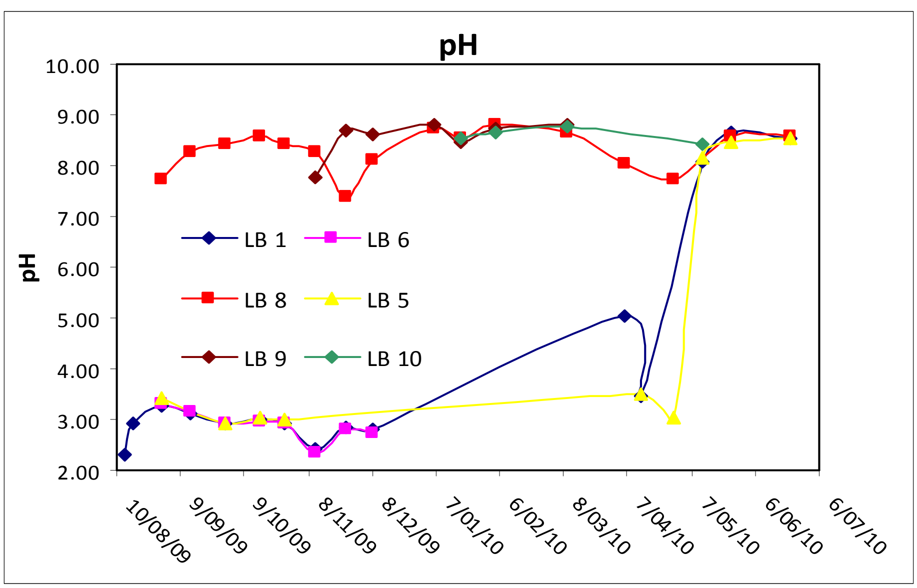

Figure 30: pH at Loveday Bay monitoring points

Further Information

Further information on water quality and quantity, and acid sulfate soils, can be found on the following websites:

- Department for Environment and Heritage www.environment.sa.gov.au/cllmm/
- River Murray Data http://data.rivermurray.sa.gov.au/ (real-time data)
- Environment Protection Authority www.epa.sa.gov.au or for specific Lower Lakes data see www.epa.sa.gov.au/environmental_info/water_quality/monitoring_programs_and_assessments/lower_lakes
- Department of Water, Land and Biodiversity Conservation www.dwlbc.sa.gov.au
- South Australian Murray–Darling Basin Natural Resource Management Board www.samdbnrm.sa.gov.au
- Murray–Darling Basin Authority www.mdba.gov.au
- Waterwatch www.waterwatch.org.au
- CSIRO acid sulfate soils www.clw.csiro.au/acidsulfatesoils/murray.html