Report 17, to end of July 2010

Lower Lakes and Tributaries

Water Quality Report

Ambient and Event-based Monitoring

Environment Protection Authority

EPA South Australia

Observations at a Glance

- ***pH and alkalinity remain satisfactory at all sites within the main water bodies of Lake Alexandrina and Lake Albert and their tributaries***
- ***Salinity and nutrient levels have stabilised due to localised rainfall and increased inflows however still remain high compared to historic levels***
- ***Acidity in Boggy Lake has decreased however significant areas of pH <6.5 remain***
- ***Acidic areas of Salt Lagoon remain due to pooling water***

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 changing water levels and acidity mobilisation in the Lower Lakes. Previous reports are contained on the EPA website[1].

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 $CaCO_3$.*

***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).*

***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*

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

primarily by wind events. Prior to drought conditions, turbidity was on average about 60 NTU in Lake Alexandrina (at Milang).

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).

Ambient Water Quality Monitoring

Ambient water quality sampling is undertaken fortnightly at 15 sites in Lake Alexandrina (including Wellington, the Goolwa Channel, Currency Creek and Finniss River tributary regions), and Lake Albert (Figure 1).

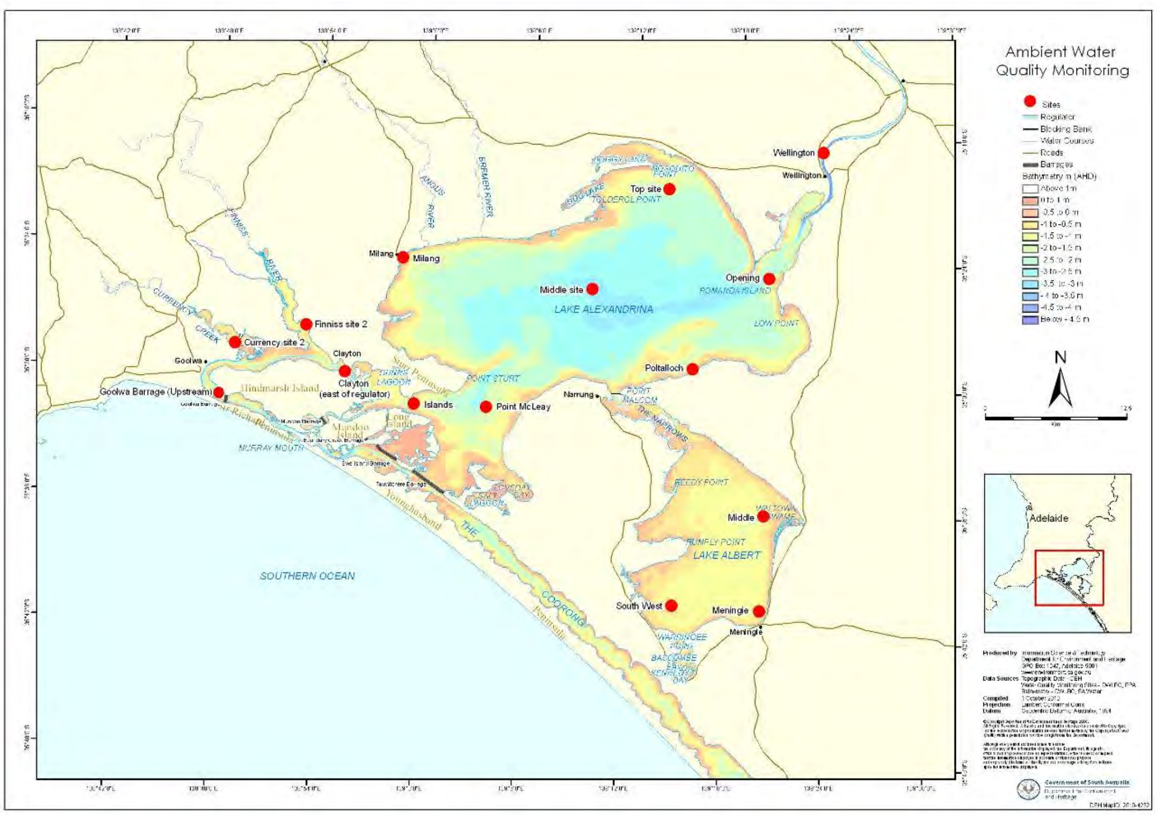

Figure 1 – Map of the ambient water quality monitoring sites

Lake Alexandrina

Ambient water quality monitoring results are discussed below for selected sites and parameters in Lake Alexandrina representing water quality trends across the lake body.

pH

- pH levels remain relatively stable and within ANZECC guideline levels (pH 6.5-9) at all sites in the main Lake Alexandrina water body (Figure 2). The recent declining trend observed from May 2010 can be attributed to significant river inflows with lower pH (7.5) diluting the lake volume. This decline is considered consistent with historical data for the lake.

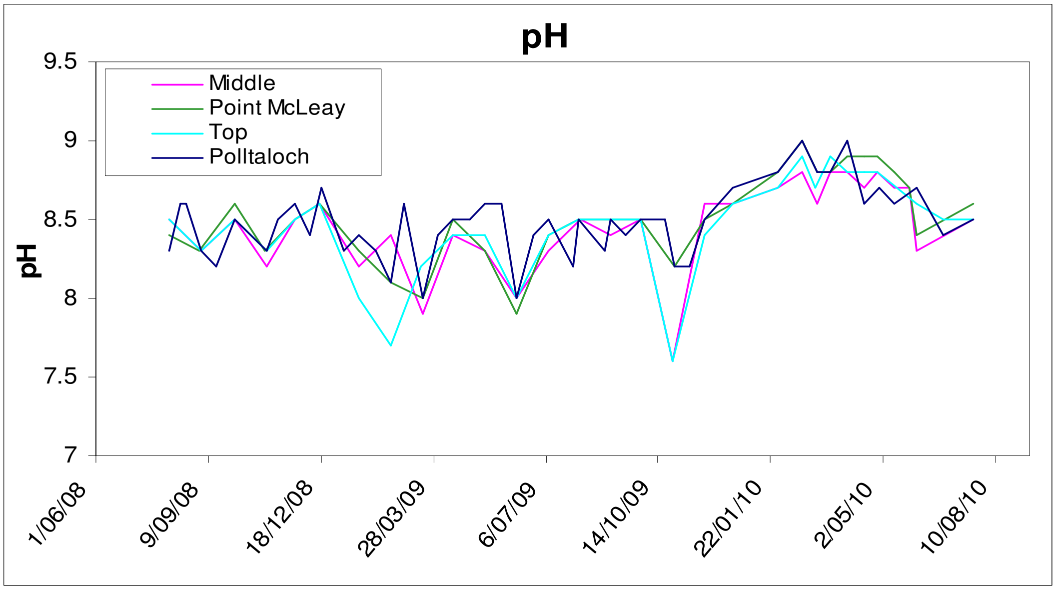

Figure 2 – pH at the Lake Alexandrina ambient monitoring sites

Alkalinity

- Alkalinity remains stable and satisfactory for all sites in the main areas of Lake Alexandrina (Figure 3). There has been a marked decline in the alkalinity at the Poltalloch site which is attributed to dilution from the increased river inflows into this region of the lake.

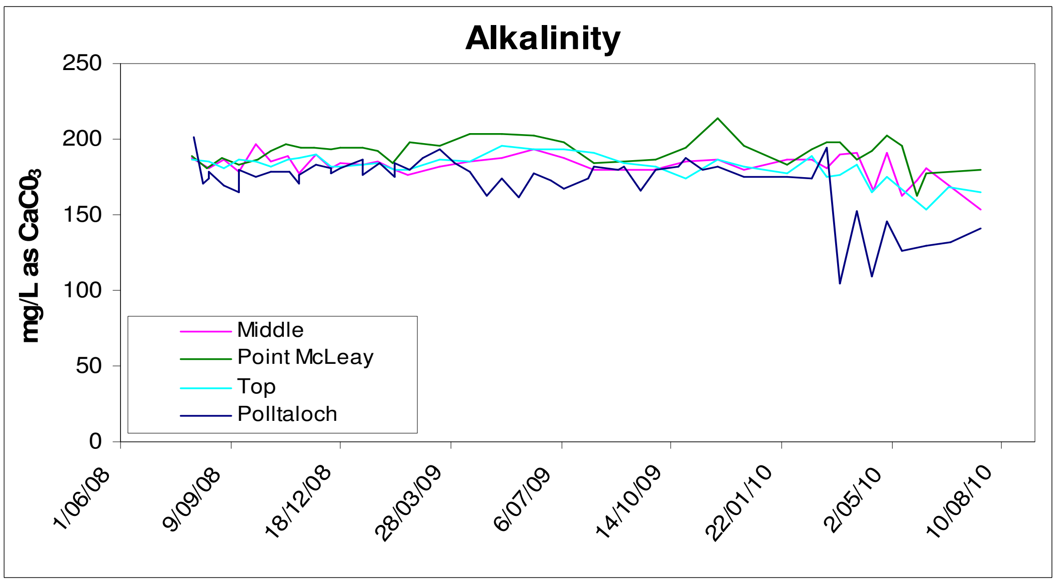

Figure 3 – Alkalinity at the Lake Alexandrina ambient monitoring sites

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 4).

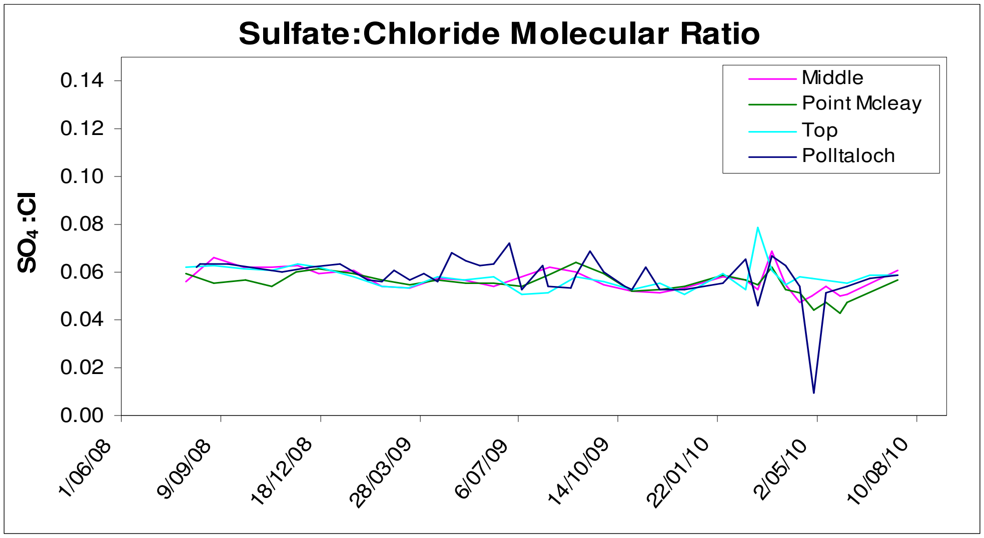

Figure 4 – Sulfate:chloride ratio at the Lake Alexandrina ambient monitoring sites

Salinity (EC)

- Salinity (as measured by electrical conductivity) has generally decreased at most sites since April, particularly at Poltalloch (Figure 5). Autumn rainfall, increased River Murray Basin inflows, and cooler autumn weather have contributed to this decline in salinity. However salinity levels are still high in comparison to historical levels (average of 700 EC prior to the drought) and guidelines to protect freshwater ecosystems[2].

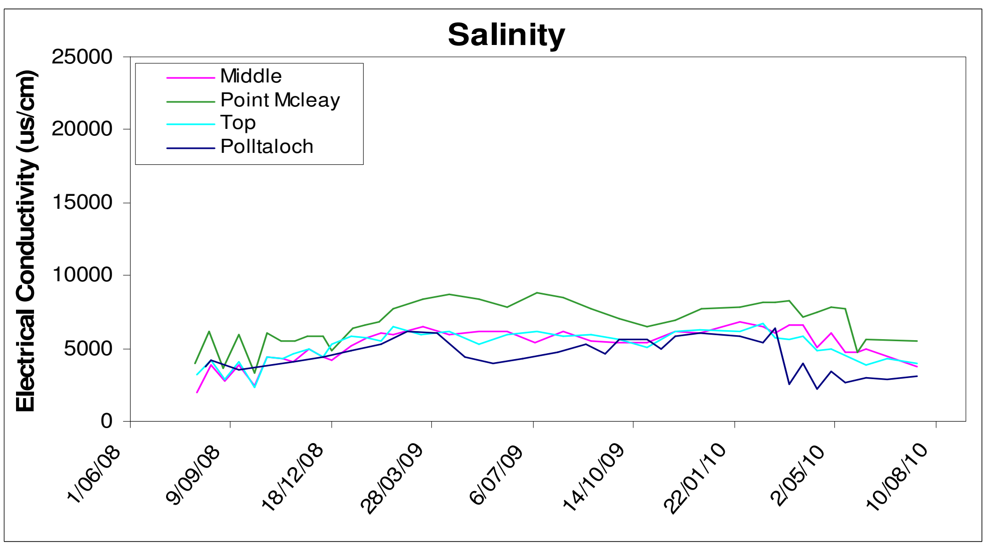

Figure 5 – Salinity at the Lake Alexandrina ambient monitoring sites

Turbidity

- Turbidity is variable in Lake Alexandrina and influenced primarily by wind events (Figure 6). Given the large fetch and shallow nature of Lake Alexandrina turbidity has historically remained at what is considered high levels for fresh water bodies.

[2] Few freshwater species are predicted to remain above 8,000 EC, and the diversity of freshwater ecosystems decreases rapidly above 5,000 EC. See Nielsen et al. (2008), *Marine and Freshwater Research*, 59, 549-559.

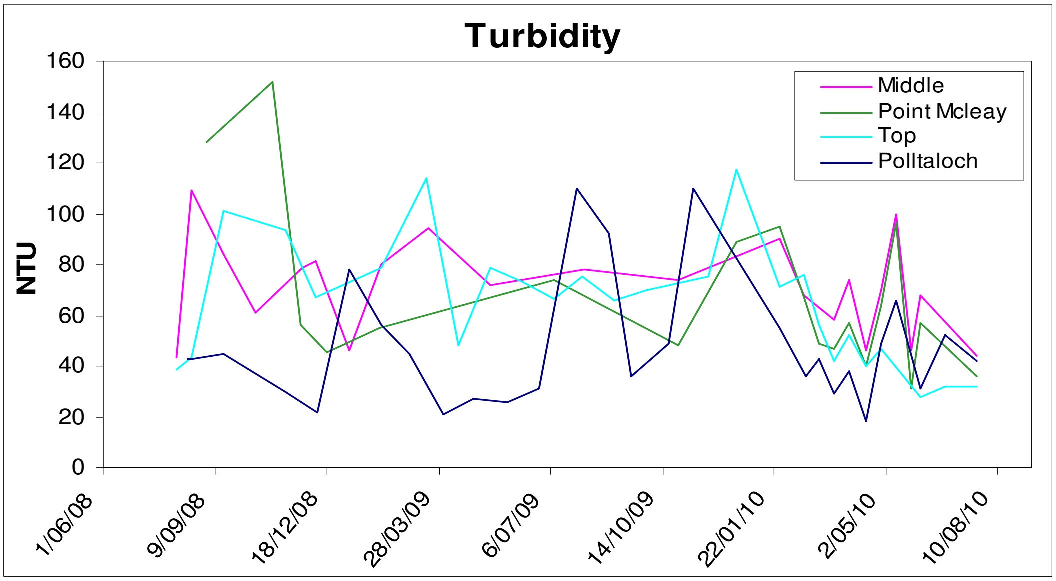

Figure 6 – Turbidity at the Lake Alexandrina ambient monitoring sites

Nutrients (total nitrogen and phosphorus)

- Total nitrogen and phosphorus levels have decreased recently (see Figures 7 and 8) which is likely due to cooler winter temperatures (slower aquatic plant growth) and some dilution from the increases in River Murray inflows. However these nutrient levels are still well in excess of the ANZECC guidelines (<1mg/L TN, <0.025 mg/L TP).

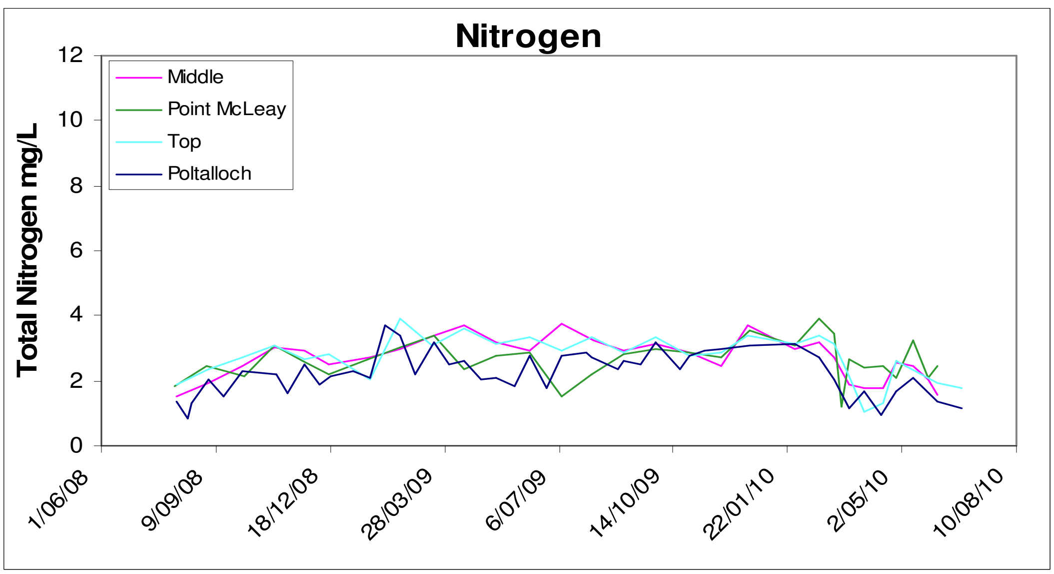

Figure 7 – Total Nitrogen in Lake Alexandrina

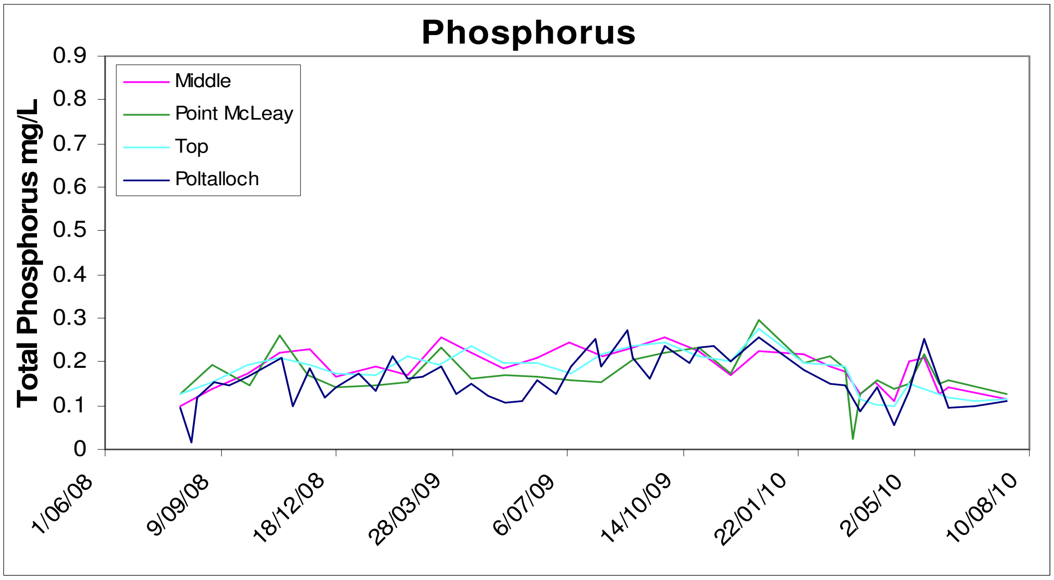

Figure 8 – Total Phosphorus in Lake Alexandrina

Chlorophyll a (algae)

- Chlorophyll *a* is also at very high levels in Lake Alexandrina (see 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.

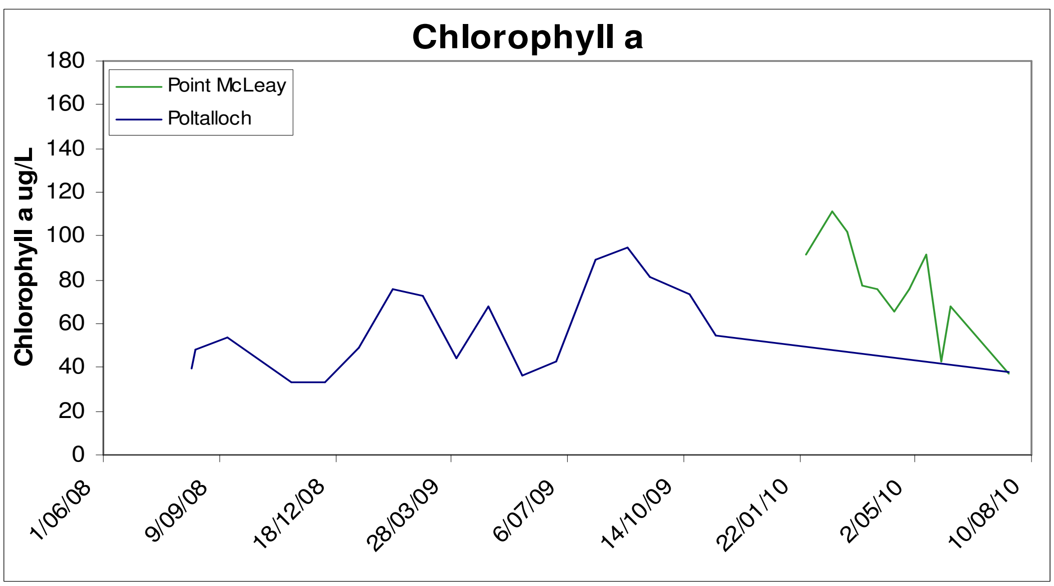

Figure 9 – Chlorophyll a in Lake Alexandrina

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).

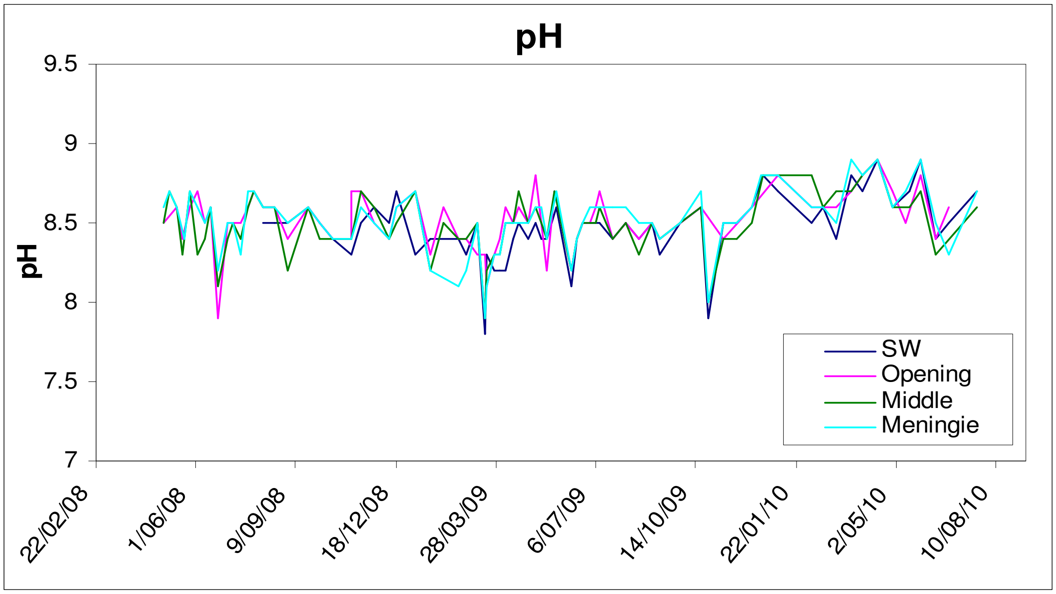

Figure 10 – pH at the Lake Albert ambient monitoring sites

Alkalinity

- Lake Albert alkalinity remains high and rapid increases were seen in January (270 - 310 mg/L as $CaCO_3$, Figure 11). Alkalinity has been variable since then but appears to be decreasing at all sites with the exception of the Opening site which continues to vary. The alkalinity fluctuations at the Opening site are similar to those for salinity (Figure 12), suggesting the trends are influenced by pumping from Lake Alexandrina and water mixing patterns.

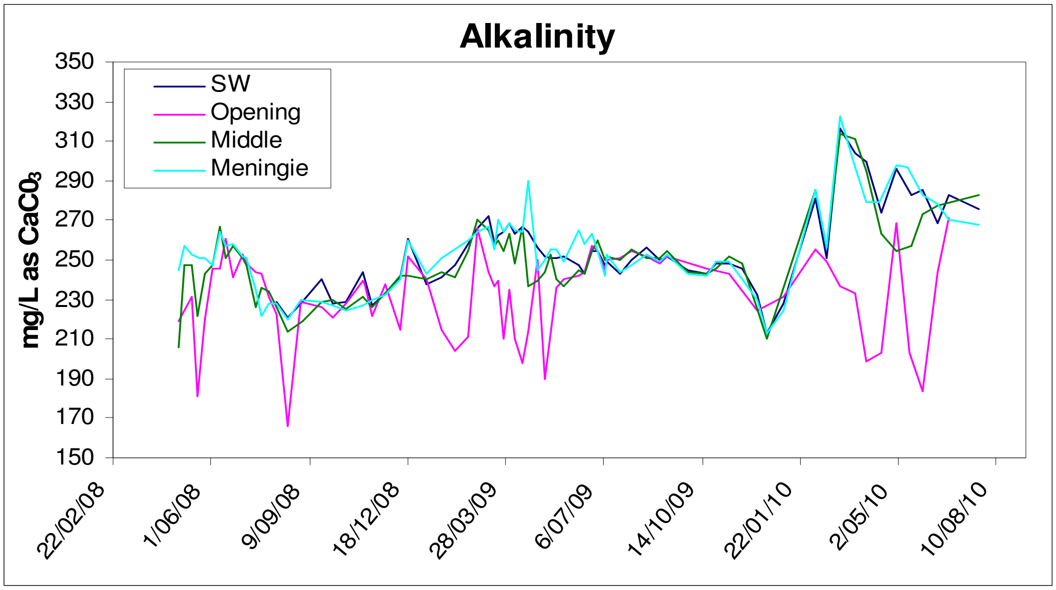

Figure 11 – Alkalinity at the Lake Albert ambient monitoring sites

Sulfate:chloride ratio

- The sulfate:chloride ratio has increased over the last month at all sites (Figure 12). This indicates that the mobilisation of sulfate from the acid sulfate sediments on the lake margins has taken place as a result of winter rainfall. As the pH and alkalinity have not been negatively affected (see Figures 10 & 11), it appears the acidity inputs have been buffered by the high alkalinity in the lake.

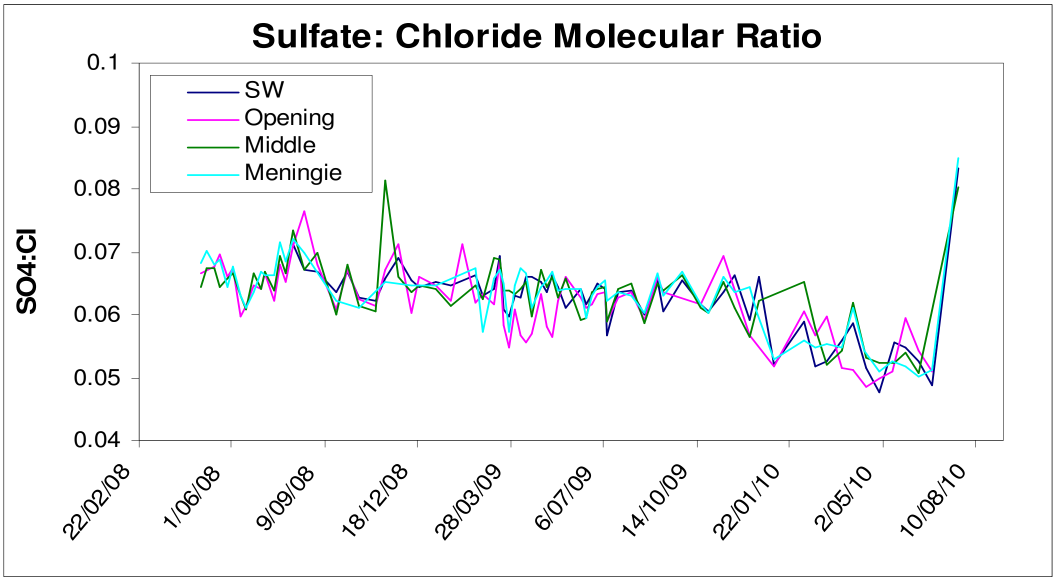

Figure 12 – Sulfate:chloride ratio at the Lake Albert ambient monitoring sites

Salinity (EC)

- Salinity remains very high compared to historical levels but has been decreasing at all sites with the exception of the Opening site which is variable. This site has experienced changes in salinity due to pumping from Lake Alexandrina[3] and mixing with more saline waters within the lake (Figure 13).

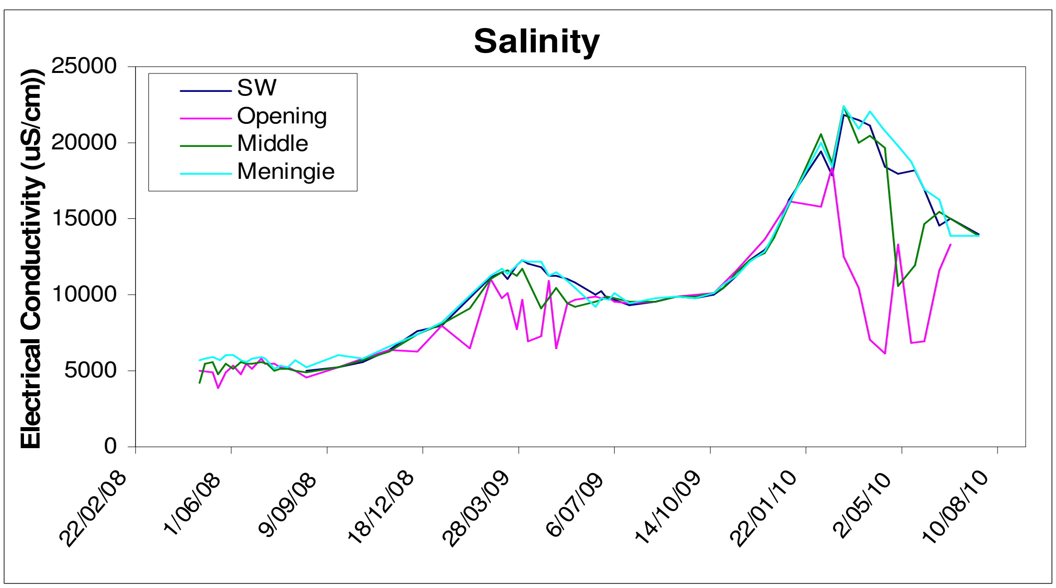

Figure 13 – Salinity at the Lake Albert ambient monitoring sites

[3] Pumping from Lake Alexandrina commenced in April 2008 and ceased initially in June 2009; it then recommenced between January and June 2010.

Turbidity

- Turbidity in Lake Albert has decreased somewhat over the last 4-5 months which may be due to the high salinities resulting in increased coagulation and settling of clay colloids (Figure 14). However turbidity remains high compared to historical levels.

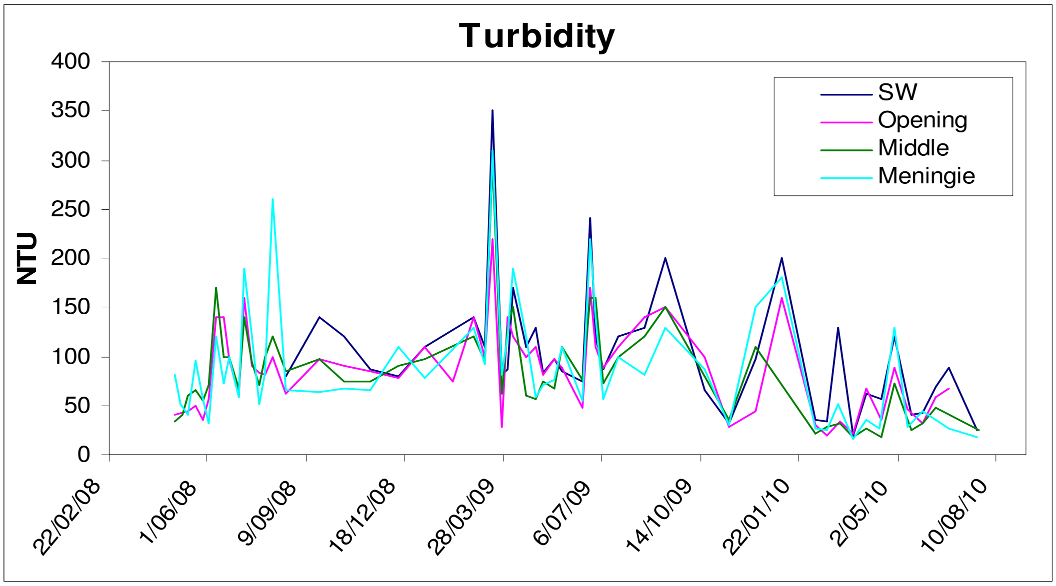

Figure 14 – Turbidity at the Lake Albert ambient monitoring sites

Nutrients (total nitrogen and phosphorus)

- Total nitrogen and total phosphorus are at very high levels in Lake Albert (see Figures 15 and 16). These levels are well in excess of the ANZECC guidelines (<1mg/L TN, <0.025 mg/L TP).

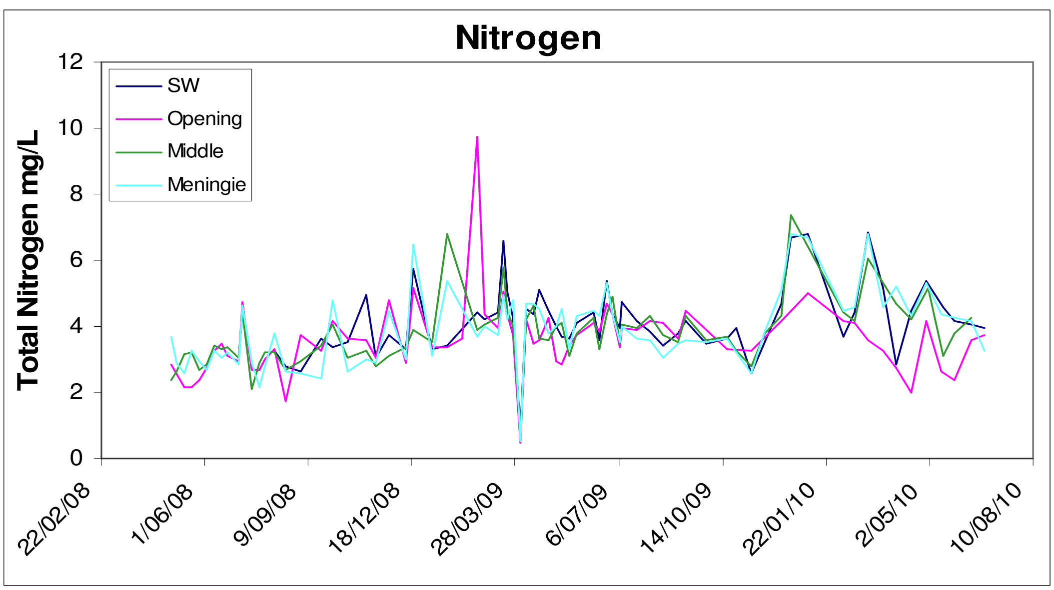

Figure 15 – Total Nitrogen in Lake Albert

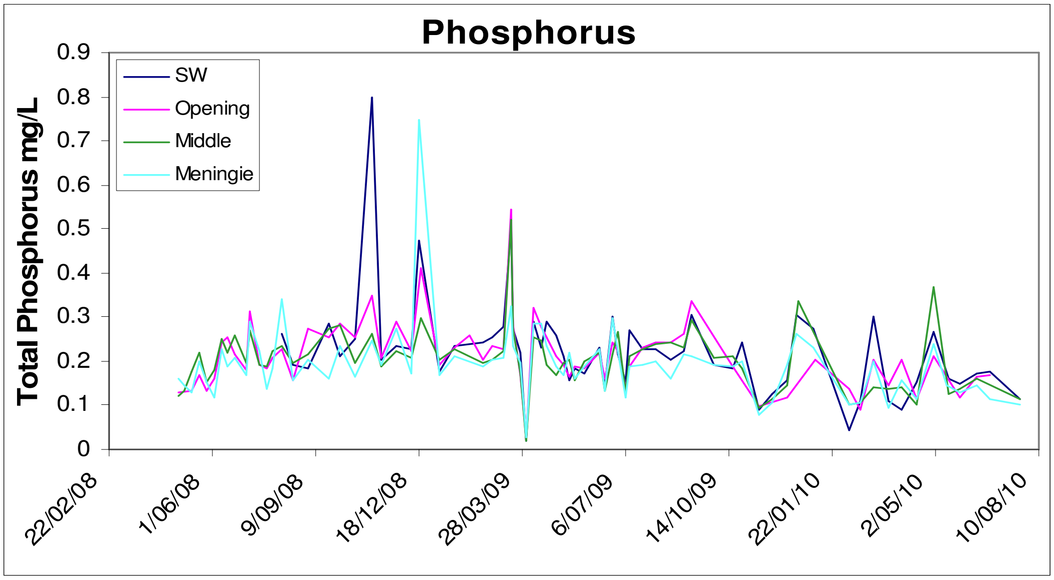

Figure 16 – Total phosphorus in Lake Albert

Chlorophyll a (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 and indicate a very nutrient enriched system (hyper-eutrophic). 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.

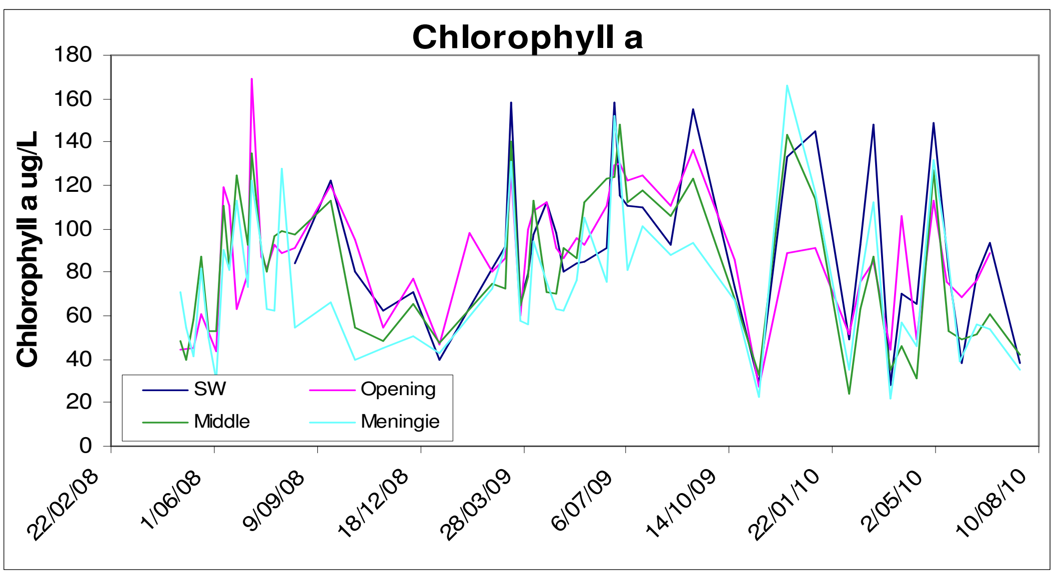

Figure 17 – Chlorophyll in Lake Albert

Goolwa Channel and Tributaries Water Quality

Ambient water quality monitoring results are discussed below for selected sites and parameters in the Goolwa Channel and tributaries region. See Figure 1 for site locations.

pH

- pH levels are stable and within ANZECC guideline levels (pH 6.5-9.0) at all sites in the Goolwa Channel and tributaries region (Figure 18).

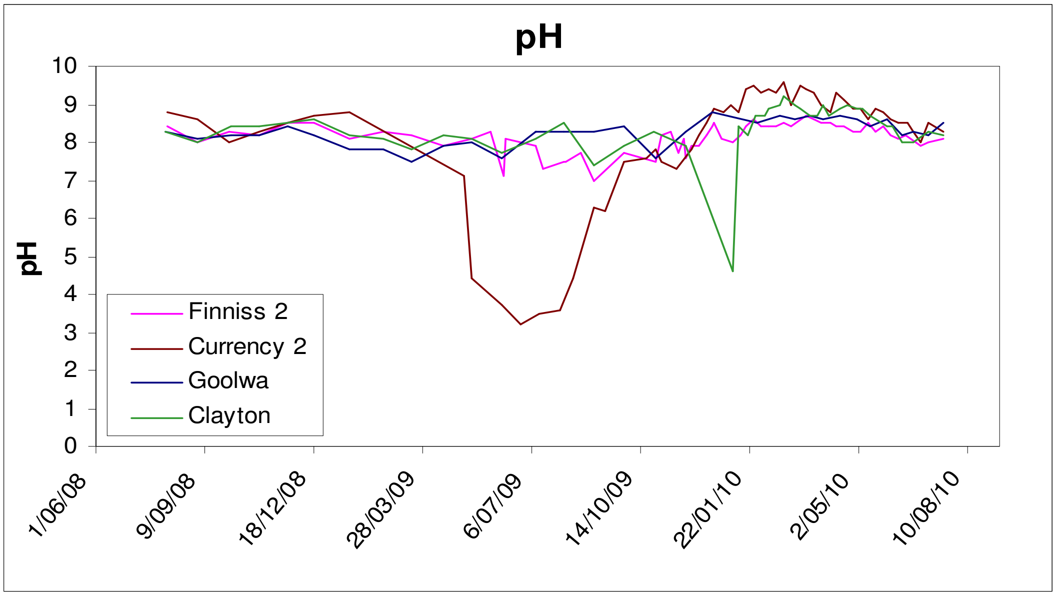

Figure 18 – pH at the Tributary ambient monitoring sites

Alkalinity

- Alkalinity at most of the Goolwa Channel and tributaries sites is satisfactory (Figure 19). The upper Finniss River region has shown some alkalinity declines due to regional tributary inflows which historically have low alkalinities at this time of year. Alkalinity has been increasing in Currency Creek with rising water levels and connection to the Goolwa Channel.

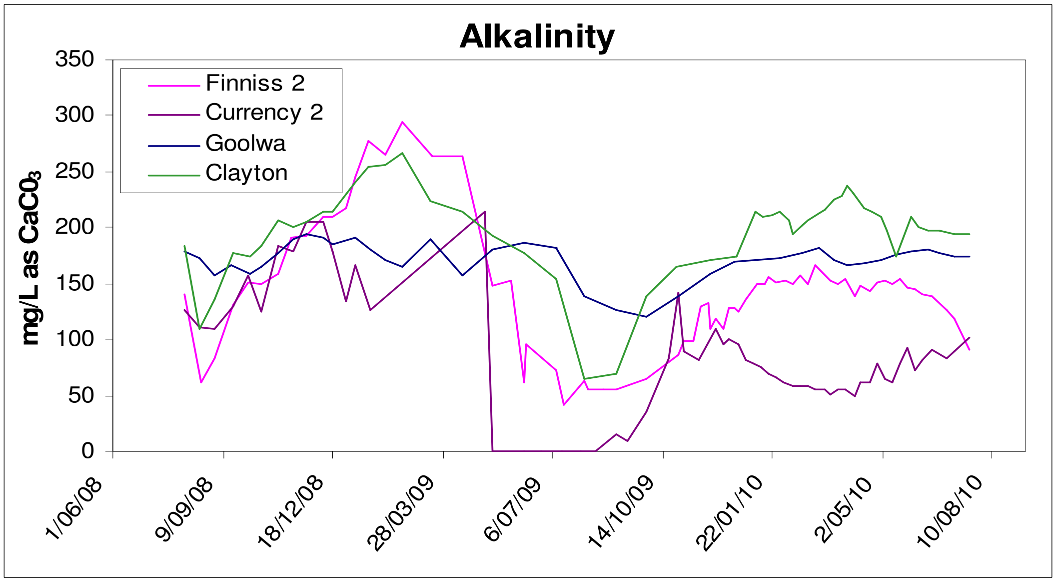

Figure 19 – Alkalinity at the Tributary ambient monitoring sites

Sulfate:chloride ratio

- The sulfate:chloride ratio has stabilised and is not showing any clear increasing trends that would suggest widespread acid sulfate soil inputs (Figure 20). Previously, during the winter of 2009, there were large increases in this ratio when the Currency Creek region acidified. The ratio at Currency Creek still remains slightly higher than the other sites.

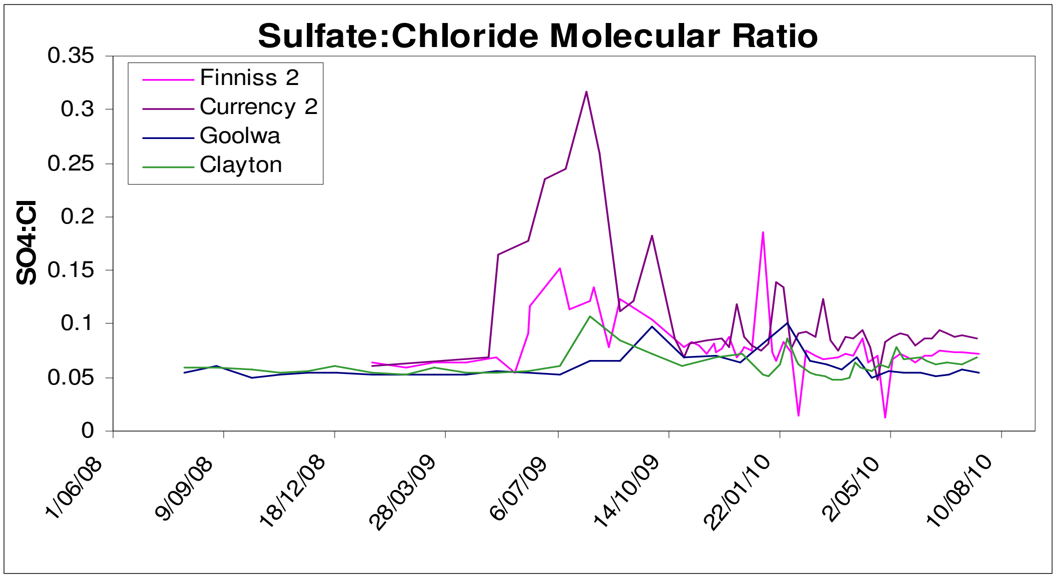

Figure 20 – Sulfate:chloride molecular ratio at the Tributary ambient monitoring sites

Salinity (EC)

- Salinity is decreasing at all sites but still remains high compared to historical levels (Figure 21). The decline in salinity is a result of dilution from inflows following rainfall in the Currency Creek and Finniss River catchments. Salinity is expected to continue to decrease over winter and early spring.

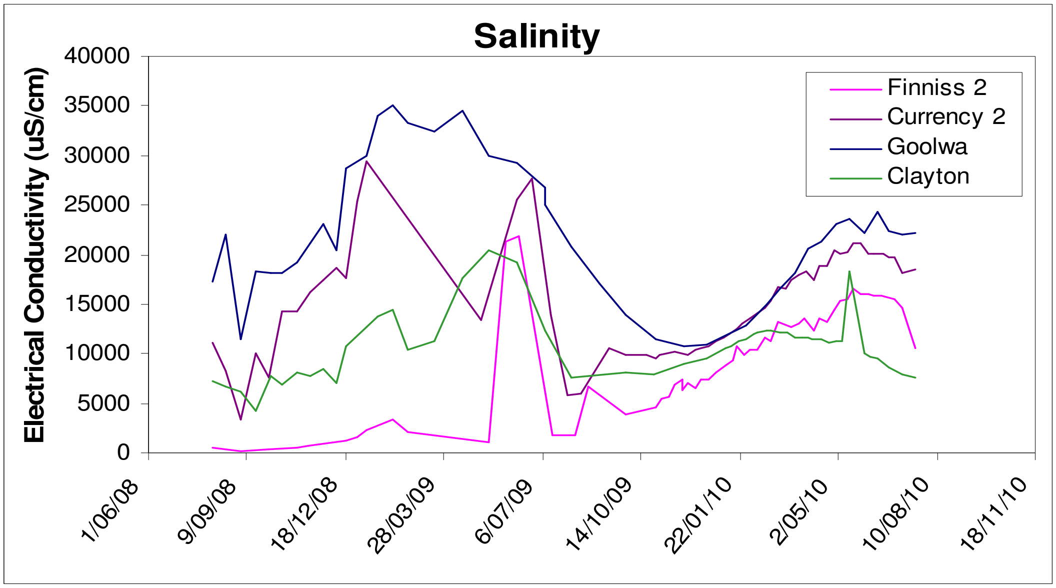

Figure 21 – Salinity at the Tributary ambient monitoring sites

Turbidity

- Since pumping into the Goolwa Channel concluded in October 2009, the turbidity at the Goolwa and Currency 2 sites downstream of the temporary regulator near Clayton has decreased markedly (Figure 22) and is at very low levels in comparison to other sites in Lake Alexandrina (see Figure 6). The very low turbidity in this region is likely due to increased settling and reduced resuspension of particles due to a reduction in wind-driven current flows following construction of the regulators.

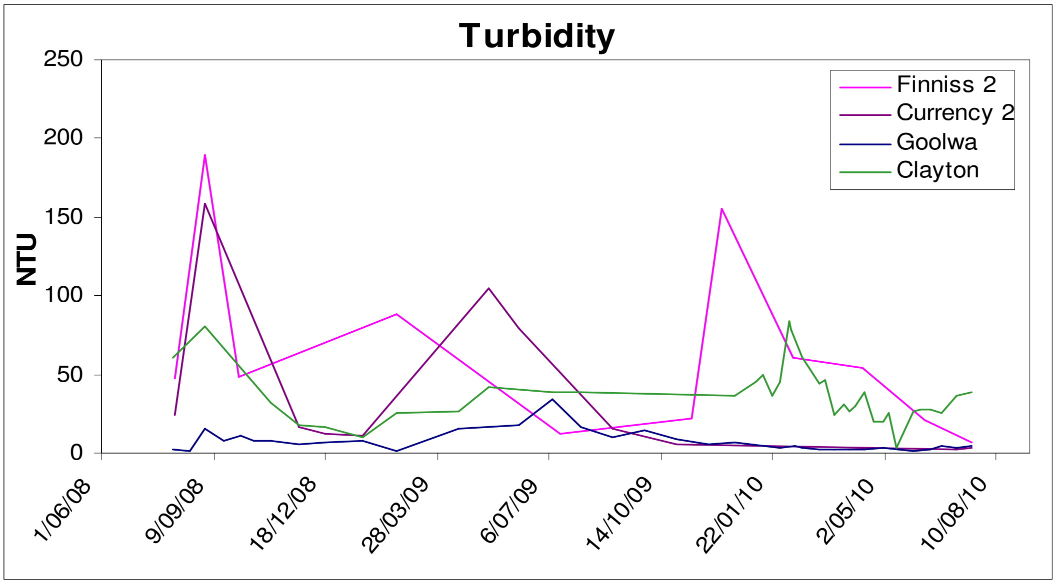

Figure 22 – Turbidity at the Tributary ambient monitoring sites

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).

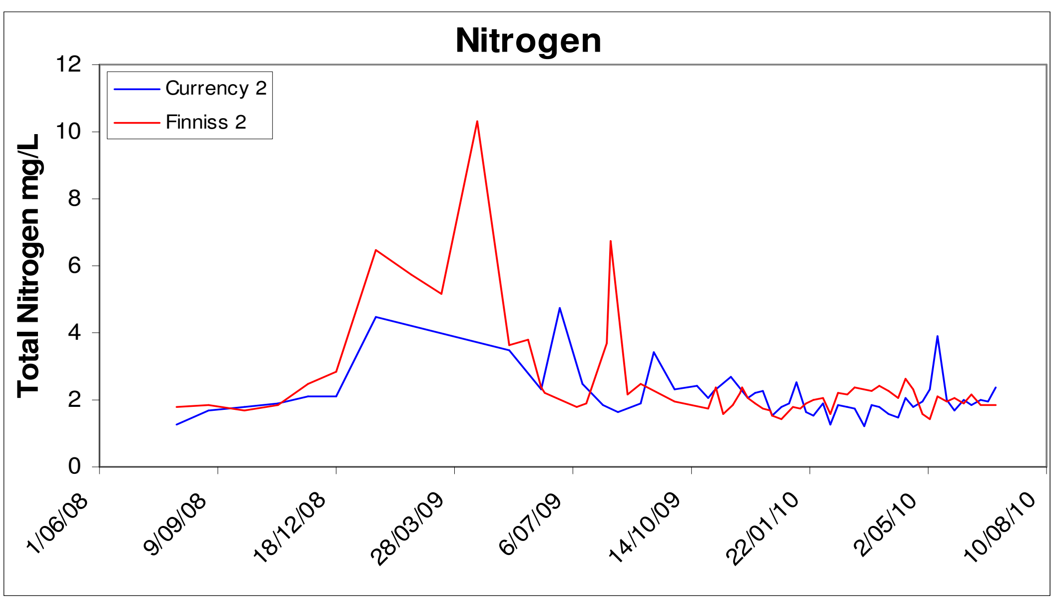

Figure 23 – Total Nitrogen at the Tributary ambient monitoring sites

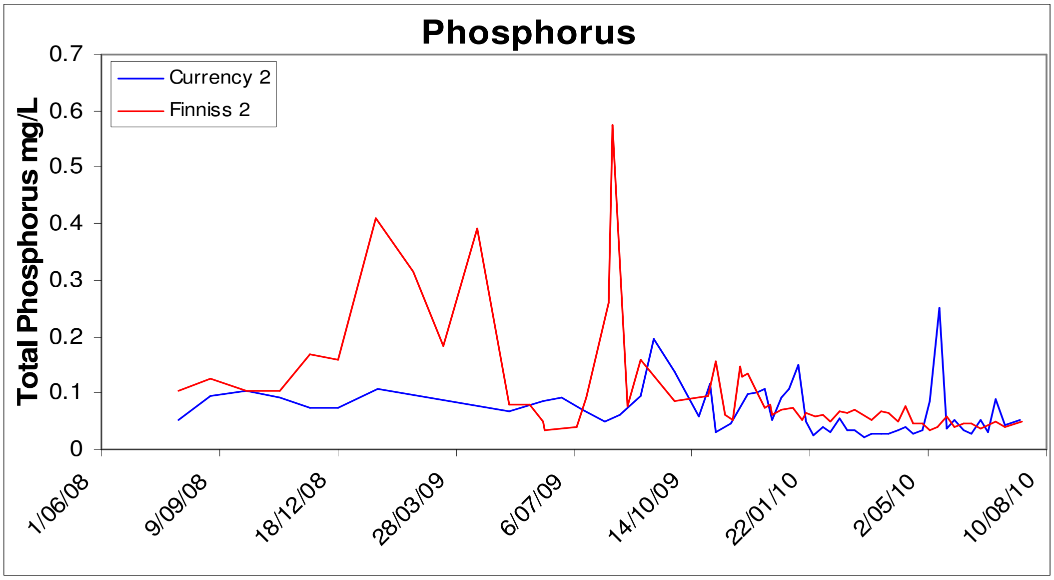

Figure 24 – Total phosphorus at the Tributary ambient monitoring sites

Chlorophyll (algae)

- Chlorophyll *a* is has declined at the lower tributary sites (Figure 25). This decline is presumably due to localised tributary flow and decreased algal growth due to colder temperatures.

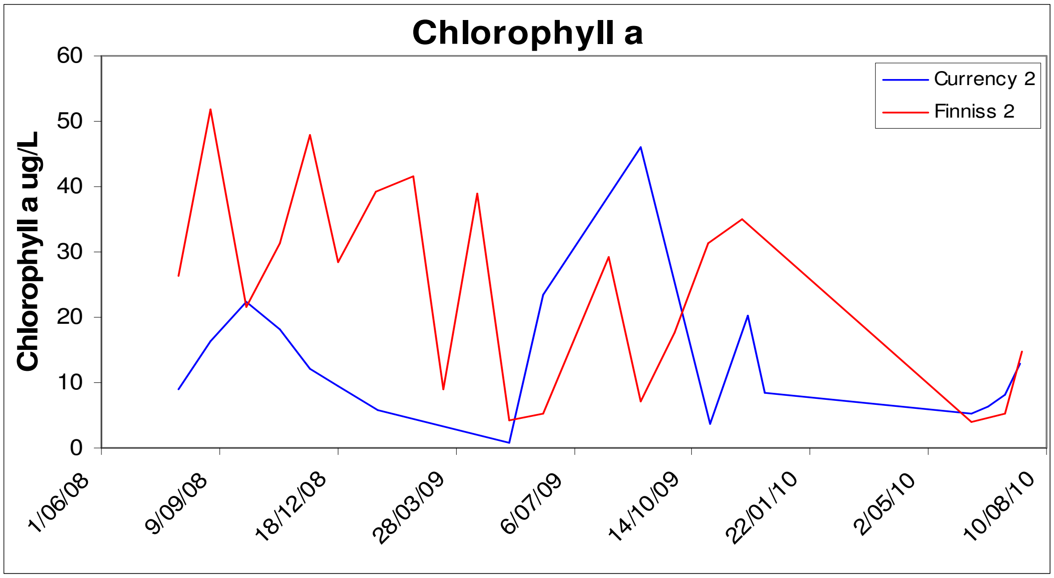

Figure 25 – Chlorophyll *a* at the Tributary ambient monitoring sites

Event-based monitoring

Event-based water quality sampling is undertaken in selected regions that have experienced acidification or are at risk of acidification (Figure 26).

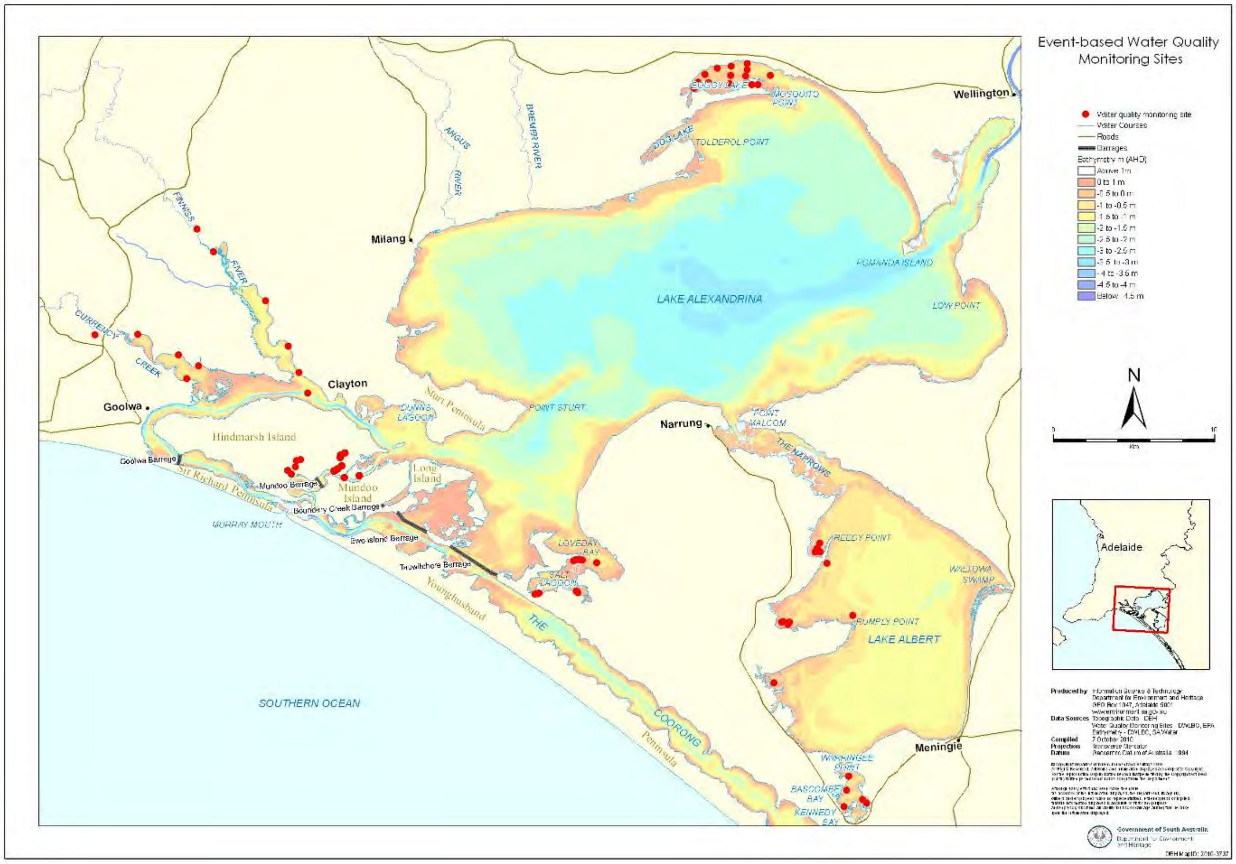

Figure 26 – Map of the event-based water quality monitoring sites

Event-based water quality monitoring is undertaken on an "as needs basis" to investigate if any localised acidification is present. The selection of sites is based upon acid sulfate soil risk assessment, in accordance with available data on the distribution of sulfidic and sulfuric materials and research and modelling into potential acidity fluxes. Site sampled were screened to identify the extent of acidity and the 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.

Currency Creek & Finniss River

Figure 27 shows a map of the event-based tributary monitoring sites in the Currency Creek and Finniss River. These sites have been monitored on an ongoing basis since June 2009 providing information on both drying down (acidification) and rewetting periods. This data has proven invaluable for underpinning management actions and assessing environmental responses to the temporary regulators near Clayton and in Currency Creek.

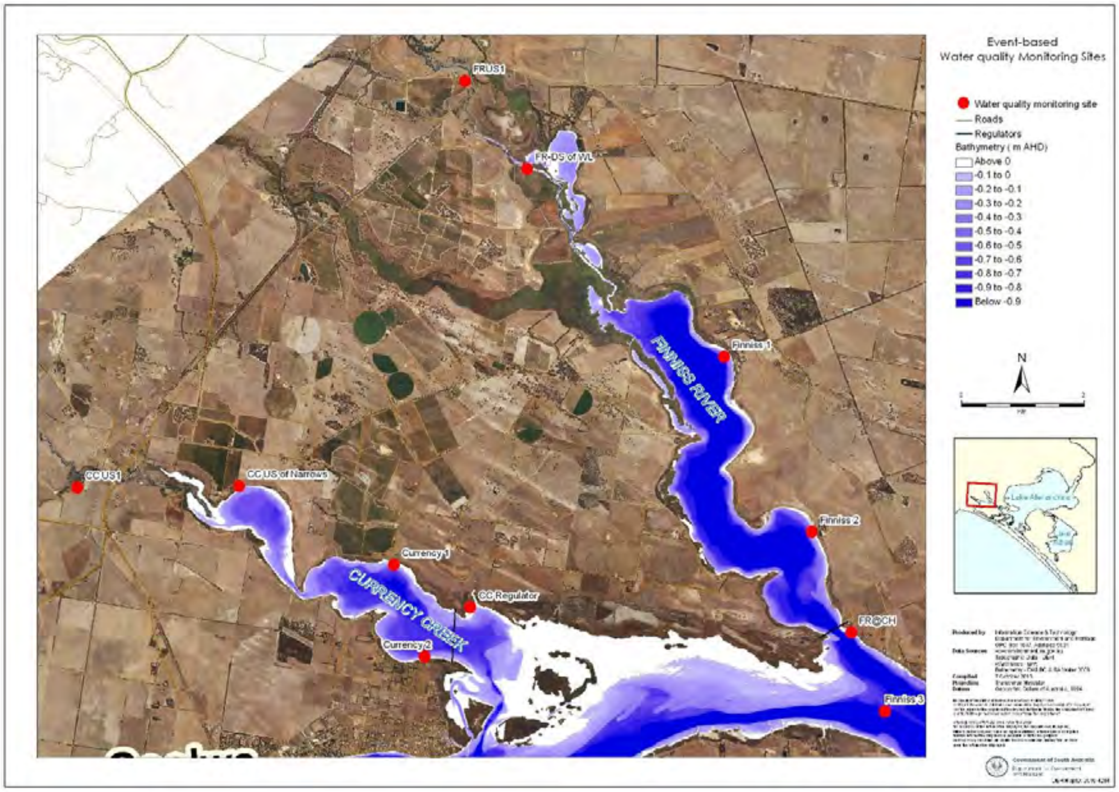

Figure 27 – Finniss River and Currency Creek event-based monitoring locations (note: Currency 2 and Finniss 2 are also ambient monitoring sites that have been sampled at a higher frequency)

Recent rainfall and tributary flows in conjunction with the temporary regulator near Clayton have led to continued water level rises at all sites within the tributaries. The water quality data for the Currency Creek region are shown in Figure 28. Both pH and alkalinity are relatively stable with the exception of the most upstream site (CC-US1) where a significant fall in alkalinity has been observed since June. This is likely due to rainfall induced surface water flows (lower alkalinity) rather than groundwater fed flows (higher alkalinity) being the dominant water source. Salinity in Currency Creek upstream of the narrows has decreased during June-July. Increased tributary flows, associated autumn rainfall, and cooler autumn weather have led to this salinity dilution. However salinity levels at all sites are still high in comparison to historical levels and guidelines to protect freshwater ecosystems.

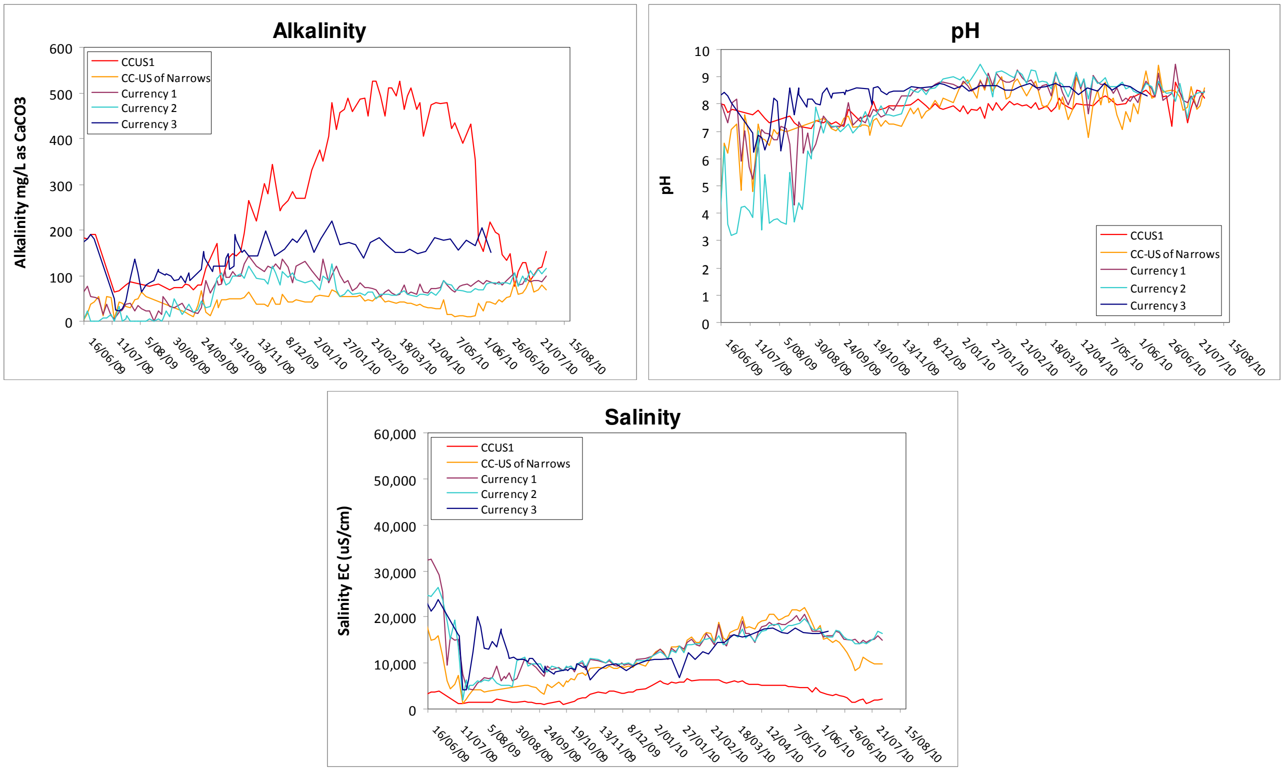

Figure 28 –Currency Creek event-based monitoring data

Finniss River water quality data can be seen in Figure 29. The FR-DS of WL site is exhibiting variable pH and low alkalinity likely due to mobilisation of acidity within the wetlands. Although higher values, a declining trend in alkalinity is observed at most of the other sites likely due to rainfall and increased tributary flows similar to the upstream Currency site (CC-US1). Salinity levels have decreased markedly at all sites due to dilution from the substantial river inflows but are still high in comparison to historical levels.

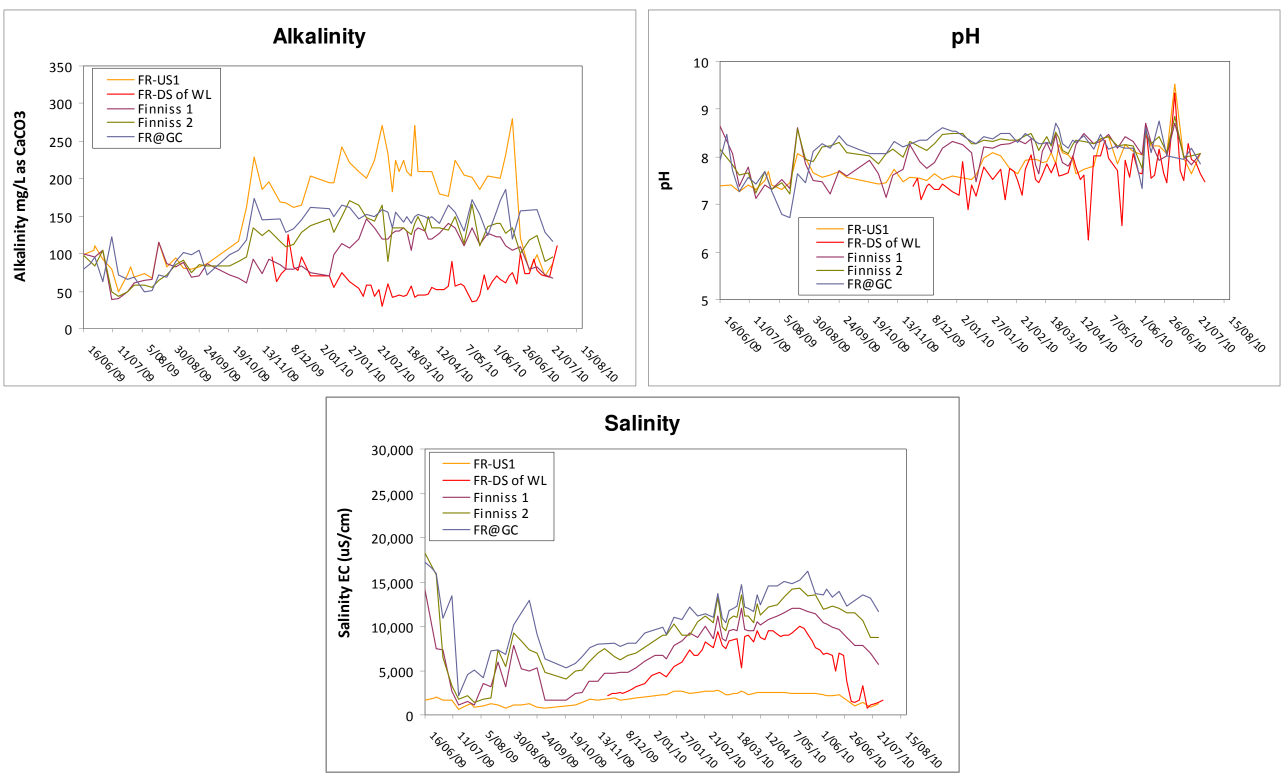

Figure 29 –Finniss River event-based monitoring data

Boggy Lake

Figure 30 shows a map of pH levels at 13 sites in Boggy Lake last sampled on 22/07/2010. During July, there was a decrease in the acidity and increase in pH at several sites along the northern margin of Boggy Lake, which is likely a result of the addition of limestone indicated by the dashed lines on the graph . However, acidity is still present at most sites (55-150 mg/L as $CaCO_3$) and pH is still well below ANZECC guidelines, and notably low in the western and southern sections (pH 4-5 as shown in figure 31). The waters in Boggy Lake increase in pH as they continue to mix with the alkaline waters of Lake Alexandrina. Continued evaluation of the monitoring data will determine whether further limestone addition is needed.

Figure 30 – Map of Boggy Lake sample sites

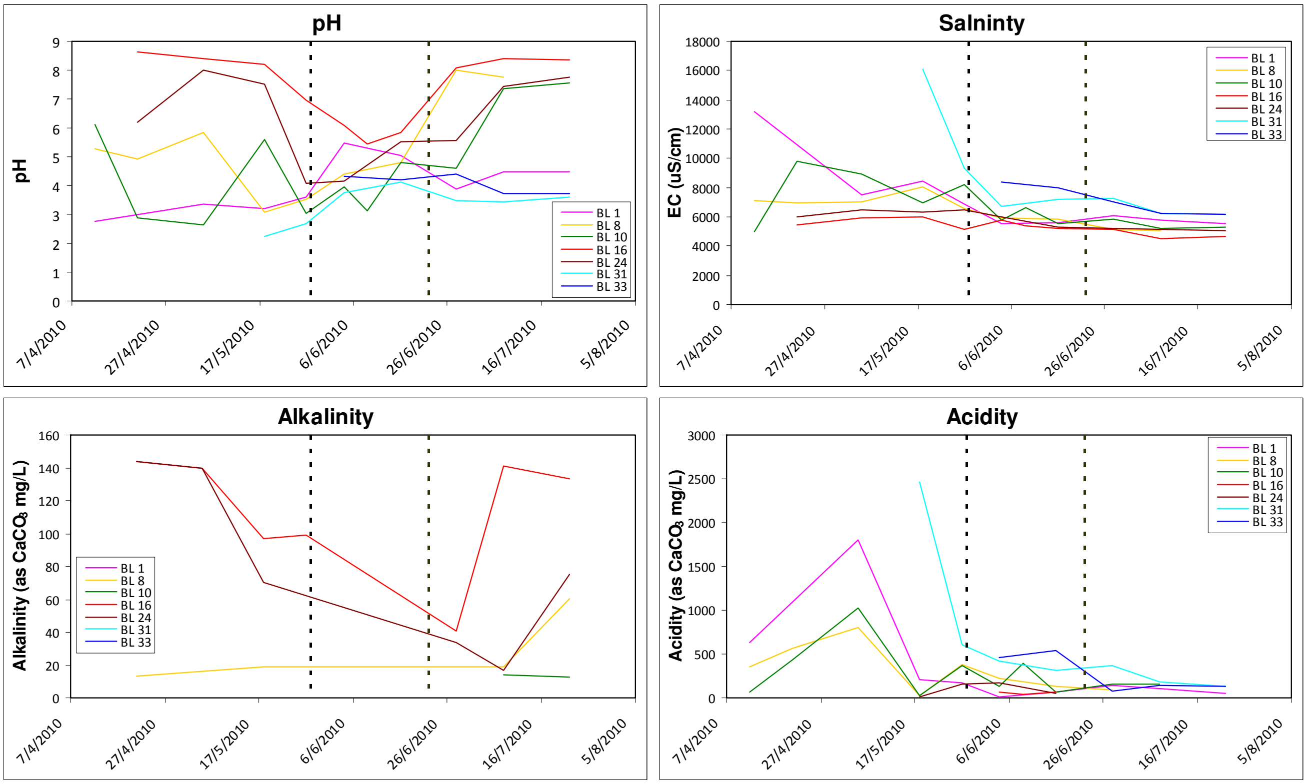

Figure 31 –Boggy Lake pH and acidity levels

Salt Lagoon

Salt Lagoon is located off the southern shore of Loveday Bay (Figures 26 and 32). When water levels are below -0.3 AHD, the lagoon is separated from Loveday Bay by a natural sand barrier (see bathymetry in Figure 31). Salt Lagoon completely dried in the summer of 2008-09 allowing the oxidation of acid sulfate soils. Following rewetting from winter rains, the lagoon displayed areas of acidic water (pH < 3) and metal precipitates. Recent samples indicate the water body is acidic displaying low pH and high acidity. Sampling will continue over the coming months to determine the extent of acidic water within the lagoon and if any major water quality issues will occur upon reconnection with Loveday Bay as the Lake Alexandrina water levels continue to rise.

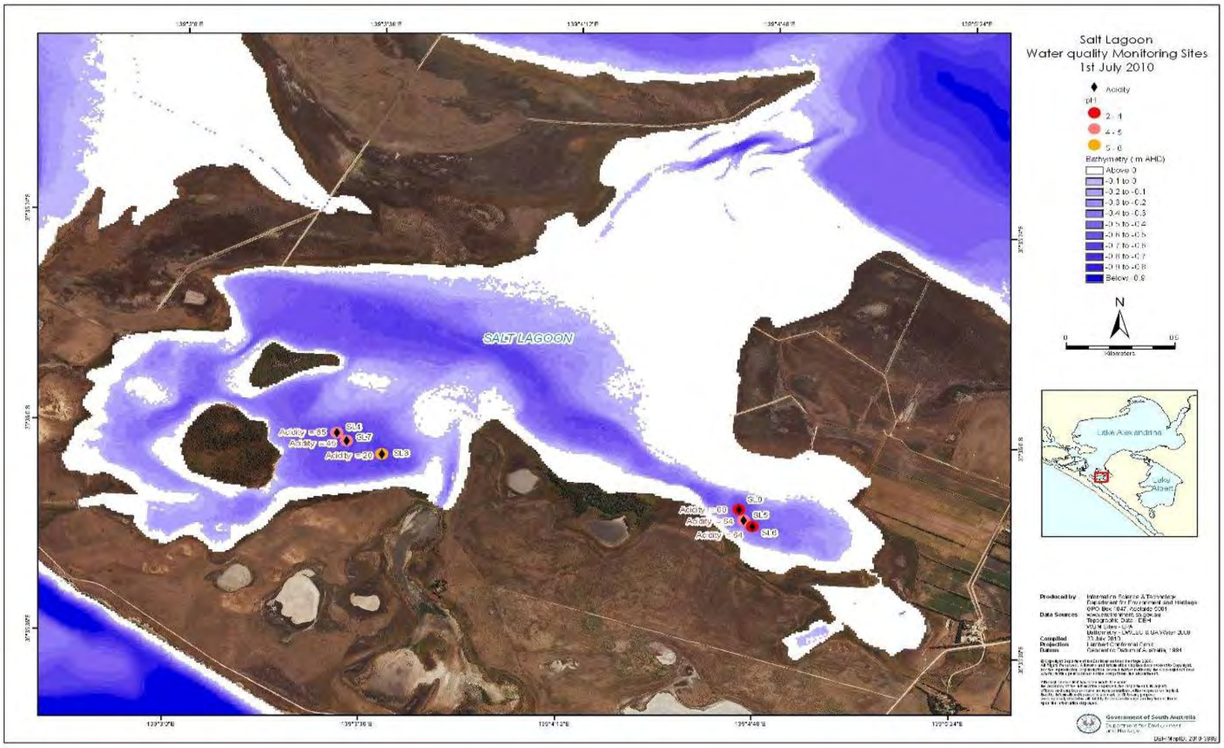

Figure 32 – Map of Salt Lagoon pH and acidity levels on 21/7/2010

Boggy Creek

The recent increase in water levels in Lake Alexandrina has resulted in a number of sites being reinundated for the first time in several years. Sediments within Boggy Creek (near Mundoo barrage) were previously identified by CSIRO to have a high net acidity, therefore the screening of surface water quality was considered to be of a high priority. Initial results have shown pH well within the ANZECC guidelines for aquatic ecosystems (Figure 33), however the alkalinity in the northern area decreased in comparison to water feeding the creek from Mundoo channel. This indicates that there are possible acidity influxes taking place that will require further investigation as water levels continue to rise and re inundate further sediments.

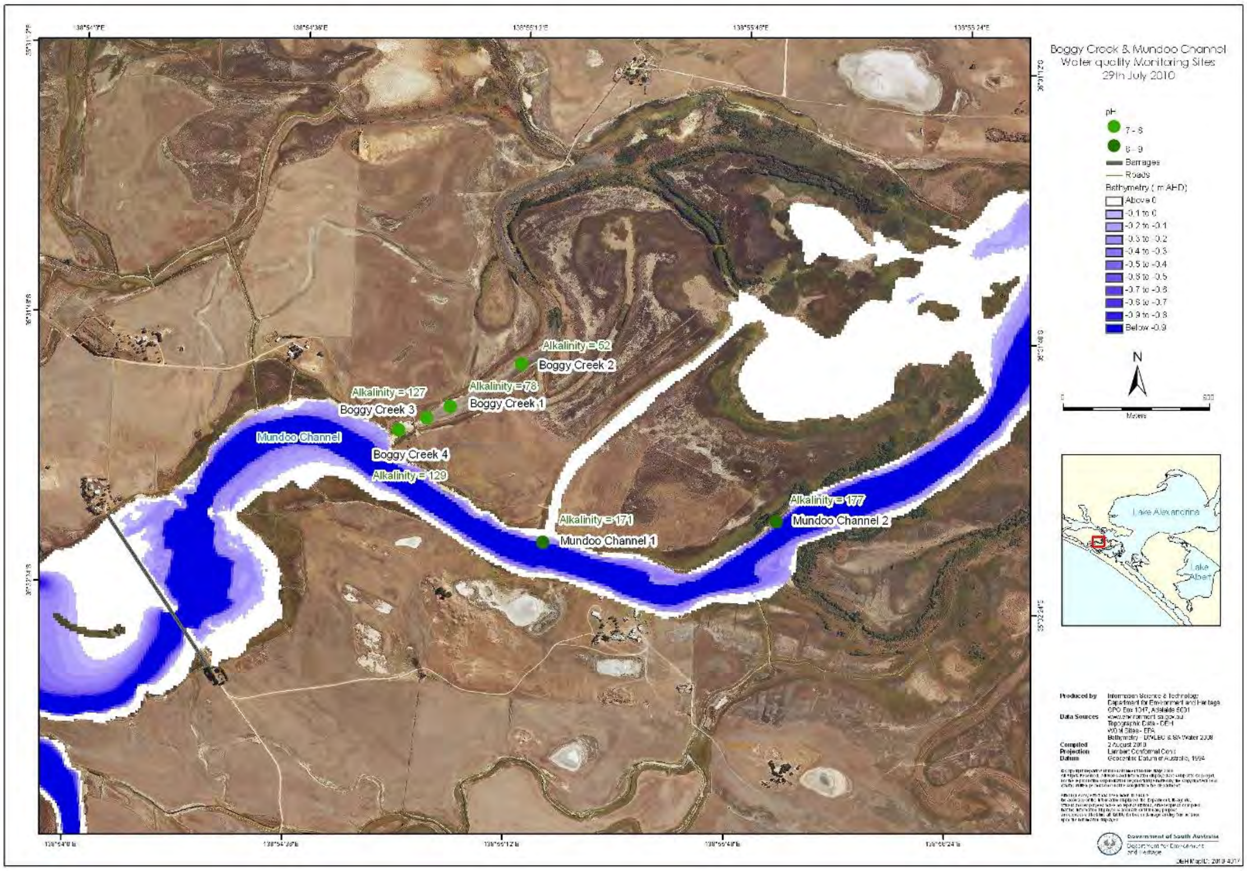

Figure 33 – Map of Boggy Creek pH levels on 29/7/2010

Further Information

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

- Department of Environment and Natural Resources 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