Lower Lakes and Tributaries

Water Quality Report

Ambient and Event-based Monitoring

Report 18, August 2010

Government of South Australia
Department of Environment and Natural Resources

EPA South Australia

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Observations at a Glance

- ***Water quality has improved across the Lower Lakes following substantial inflows of floodwater from the Murray-Darling Basin***
- ***Salinity levels have decreased due to dilution from lake refill but still remain high compared to historic levels***
- ***pH and alkalinity remain satisfactory at all sites in the main lake areas and tributaries***
- ***Localised acidity in Boggy Lake decreased but significant areas with pH <6.5 remain, and acidic water was also identified in Boggy Creek near Mundoo barrage.***

Background

The Environment Protection Authority (EPA), Department of Environment and Natural Resources (DENR), and the Department for Water (DFW) are co-ordinating a monitoring program 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 (total nitrogen and total phosphorus), chlorophyll *a* and metals (aluminium and iron). 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 to the water body 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).

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

***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).**

***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 cyanobacteria, phytoplankton, macrophytes and filamentous algae. Prior to drought conditions, TN was on average about 1.2 mg/L in Lake Alexandrina (at Milang) and 1.6 mg/L in Lake Albert (at Meningie) with TP on average about 0.15 mg/L in Lake Alexandrina (at Milang) and in Lake Albert (at Meningie).**

***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).**

***Metals*   metal concentrations in the Lower Lakes allow us to determine what processes are proceeding within sediments. During concentration events (i.e. evaporation and low inputs) volumes of metals are expected to increase, alternatively during flooding events the volume of metals will be diluted and expected to reduce. Additional to this, as sediments acidify and the pH is reduced, metals that have been previously unavailable and bound up within sediment are liberated. This increase in metal concentration can be used as an indicator of acid sulfate soil impacts.**

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).

Ambient Water Quality Monitoring

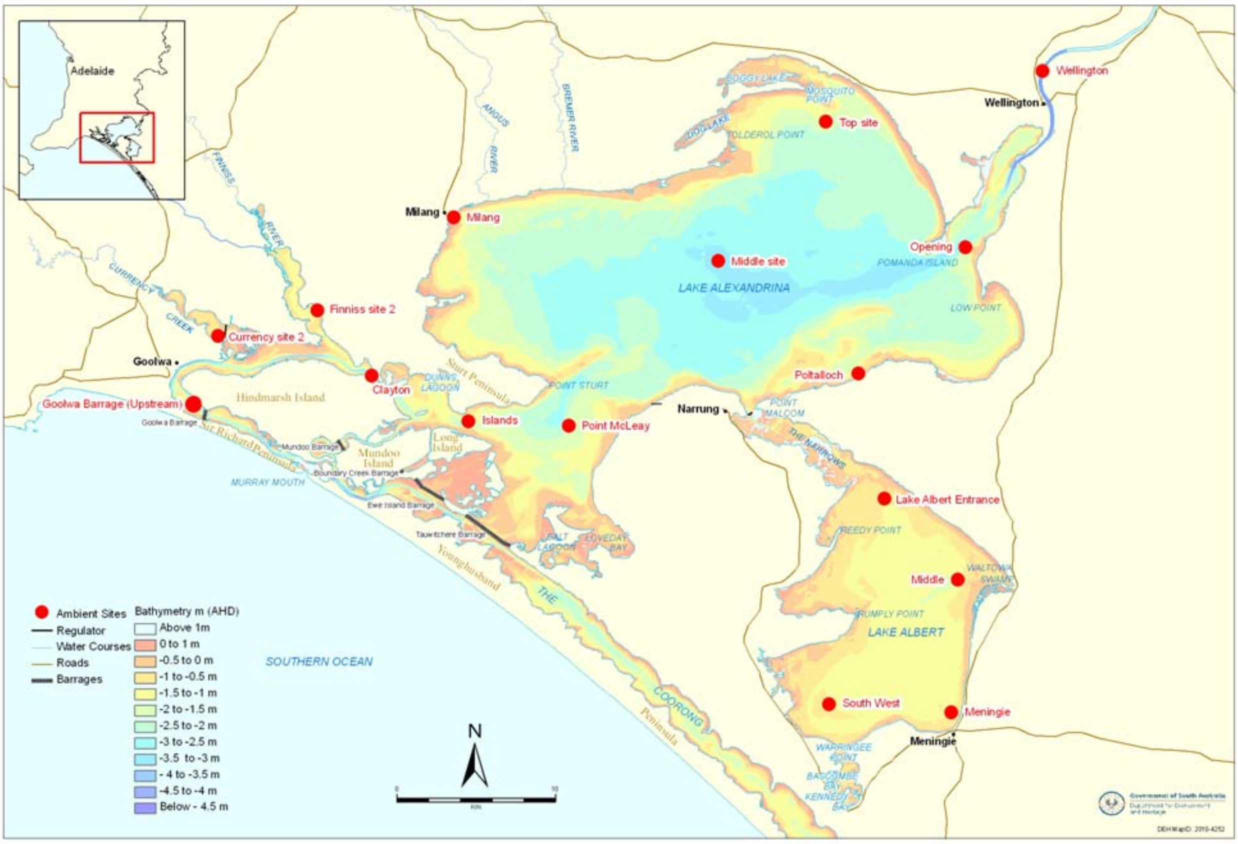

Figure 1 – Lower Lakes and tributaries ambient monitoring sites

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. The 4 sites selected for reporting have been chosen as they are representative of the water body, incorporating water entering from the River (Opening) and a transect across Lake Alexandrina from the northern corner (Top) through the centre (Middle) to the southern edge of the Lake before it enters the Goolwa Channel (Point McLeay)

pH

- pH levels remain relatively stable and within ANZECC guideline levels (pH 6.5-9.0) at sites in Lake Alexandrina (see Figure 2 showing four representative sites in the main water body).

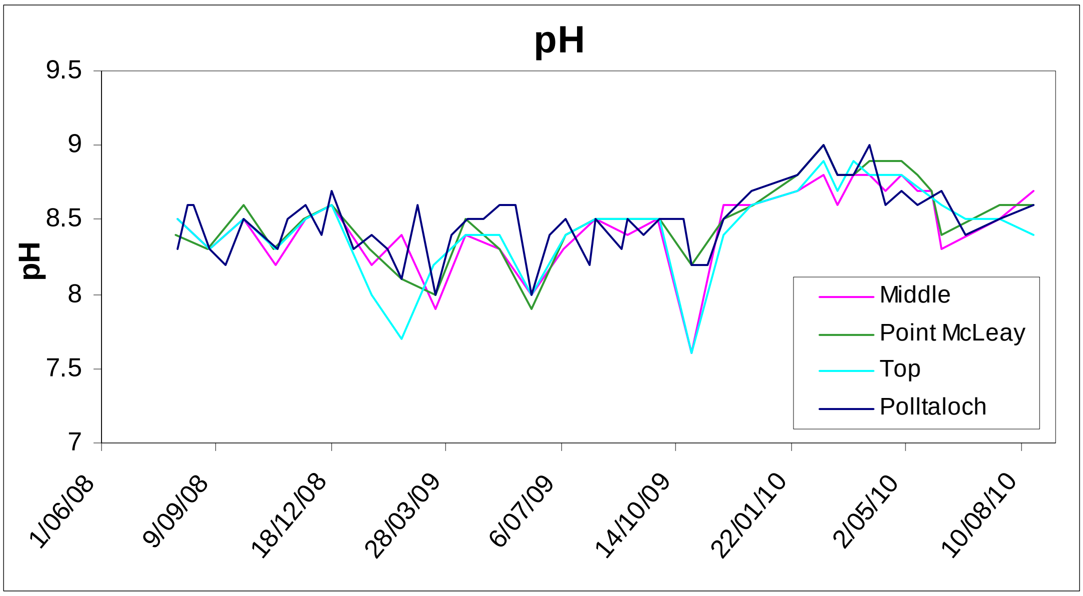

Figure 2 – pH at the Lake Alexandrina ambient monitoring sites

Alkalinity

- Alkalinity remains stable and satisfactory for sites in the main areas of Lake Alexandrina (Figure 3). Additional inflows and mixing within Lake Alexandrina has led to a general declining trend in alkalinity since May 2010. This is consistent with historical data and does not indicate widespread acidity driven alkalinity declines.

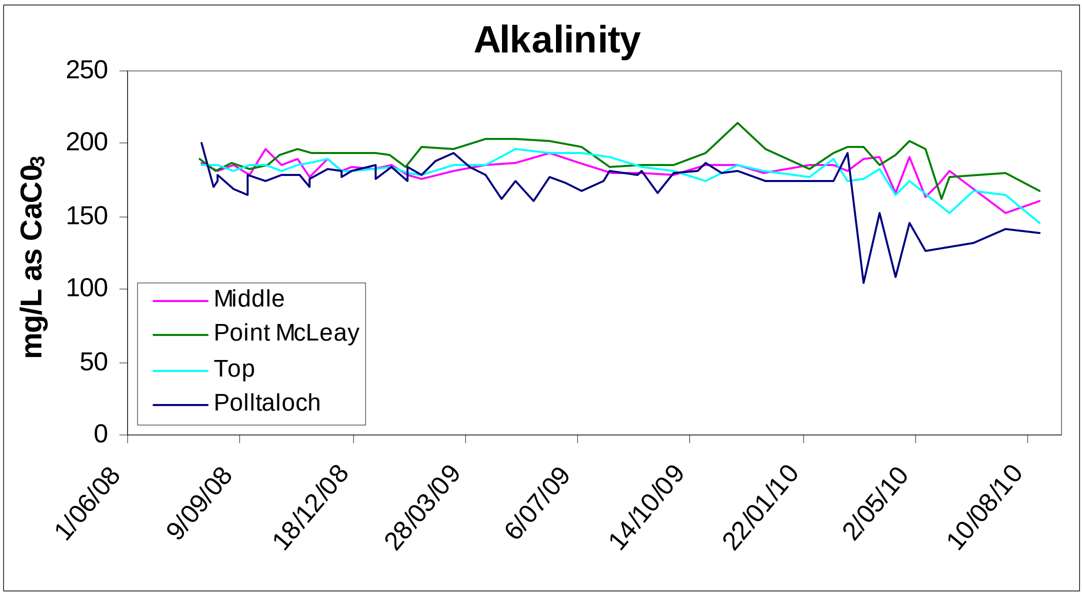

Figure 3 – Alkalinity at the Lake Alexandrina ambient monitoring sites

Sulfate:chloride ratio

- The sulfate:chloride ratio continues to show some variability but no clear trend that would suggest widespread acid sulfate soil influences (Figure 4). Over August the sulfate chloride ratio has been particularly variable at a number of sites possibly indicating sulfate cycling within Lake Alexandrina following increased water levels and inundation of sediments.

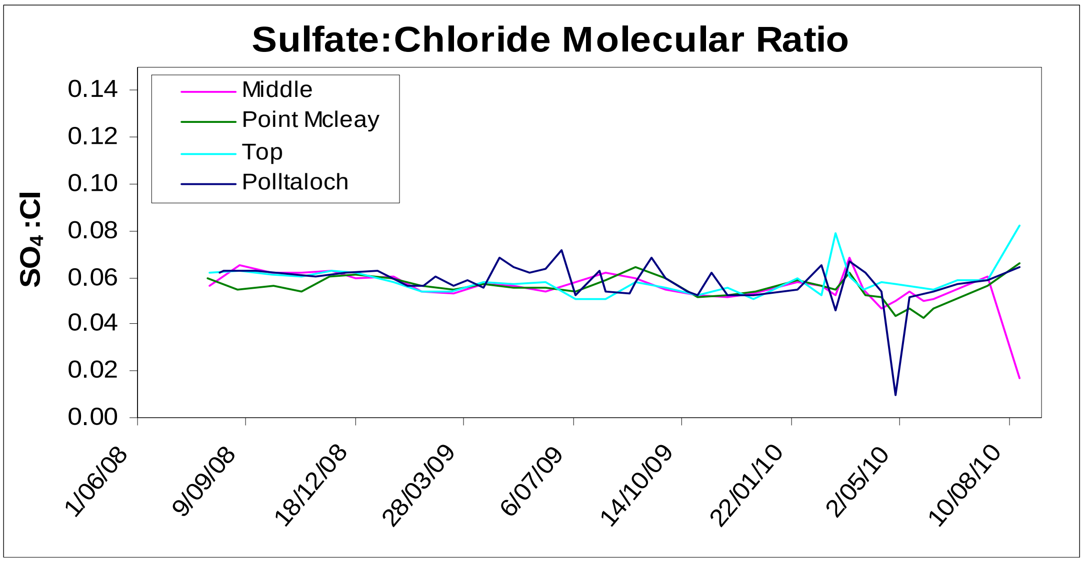

Figure 4 – Sulfate:chloride ratio at the Lake Alexandrina ambient monitoring sites

Salinity (EC)

- Salinity has stabilised across the sites in the middle of Lake Alexandrina (Figure 5). Winter rainfall, increased Murray-Darling Basin inflows, and cooler weather have contributed to a salinity decline. 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].

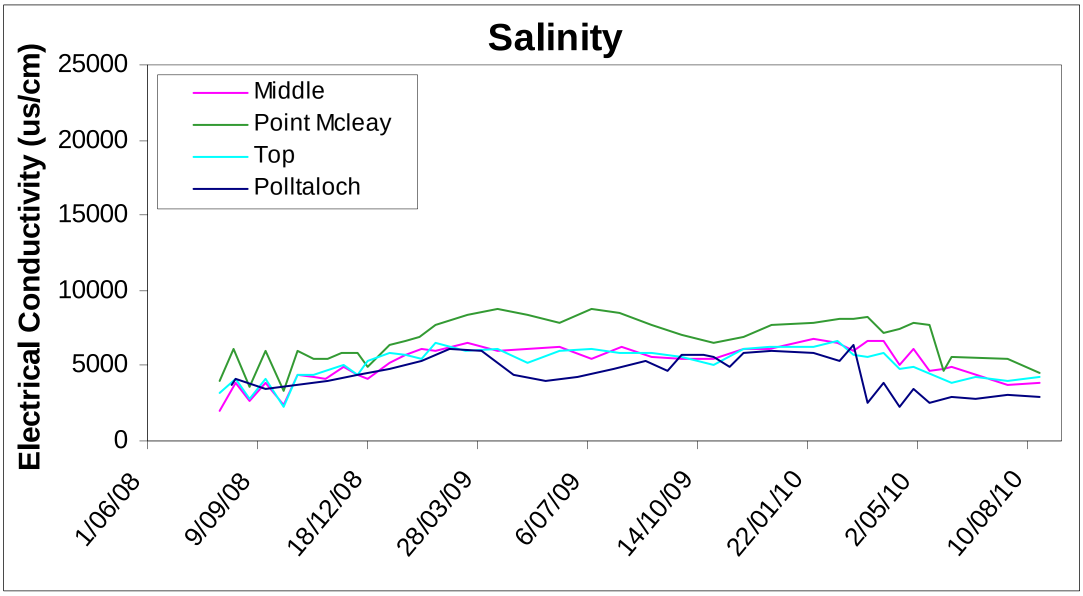

Figure 5 – Salinity at the Lake Alexandrina ambient monitoring sites

[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.

Turbidity

- Recent Murray-Darling basin inflows have led to a marked uniform increase in turbidity throughout the lake (Figure 6). This is consistent with historical data which show that floodwaters contain high suspended particle levels. The large fetch and shallow nature of Lake Alexandrina generally mean high levels of turbidity compared to other freshwater bodies.

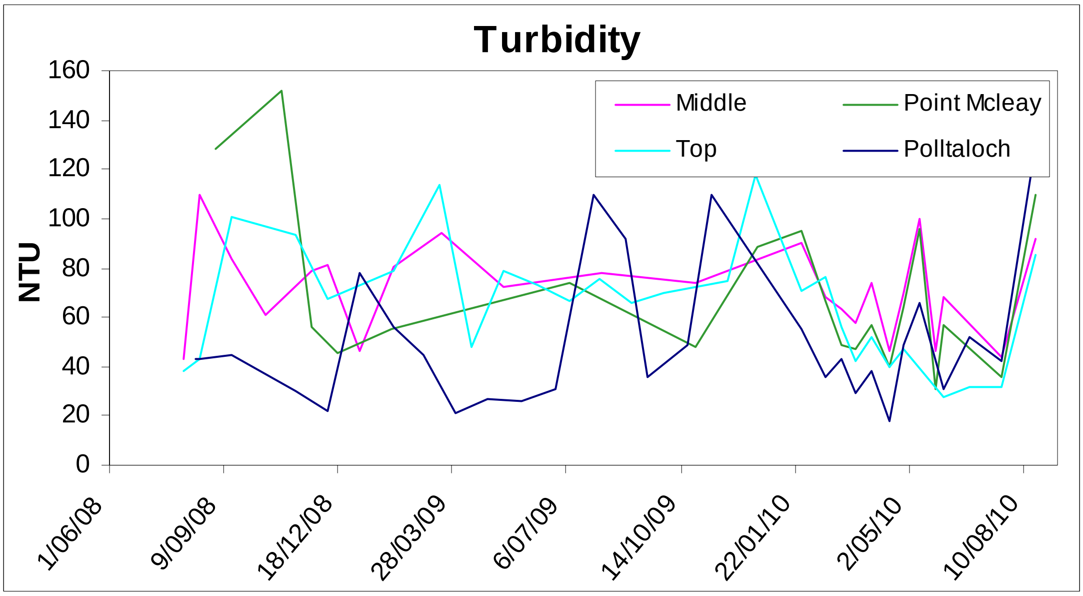

Figure 6 – Turbidity at the Lake Alexandrina ambient monitoring sites

Nutrients (total nitrogen and phosphorus)

- Total nitrogen and phosphorus levels have increased recently (Figures 7 and 8) which is likely due to inputs from flood inflows. While upstream monitoring shows high levels of nutrients, the nutrient levels remain high compared to historical levels and are well in excess of the ANZECC guidelines for freshwater ecosystems (<1 mg/L TN, <0.025 mg/L TP).

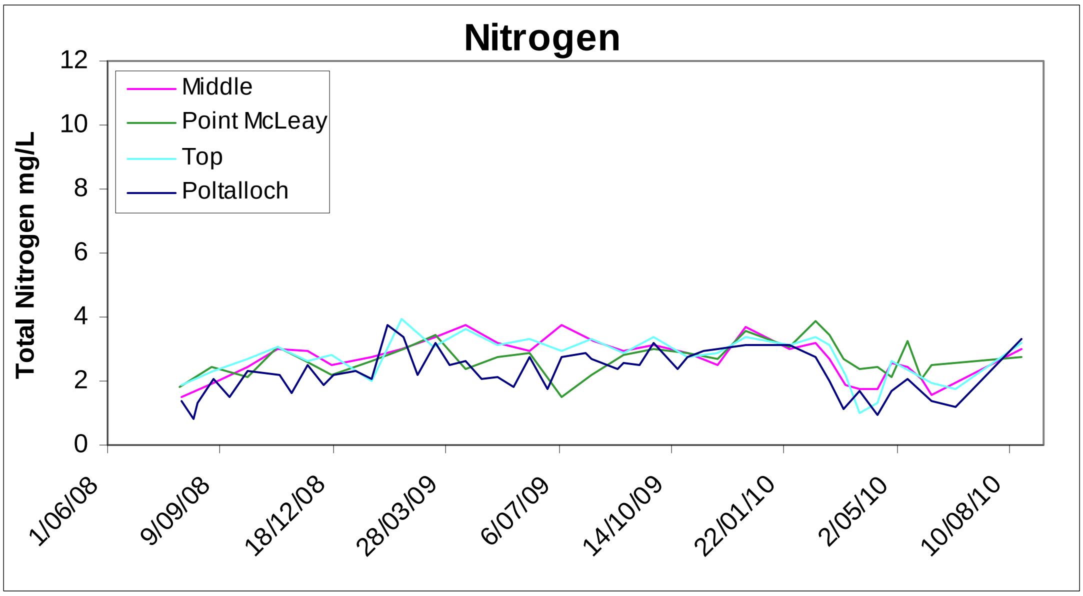

Figure 7 – Total Nitrogen in Lake Alexandrina

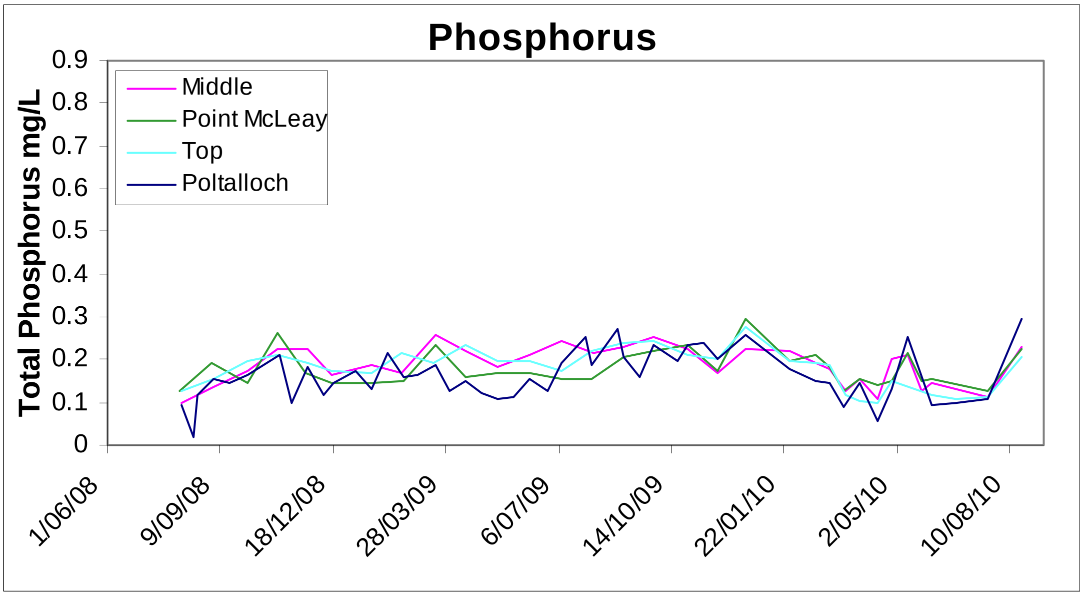

Figure 8 – Total Phosphorus in Lake Alexandrina

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. Recent increases in chlorophyll *a* in Lake Alexandria are likely due to increased nutrient (likely soluble phosphorus) inputs and availability from the floodwater inflows. While the chlorophyll *a* levels in Lake Alexandrina are very high, no potentially toxic blue-green algal blooms are currently observed.

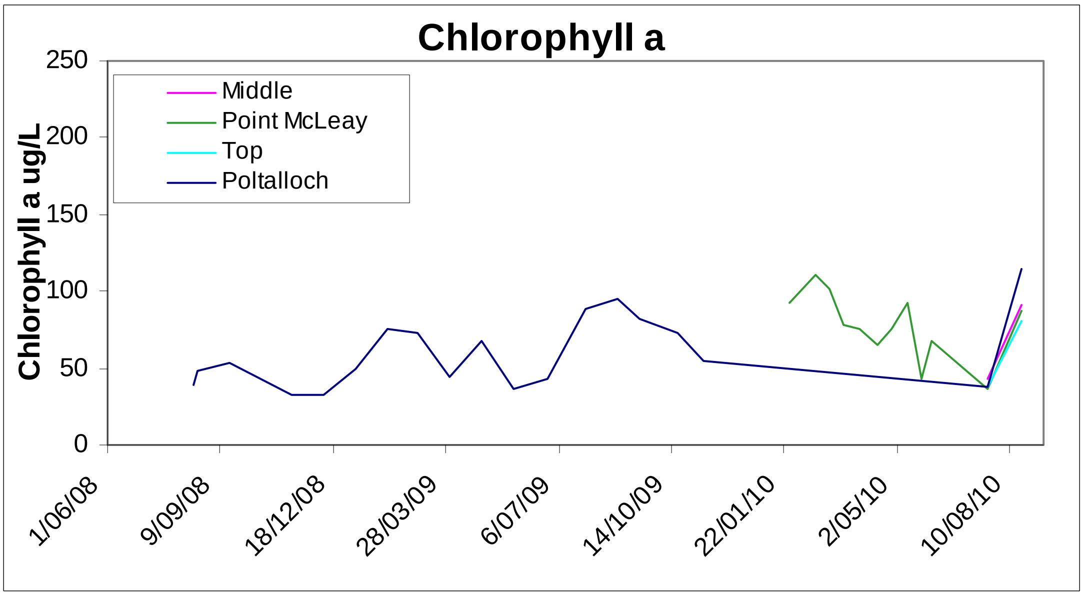

Figure 9 – Chlorophyll a in Lake Alexandrina

Metals

- Total aluminium and iron concentrations within Lake Alexandrina have been variable until recently where a noticeable decline in concentrations has occurred across the lake (Figures 10 and 11). The recent decreases are likely a result of dilution as the lake refills. In general the concentrations of iron and aluminium are correlated to each other and the trends appear to be related to inflows and wind events.

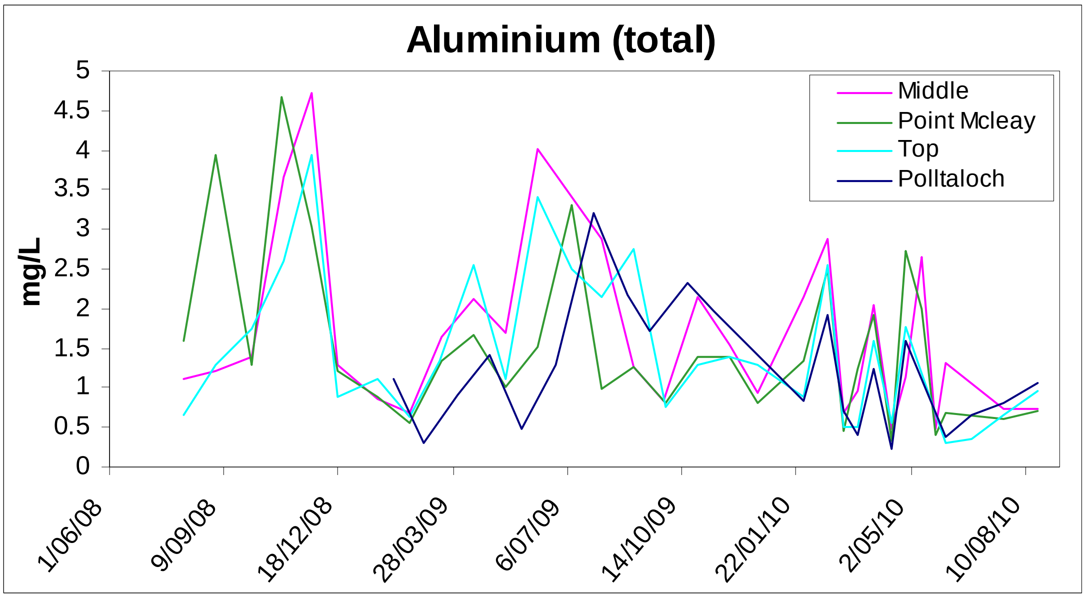

Figure 10 – Total Aluminium in Lake Alexandrina

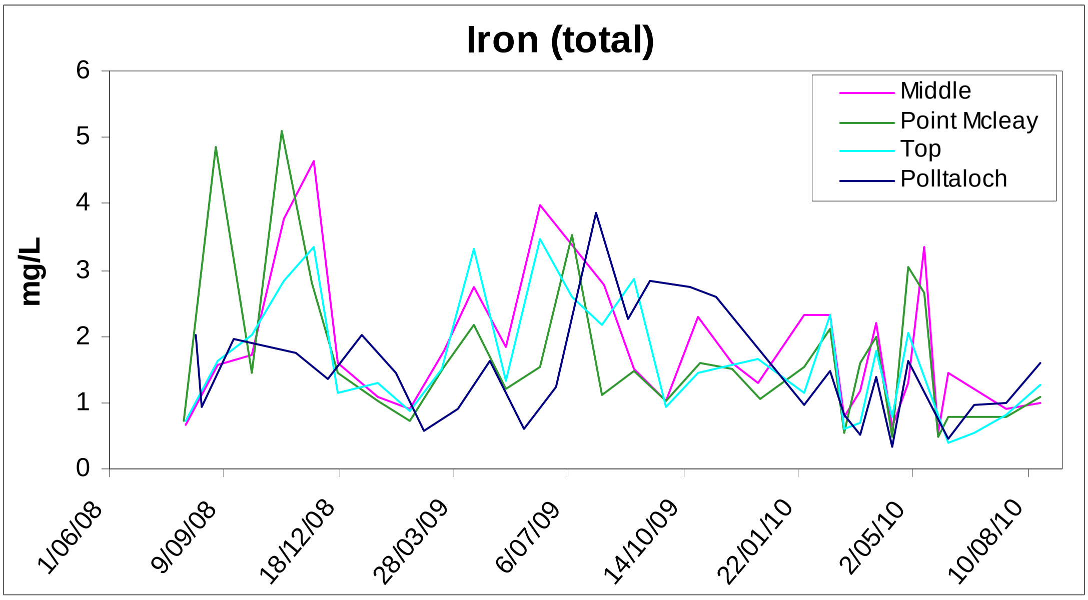

Figure 11 – Total Iron in Lake Alexandrina

Lake Albert Water Quality

Ambient water quality monitoring results are discussed below for selected sites and parameters in Lake Albert. The Lake Albert Opening site is not a part of the ambient program but rather part of the long term pumping program however is included as a part of the ambient program reporting to assist in interpretation of water quality data.

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 12).

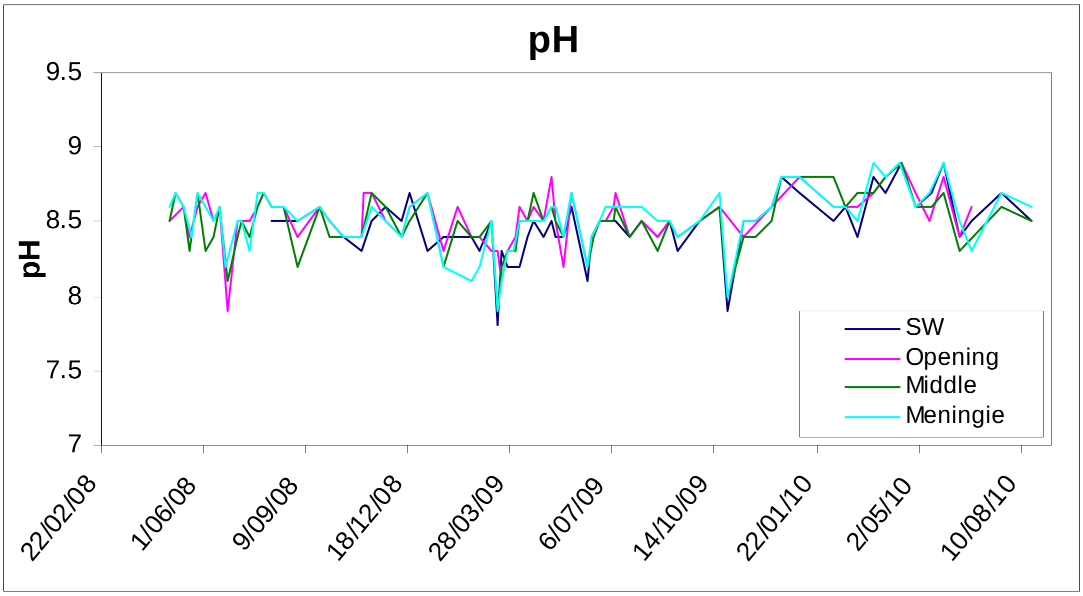

Figure 12 – pH at the Lake Albert ambient monitoring sites

Alkalinity

- Lake Albert alkalinity remains high (Figure 13). Alkalinity has been variable but appears to be increasing at all sites. The alkalinity fluctuations at the Opening site are similar to those for salinity (Figure 15), suggesting the trends are influenced by water mixing patterns.

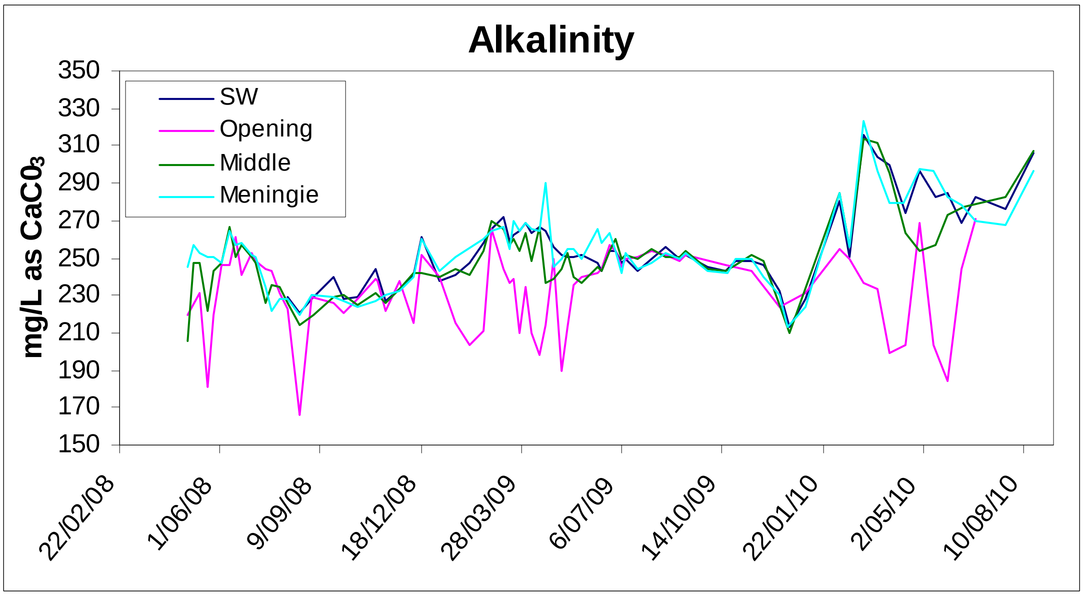

Figure 13 – Alkalinity at the Lake Albert ambient monitoring sites

Sulfate:chloride ratio

- The sulfate:chloride ratio decreased over August after a spike in July at the Middle, Meningie and SW sites (Figure 14). This indicates the possible reduction of sulfate from the acid sulfate sediments on the lake margins has taken place as a result of increased water levels.

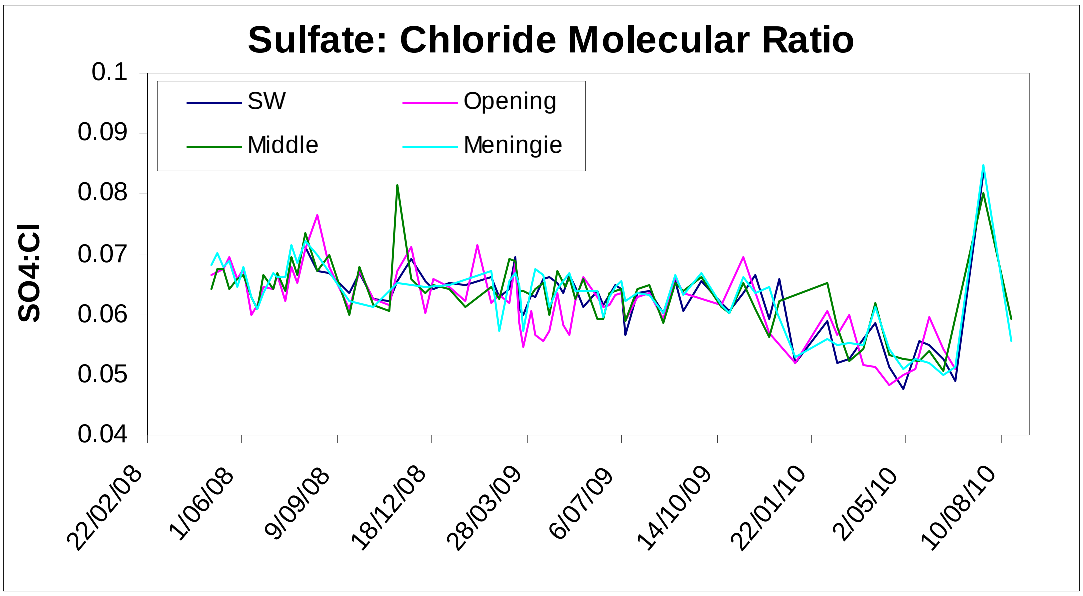

Figure 14 – Sulfate:chloride ratio at the Lake Albert ambient monitoring sites

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 (Figure 15). This site has experienced changes in salinity due to pumping from Lake Alexandrina[3] and mixing patterns of this fresher water with the more saline waters within the lake.

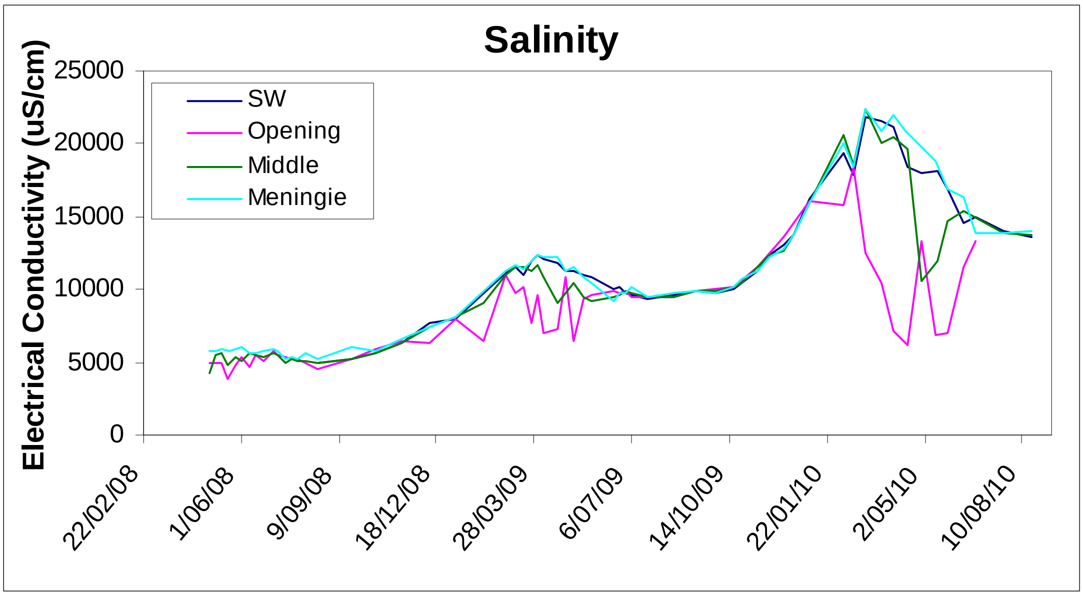

Figure 15 – Salinity at the Lake Albert ambient monitoring sites

[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 increased in August which may be due to the increased frequency of wind driven resuspension of sediment from the lakebed in winter (Figure 16). Turbidity remains very high compared to historical levels.

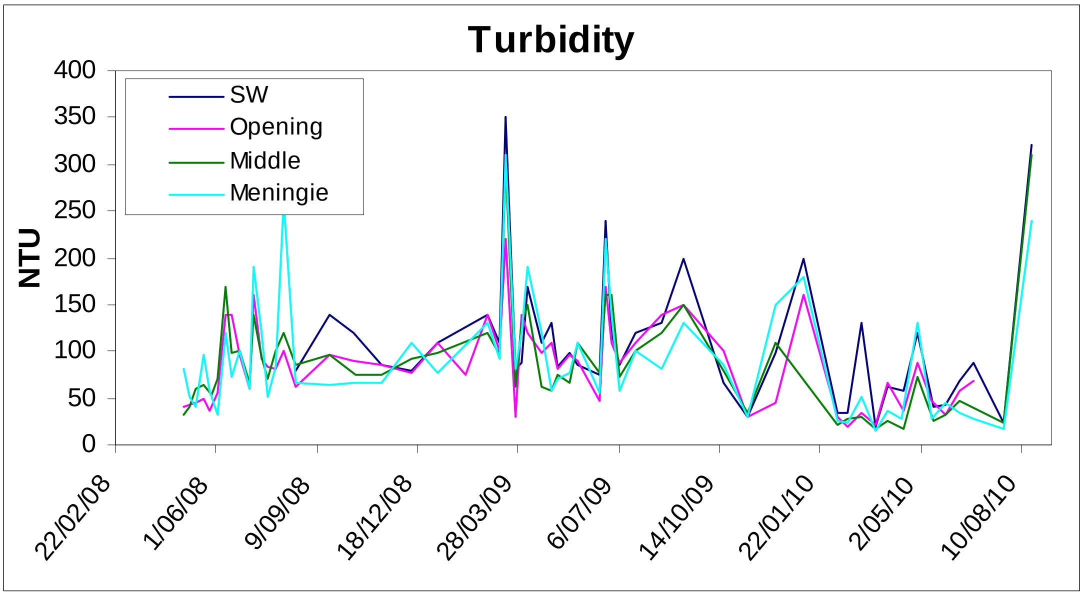

Figure 16 – Turbidity at the Lake Albert ambient monitoring sites

Nutrients (total nitrogen and phosphorus)

- Total nitrogen and total phosphorus are at very high levels in Lake Albert (see Figures 17 and 18) compared to historical levels and well in excess of the ANZECC guidelines (<1mg/L TN, <0.025 mg/L TP).

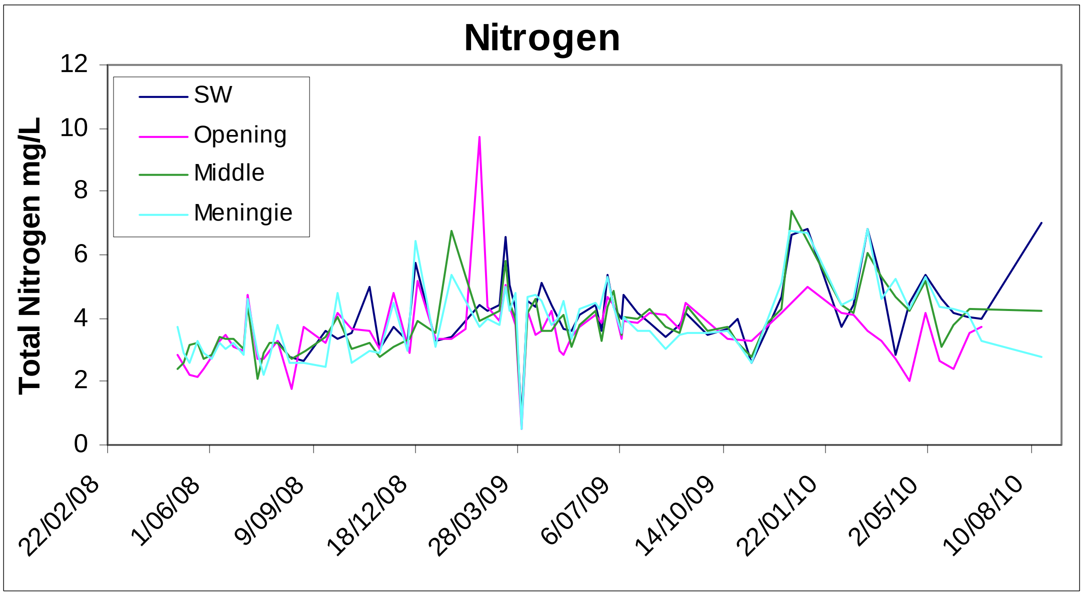

Figure 17 – Total Nitrogen in Lake Albert

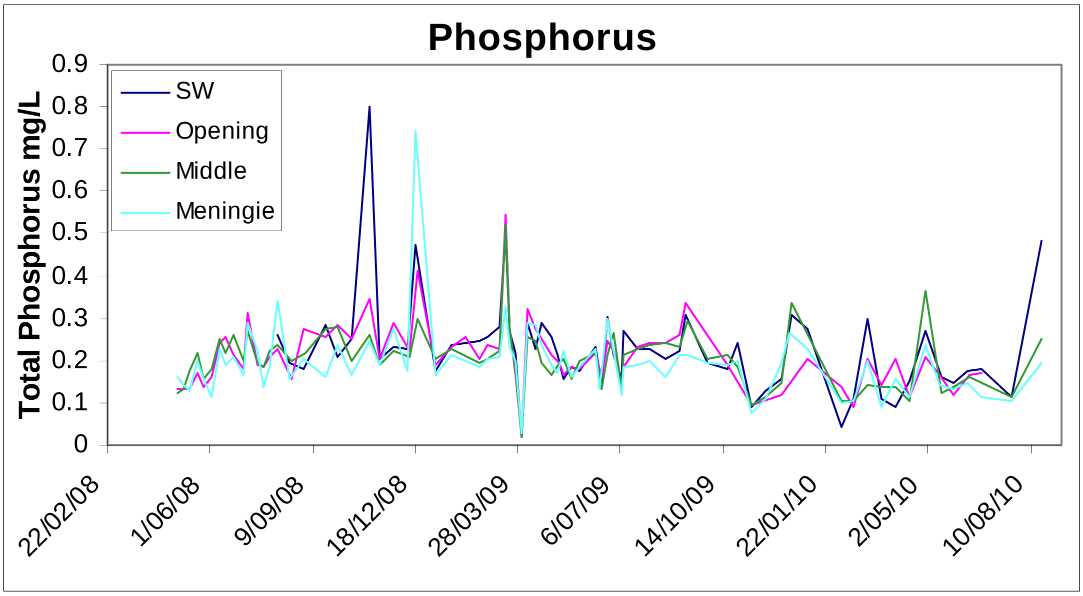

Figure 18 – Total phosphorus in Lake Albert

Chlorophyll a (algae)

- Chlorophyll *a* is variable but remains at very high levels in Lake Albert (Figure 19). 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, although this will continue to be monitored closely over coming months as a large *Nodularia* (potentially toxic blue-green algae) bloom formed in the winter of 2009.

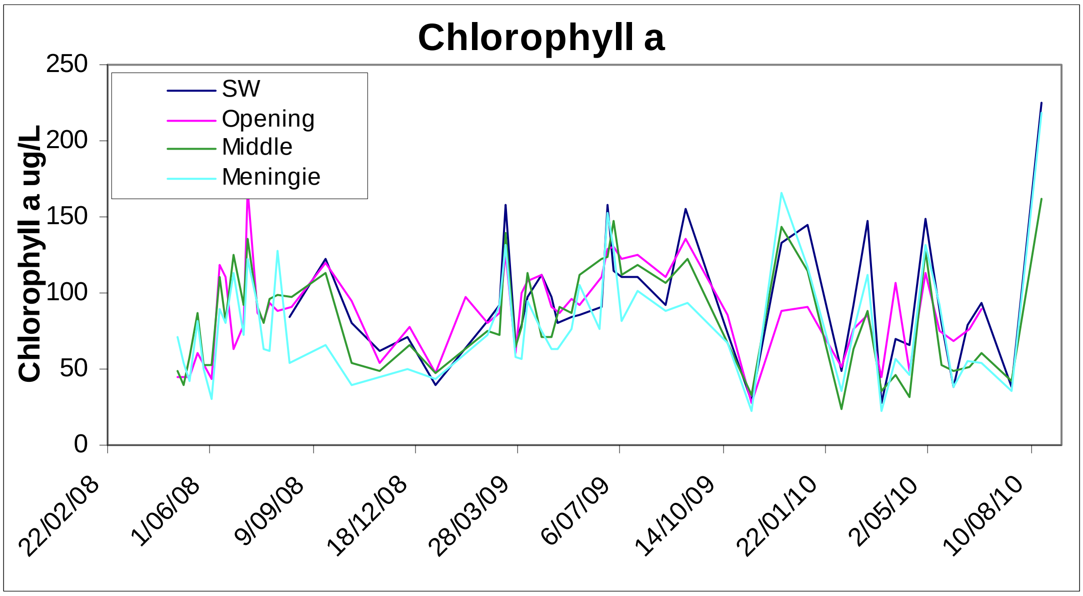

Figure 19 – Chlorophyll in Lake Albert

Metals

- Total aluminium and iron concentrations within Lake Albert have been high and quite variable, reaching concentrations up to 20 mg/L. These high levels are likely linked to the high suspended sediment levels, lack of flushing of the lake during the drought, and possible acid sulfate soil inputs. There is a notable shift to generally lower concentrations across the lake from late 2009 (Figures 20 and 21). The decline in metal concentrations appears to coincide with pumping from Lake Alexandrina to Lake Albert, and indicates metal concentrations are influenced by concentration and dilution through evaporation and inflows rather that significant external inputs due to liberation from sediments during low pH events.

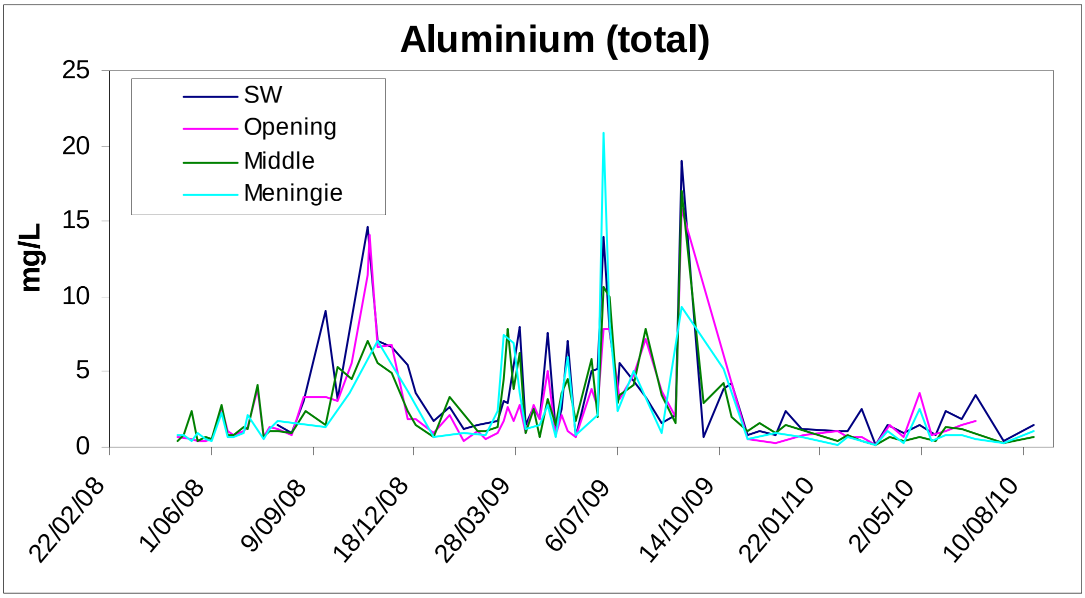

Figure 20 – Total aluminium in Lake Albert

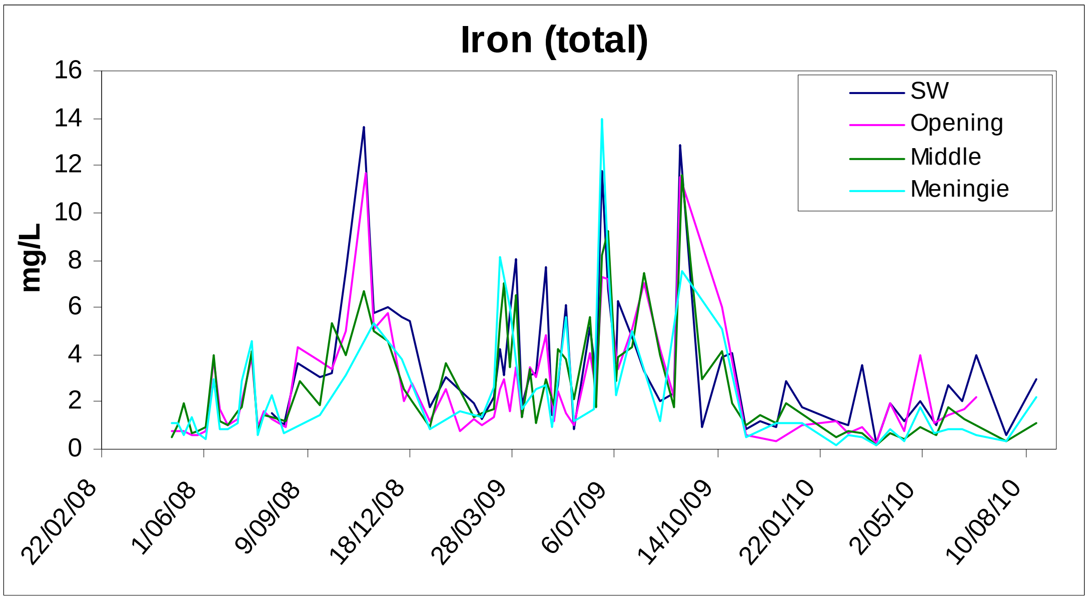

Figure 21 – Total iron in Lake Albert

Goolwa Channel and Tributaries Water Quality

Ambient and event based water quality monitoring results are discussed below for selected sites and parameters in the Goolwa Channel and tributaries region (Figures 1 and 22 for site locations). Due to the nature of the monitoring program in the region the ambient and event based sites have been included in this section to compare data collected over the month. Due to the number of sites in the region not all of the sites sampled are reported on, however the sites selected represent below show all major water quality trends. The full data set can be viewed online.

Event-based Water Quality Monitoring

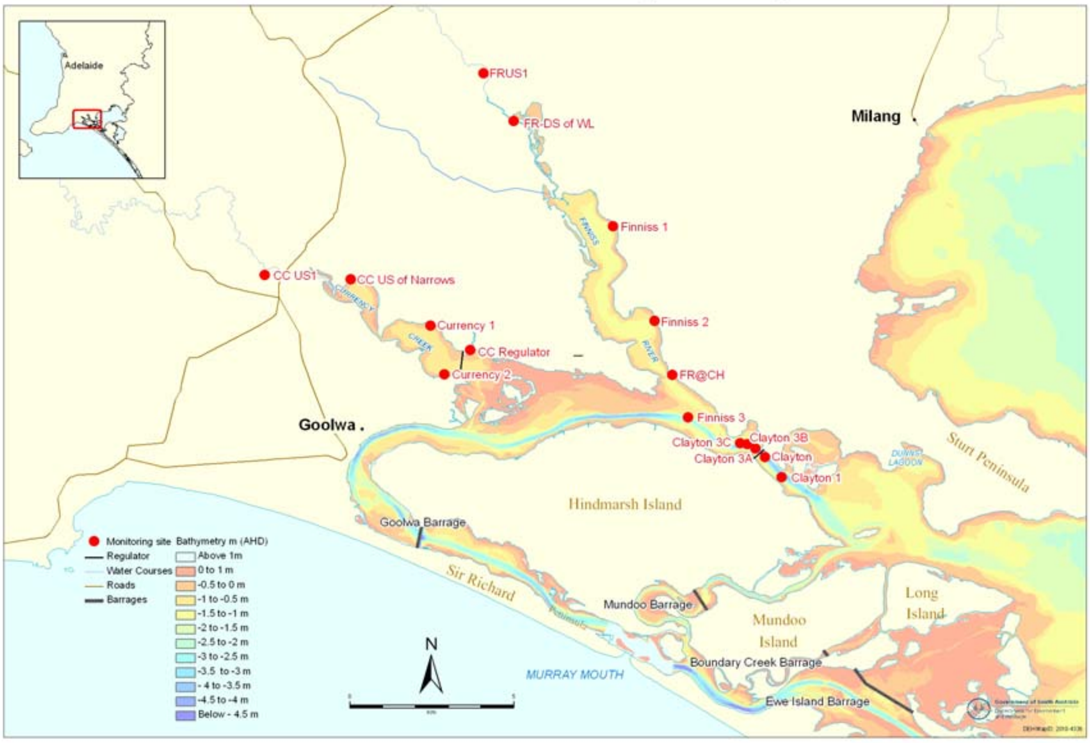

Figure 22 – Goolwa Channel and tributaries ambient and event-based monitoring sites

pH

- pH levels are currently stable and within ANZECC guideline levels (pH 6.5-9.0) at all sites in the Goolwa Channel and tributaries region (Figure 23).

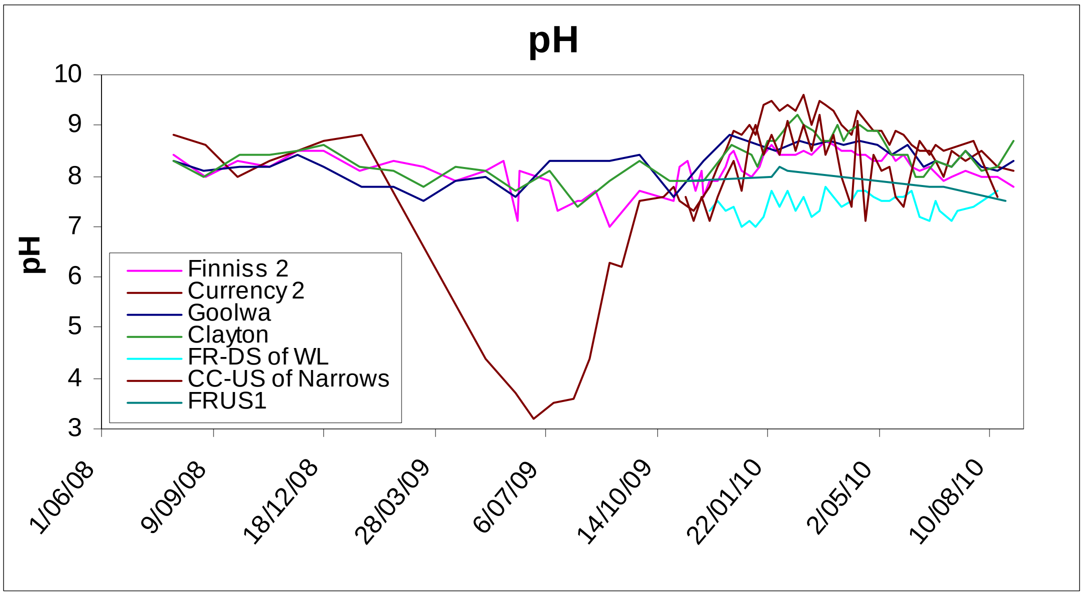

Figure 23 – pH at the Goolwa Channel and tributary monitoring sites

Alkalinity

- Alkalinity at all of the Goolwa Channel and tributaries sites is within a satisfactory range (Figure 24). 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 stabilised in Currency Creek with rising water levels and connection to the Goolwa Channel.

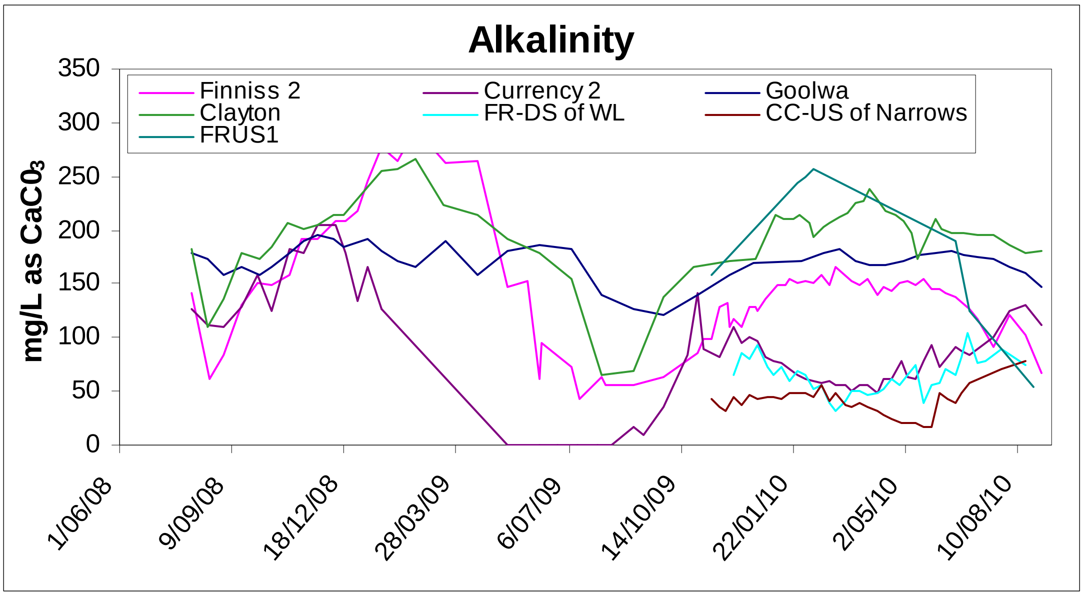

Figure 24 – Alkalinity at the Goolwa Channel and tributary monitoring sites

Sulfate:chloride ratio

- The sulfate:chloride ratio has stabilised and is not showing any increasing trend that would suggest widespread acid sulfate soil inputs (Figure 25). The ratio at Currency Creek has become more similar to that seen in the Goolwa channel indicating hydraulic connection and mixing with the Goolwa pool water.

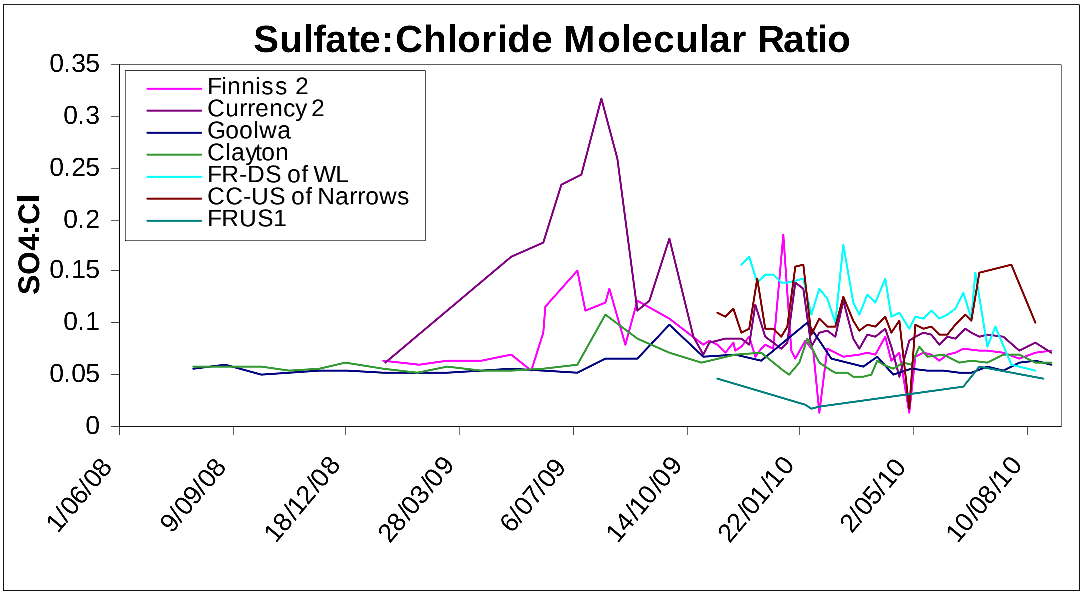

Figure 25 – Sulfate:chloride molecular ratio at the Goolwa Channel and tributary monitoring sites

Salinity (EC)

- Salinity is decreasing at all sites but still remains high at some sites compared to historical levels (Figure 26). 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 spring.

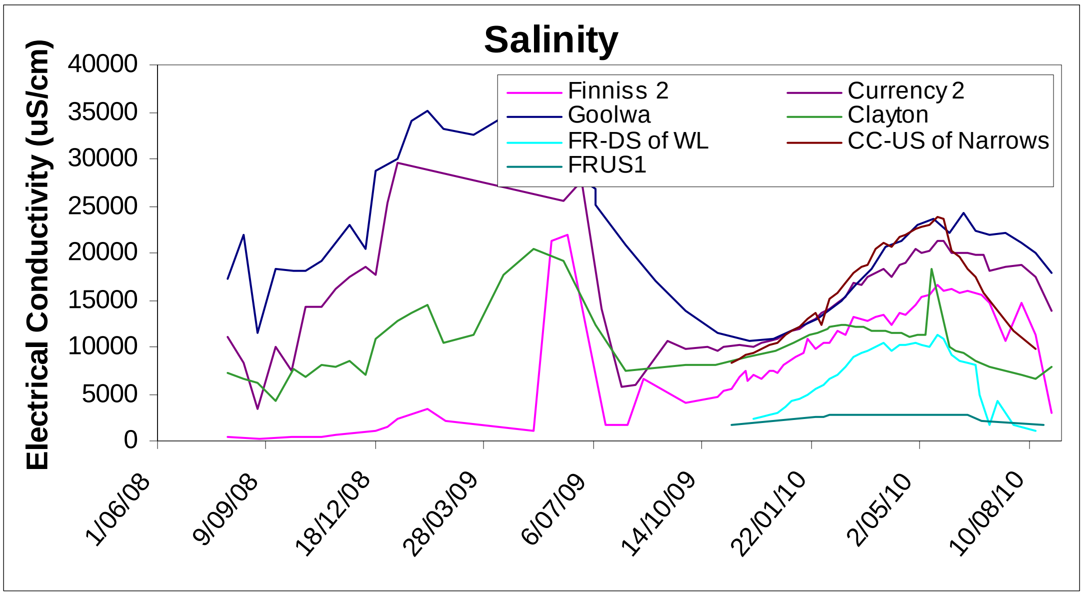

Figure 26 – Salinity at the Goolwa Channel and tributary monitoring sites

Turbidity

- Turbidity remains variable in the Goolwa Channel and tributaries sites (Figure 27), however it 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.

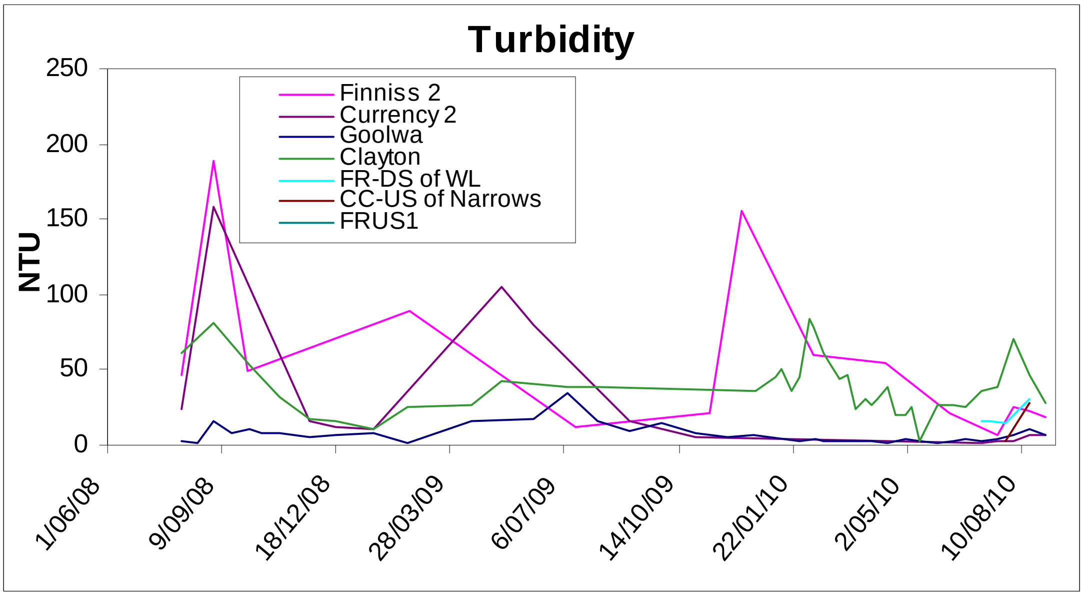

Figure 27 – Turbidity at the Goolwa Channel and tributary monitoring sites

Nutrients (total nitrogen and phosphorus)

- Nutrients analysed from the channel and tributary indicate total nitrogen and phosphorus are quite stable at high levels in the tributaries, although levels are presently much lower than during last winter. This is likely due to dilution over wetter periods. (Figures 28 and 29). The exception to this is Phosphorous at the FRUS1 site where levels have increased considerably, this is likely due to localised runoff from cleared farmland entering streams and river contributing to the nutrient loads.

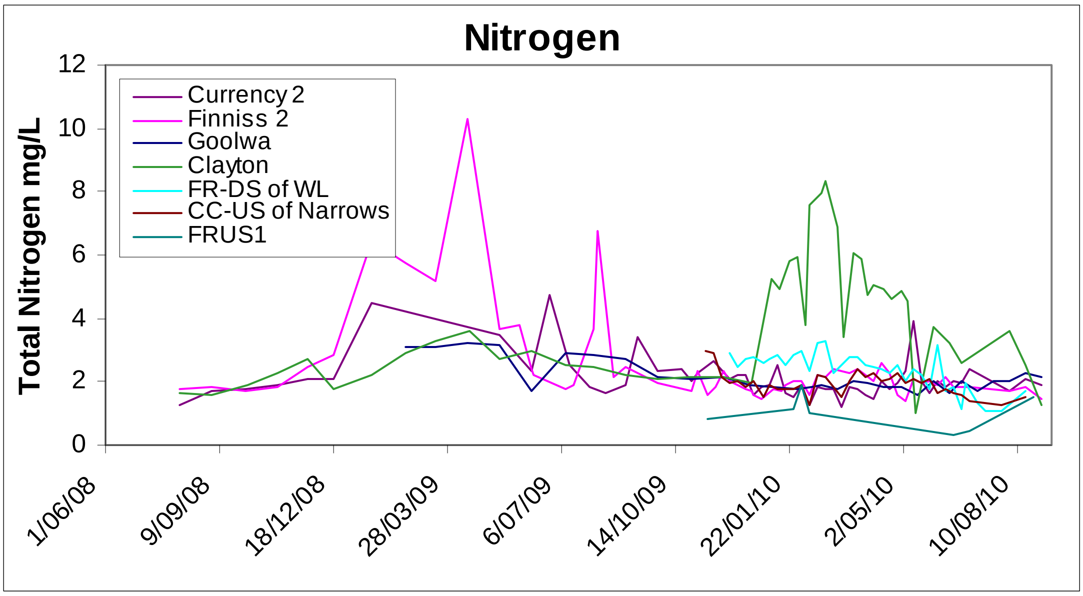

Figure 28 – Total nitrogen at the Goolwa Channel and tributary monitoring sites

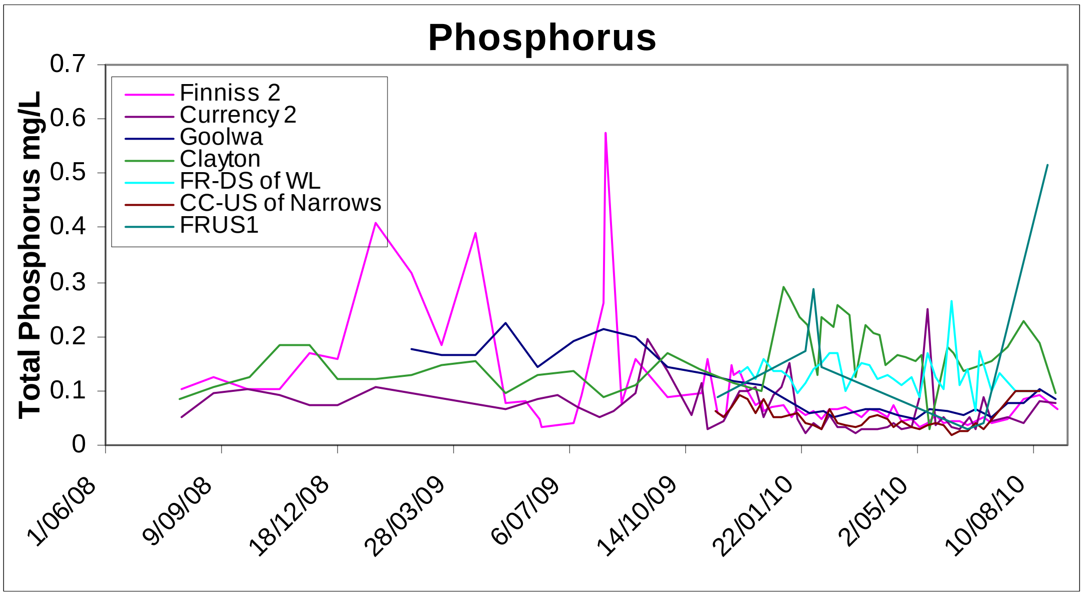

Figure 29 – Total phosphorus at the Goolwa Channel and tributary monitoring sites

Chlorophyll (algae)

- Chlorophyll *a* has declined at all lower tributary and channel sites with the exception of FR – DS of WL which recorded a small increase however it still remains lower than all other sites in the region.(Figure 30). The decline is likely due to dilution from localised tributary inflows and decreased algal growth due to colder temperatures over winter.

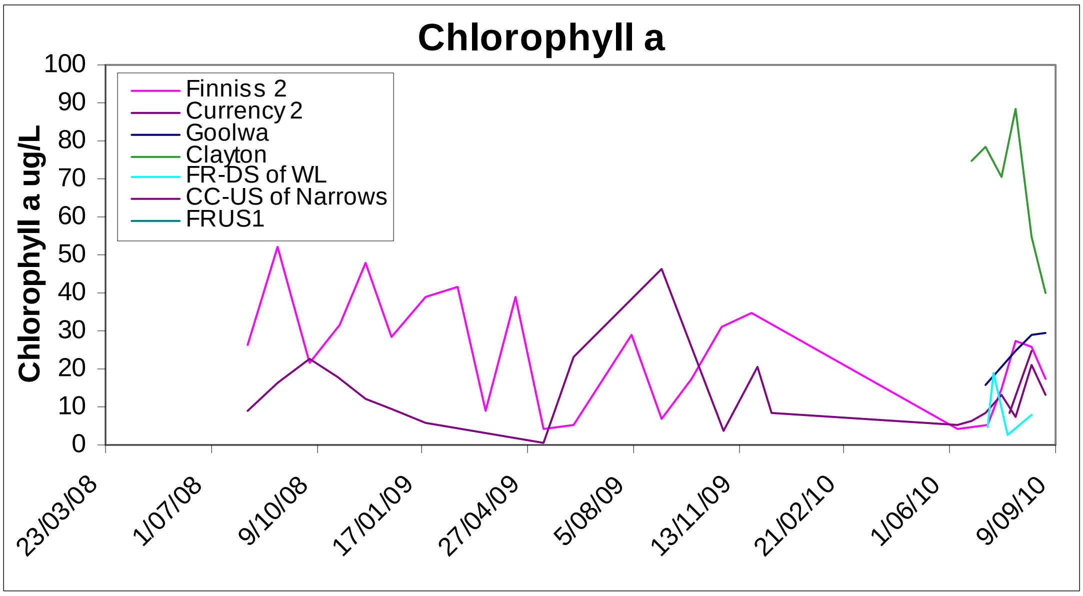

Figure 30 – Chlorophyll *a* at the Goolwa Channel and tributary monitoring sites

Metals

- Total aluminium and iron concentrations within the tributaries have been relatively low since the limestone addition to neutralise acidity in the winter of 2009 and completion of the Goolwa Channel temporary regulator near Clayton to stabilise water levels and prevent further acid sulfate soil impacts (Figures 31 and 32). There has been a number of 'spikes' in iron concentration at a site FR-DS of WL that correspond to low pH and alkalinity (see Figures 23 and 24). These are likely linked to outflows from the adjacent wetlands found by CSIRO to be acidic.

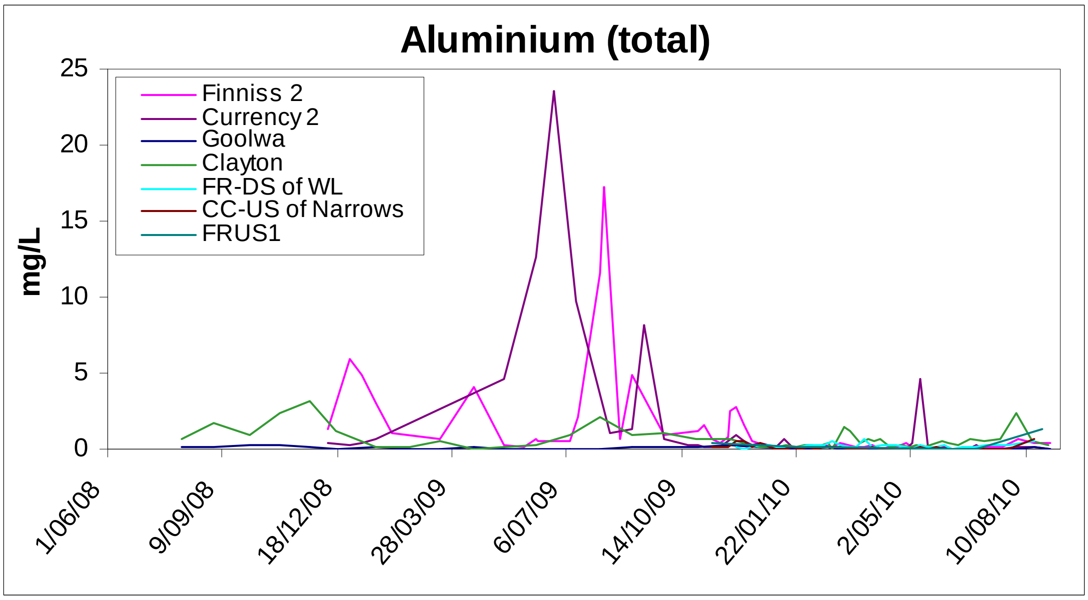

Figure 31 – Total aluminium at the Goolwa Channel and tributary monitoring sites

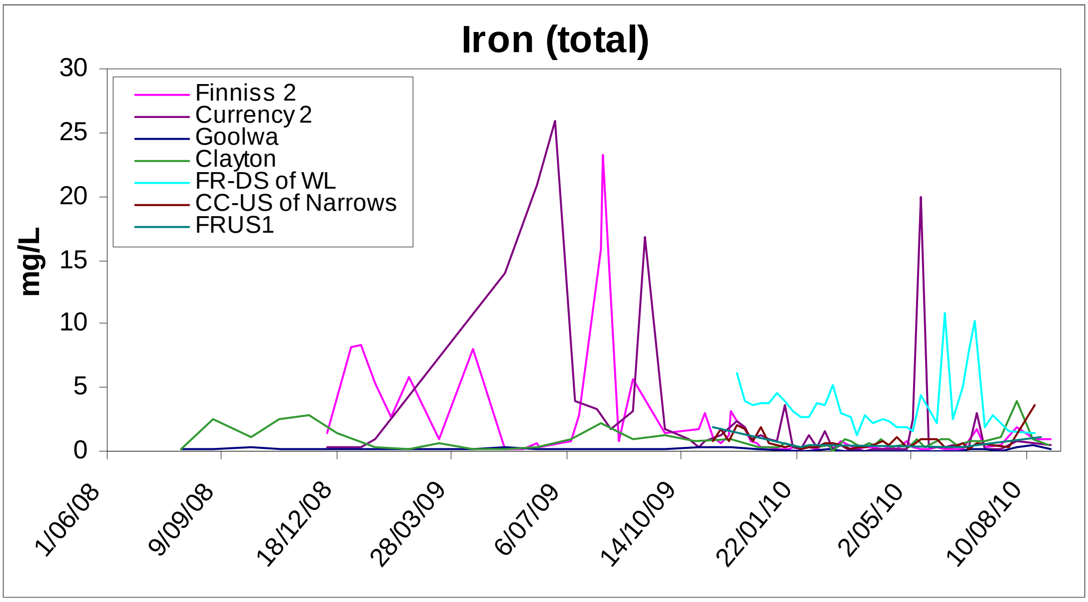

Figure 32 – Total iron at the Goolwa Channel and tributary monitoring sites

Event-based monitoring

Event-based water quality sampling is undertaken in selected regions that have experienced acidification or are at risk of acidification (Figure 33). 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. High risk locations were initially screened to identify the presence and extent of any acidity, and the frequency of further 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.

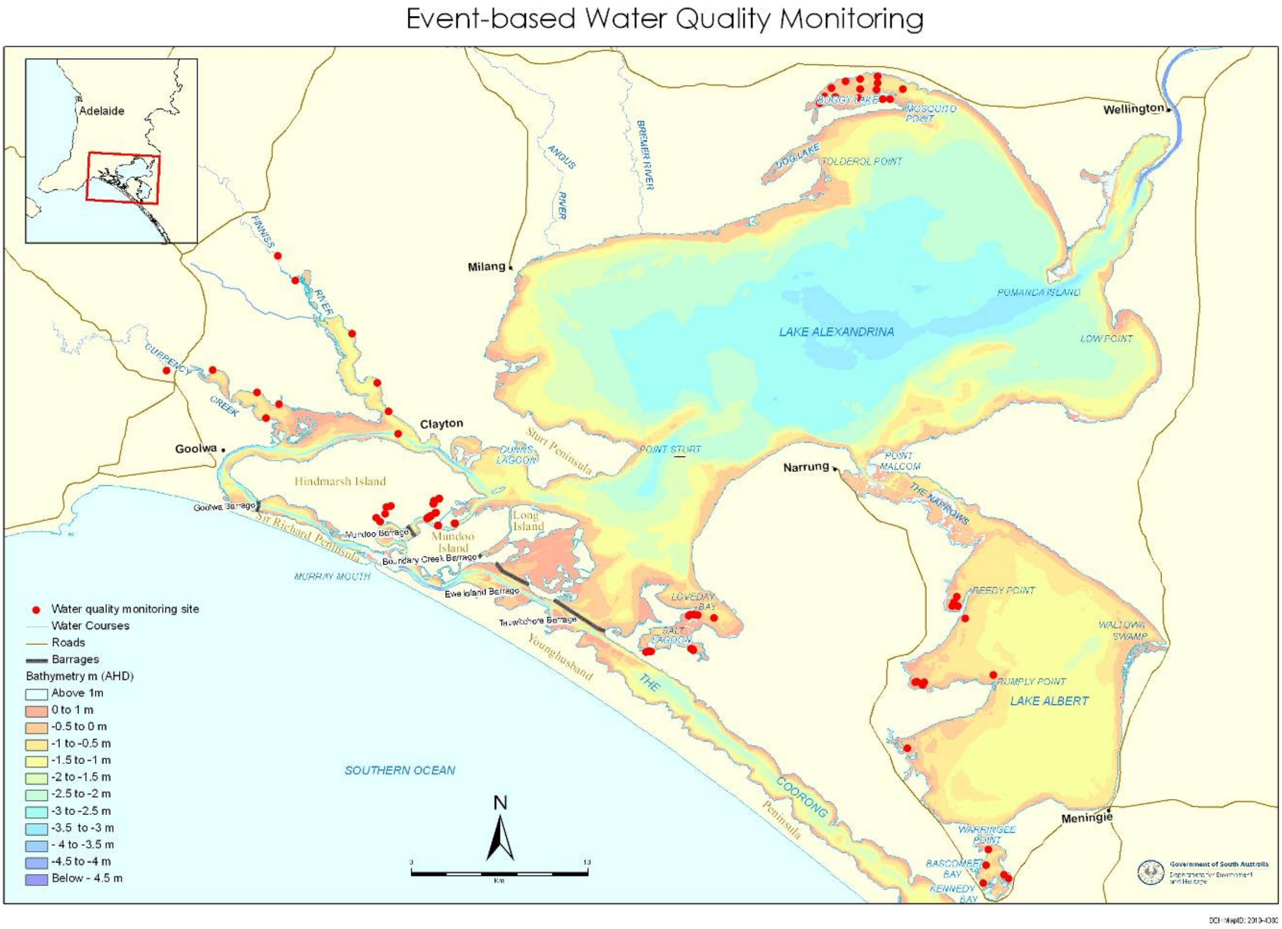

Figure 33 – Map of the event-based water quality monitoring sites

Boggy Lake

Figure 34 shows a map of sampling locations in Boggy Lake for 11/08/2010, with water quality results from selected sites shown in Figure 35. During August, there has been no observed increase in the acidity however low pH water has persisted at a number of sites. Sites located on the eastern margin continued to mix with freshening Lake Alexandrina water allowing additional alkalinity to be imported into the region. Limestone addition was undertaken in May and June 2010 to increase the region's buffering capacity and continued monitoring will determine whether further limestone dosing is needed.

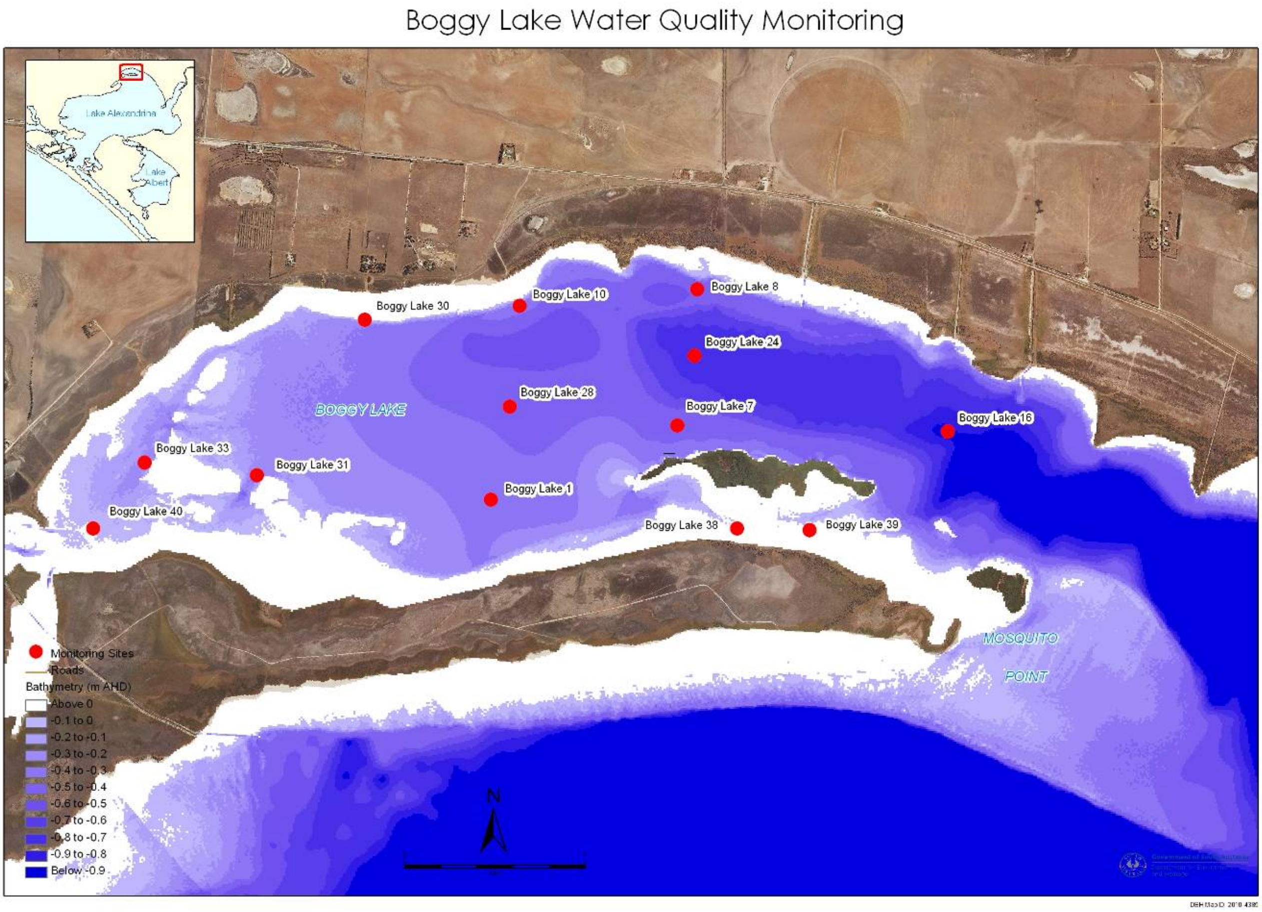

Figure 34 – Map of Boggy Lake monitoring sites

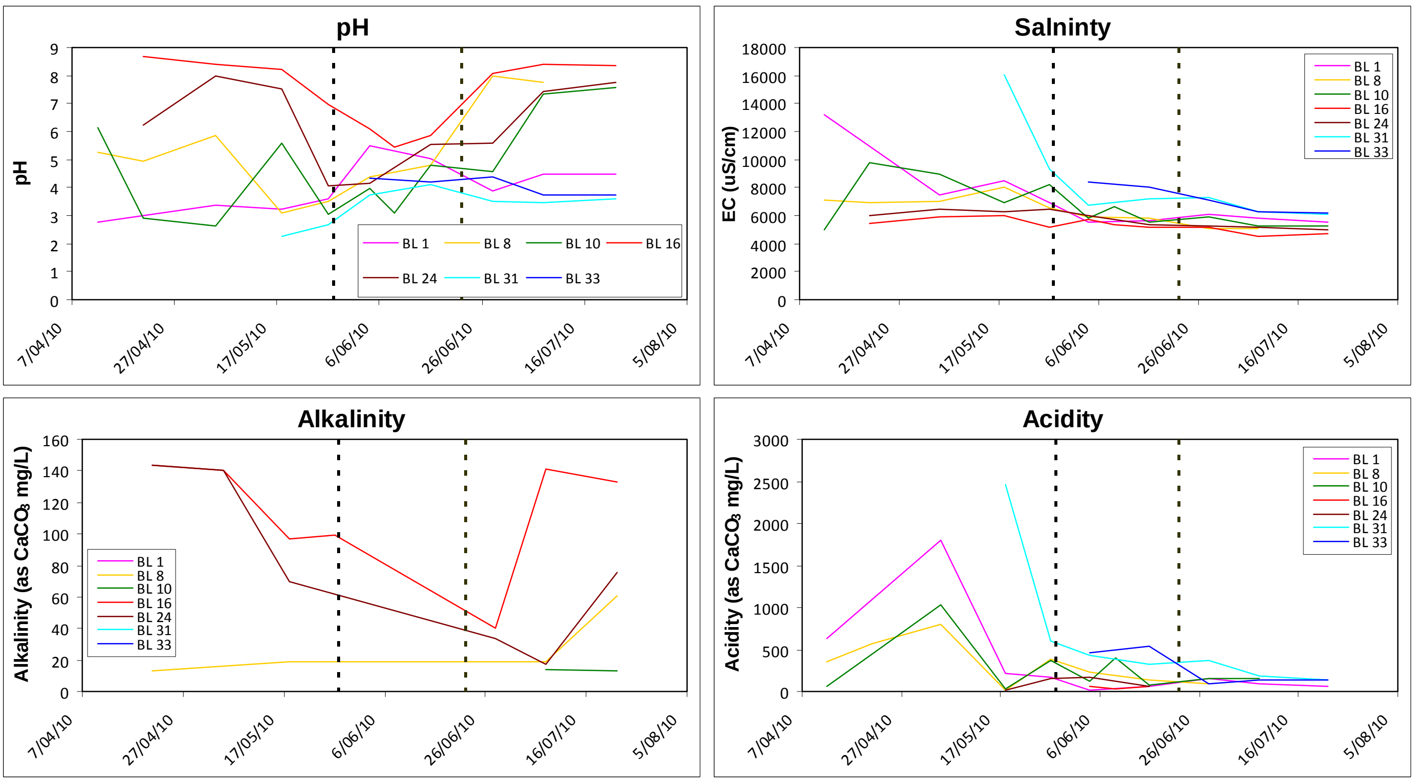

Figure 35 –Boggy Lake water quality results

Reedy and Rumply Point

Figure 36 shows the locations of the monitoring undertaken at Reedy and Rumply Points on the western margin of Lake Albert. As water levels have increased, large areas of exposed sediment and isolated pools of water have been reflooded. This has led to acidity at all sites being neutralised, with pH values above the ANZECC guideline (pH>6.5, Figure 37). The primary reason for this neutralisation is likely to be increased connection and dilution with the highly alkaline lake waters.

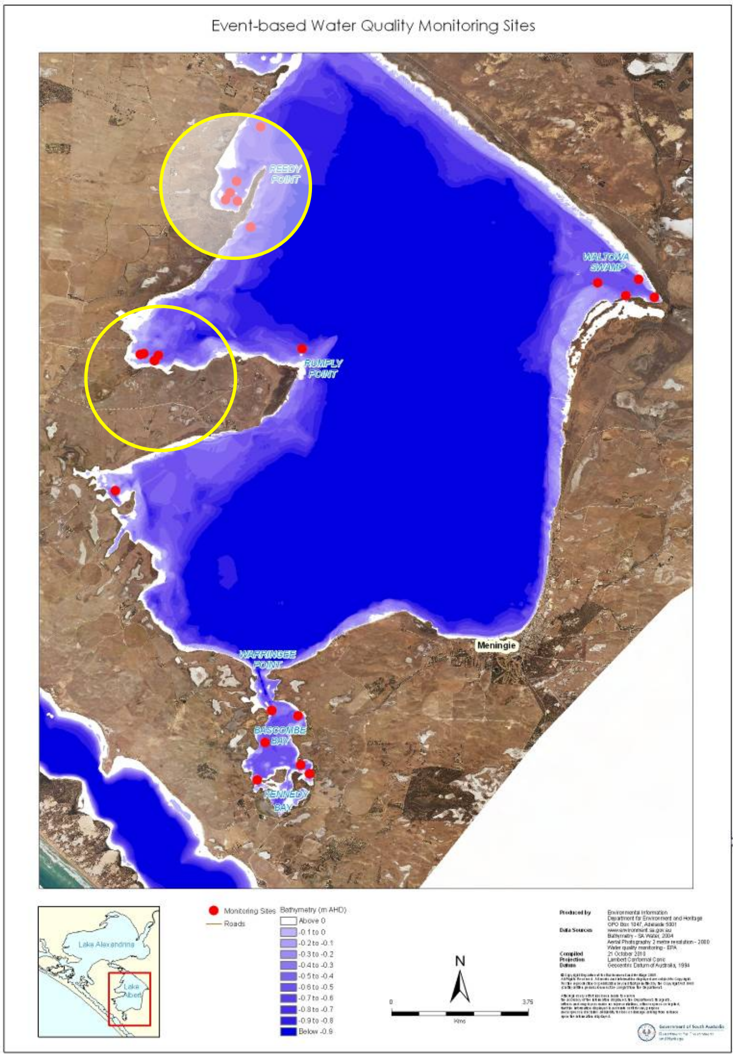

Figure 36 – Map of Reedy and Rumply Point monitoring site

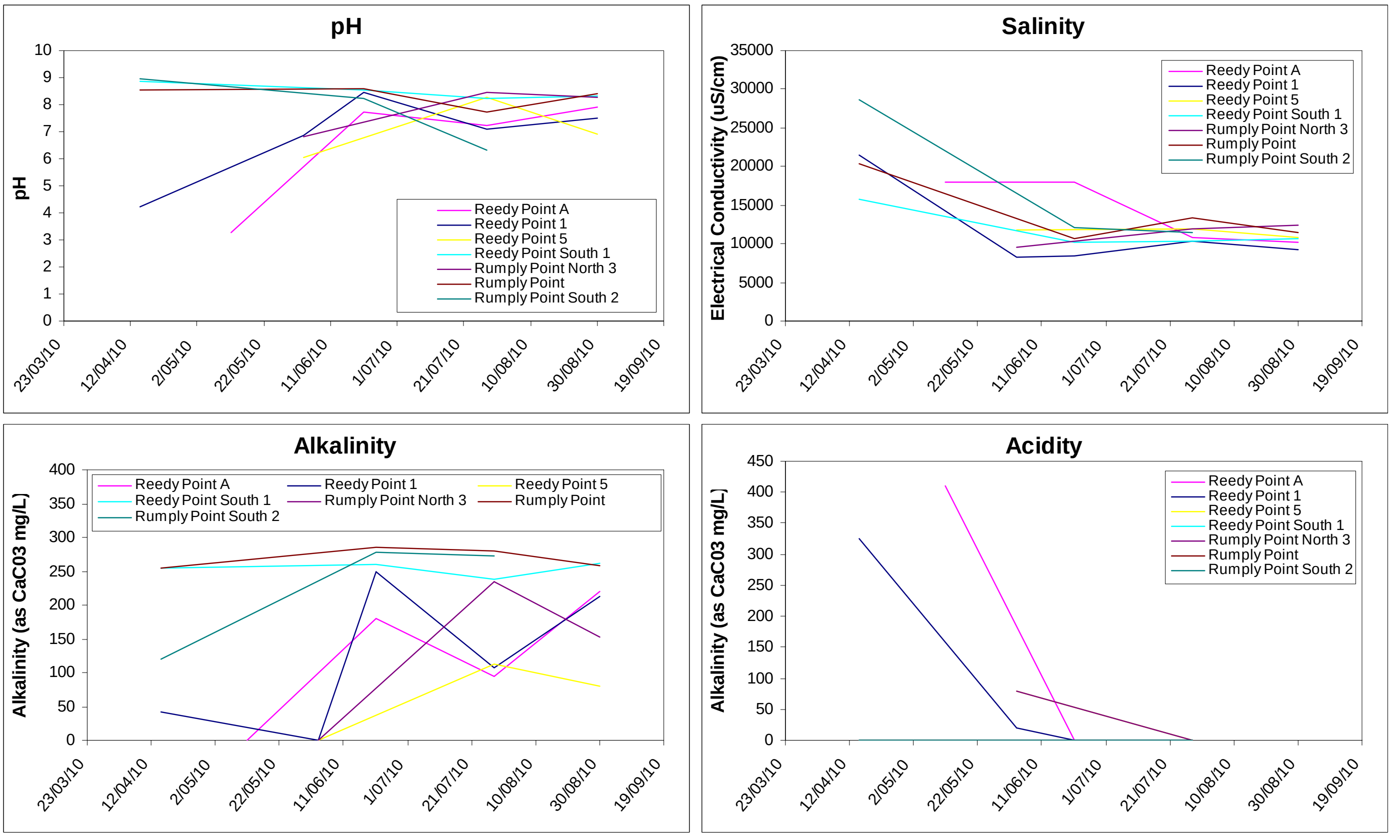

Figure 37–Reedy and Rumply Point water quality results

Boggy Creek

The continued 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, Figure 38) 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 throughout July showed pH within the ANZECC guidelines for aquatic ecosystems. However during August, three sites in the northern section of Boggy Creek had low pH, little to no alkalinity, and acidity (Figure 39). As water levels have continued to rise and addition water exchange has taken place there is a notable decline in the level of acidity indicating a net import of alkalinity into the region. Continued sampling and evaluation of the monitoring data will determine whether management intervention is required.

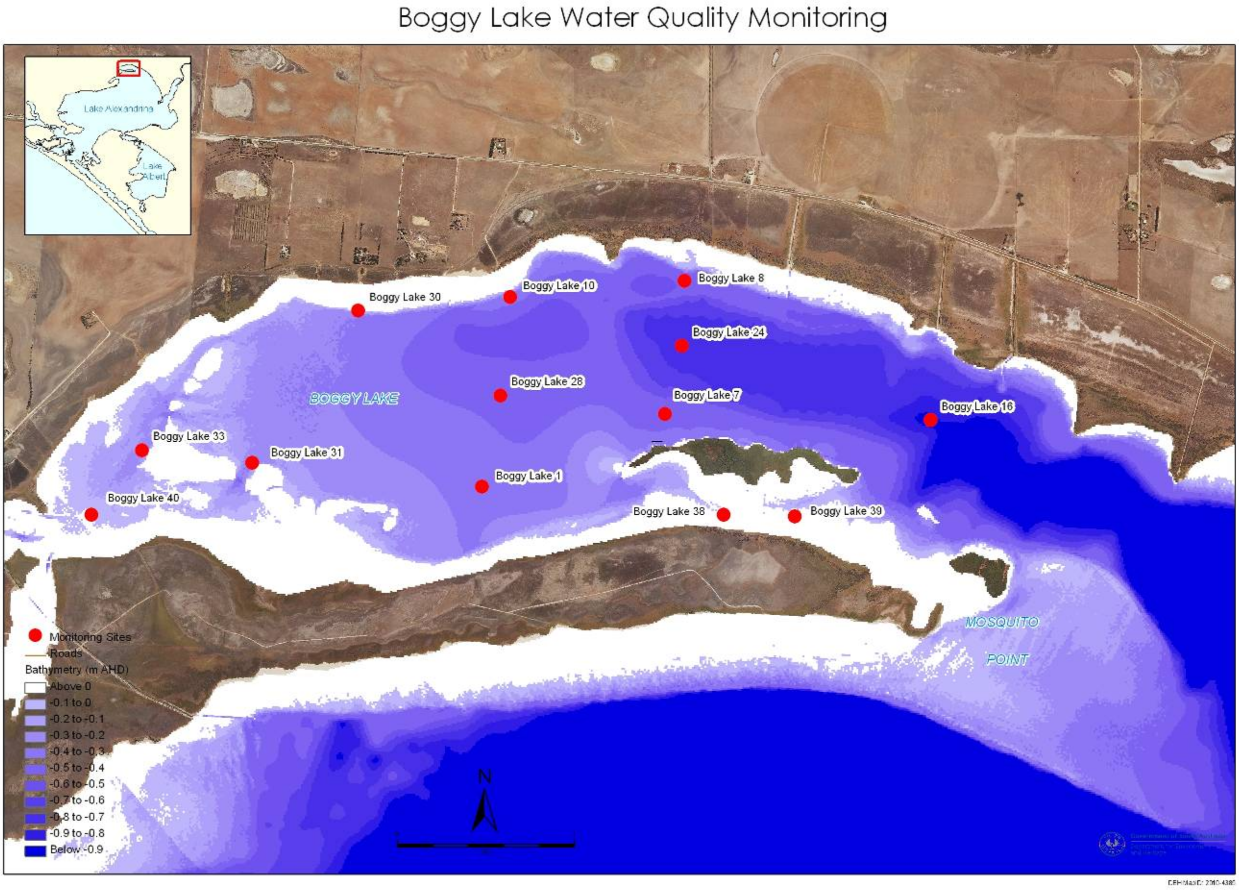

Figure 38 – Map of Boggy Creek sample sites

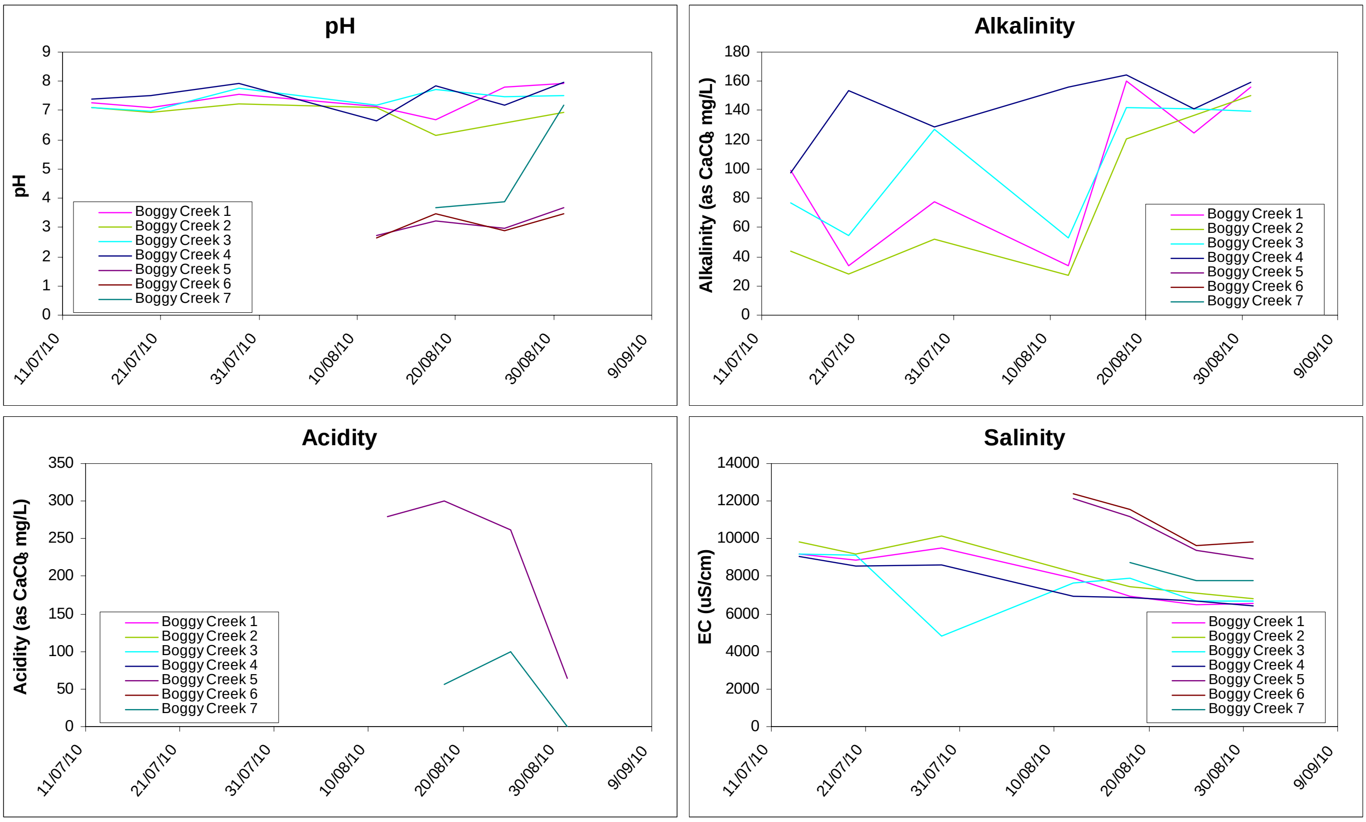

Figure 39 – Boggy Lake water quality results

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 for Water www.waterforgood.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