Lower Lakes and Tributaries

Water Quality Report

Ambient and Event-based Monitoring

Report 22, December 2010

Government
of South Australia
Department of Environment
and Natural Resources

EPA
South Australia

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Observations at a Glance

- ***Water quality continues to improve across the Lower Lakes following substantial inflows of floodwater from the Murray-Darling Basin***
- ***Salinity levels continue to decrease due to dilution from river inflows and export of salt through the barrages but still remain high in Lake Albert***
- ***pH and alkalinity remain satisfactory at all sites***

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 water quality 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 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. The pH in the Lower Lakes region is 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 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. This ratio is usually about 0.06 (SO_4:Cl) ***in the 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 the 2007–2009 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

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

of light reflected from a given sample. Turbidity is very variable in the shallow Lower Lakes and influenced primarily by wind events. Prior to the 2007–2009 drought conditions, turbidity was on average about 60 NTU in Lake Alexandrina (at Milang).

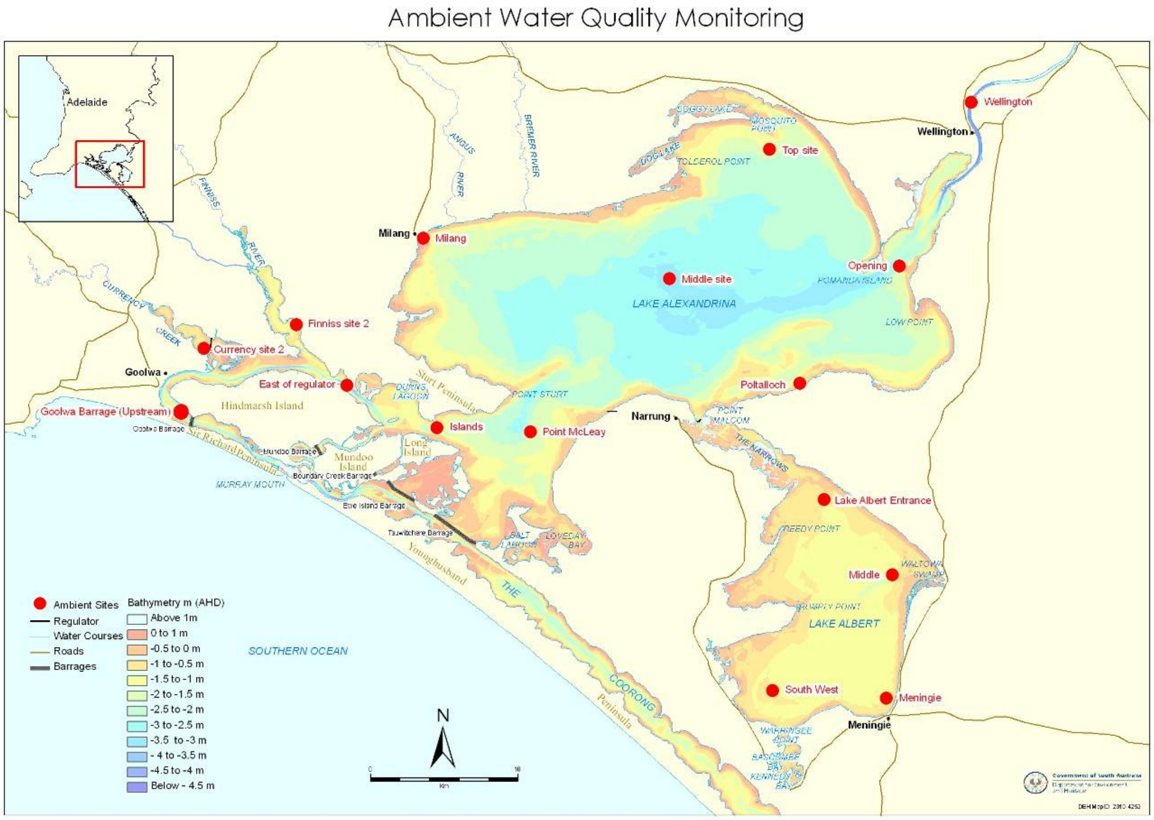
Nutrients - total nitrogen (TN) and total phosphorus (TP) are the total amount of nitrogen and phosphorus present in the water body. Nitrogen can be present in different forms (e.g. organic nitrogen in plant material, ammonia, nitrate and nitrite). Phosphorus can also be present in different forms (e.g. 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 the 2007–2009 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 a 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 the 2007–2009 drought conditions, chlorophyll a was on average about 24 μg/L in Lake Alexandrina (at Milang) and 35 μg/L in Lake Albert (at Meningie).

Metals such as iron and aluminium are measured primarily to determine interactions between sediments and the lake water body. During water level declines (i.e. due to evaporation and low inflows during droughts) metal concentrations are expected to increase. Similarly during large wind events total metal levels may also increase as they form part of the suspended solids composition. During floodwater inflows the concentration of metals may be diluted. Additional to this, if exposed acid sulfate sediments acidify and the pH is reduced, metals that were previously bound up within sediment are released. If these exposed sediments are rewet, any subsequent increase in metal concentrations in the water body may indicate acid sulfate soil impacts.

Ambient Water Quality Monitoring

Ambient water quality sampling is undertaken fortnightly at 16 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. The five sites selected for reporting have been chosen as they are representative of the water body, incorporating water entering from the river (Wellington) and a transect across Lake Alexandrina from the northern corner (Top) through the centre (Middle) to the southern edge of the lake (Point McLeay) before it enters the Goolwa Channel. The site on the western margin (Poltalloch) provides an indication of the water quality near the entrance to Lake Albert.

pH

- pH levels have fluctuated over December however remain within ANZECC guideline levels (pH 6.5-9.0) at all sites in Lake Alexandrina (Figure 2). The site at Wellington within the river channel continues to display a lower pH which is typical of floodwaters. The pH in Lake Alexandria has shown some general declining trends since the onset of flood conditions in response to the lower pH of the river inputs.

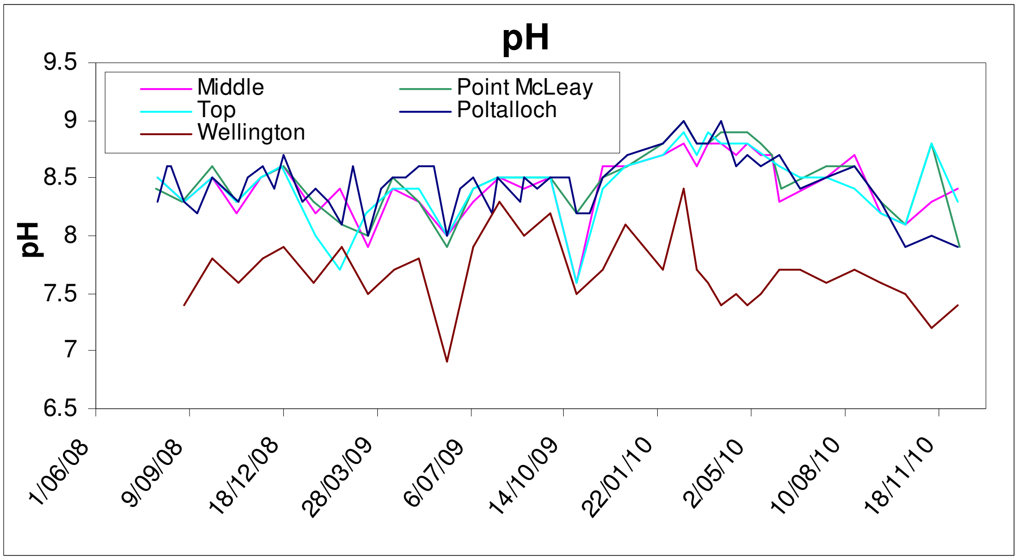


Figure 2 – pH at the Lake Alexandrina ambient monitoring sites

Alkalinity

- Alkalinity continues to decline in the main areas of Lake Alexandrina (Figure 3). The observable decline in alkalinity since May 2010 is consistent with substantial dilution of lake water with lower alkalinity river water (Wellington Site).

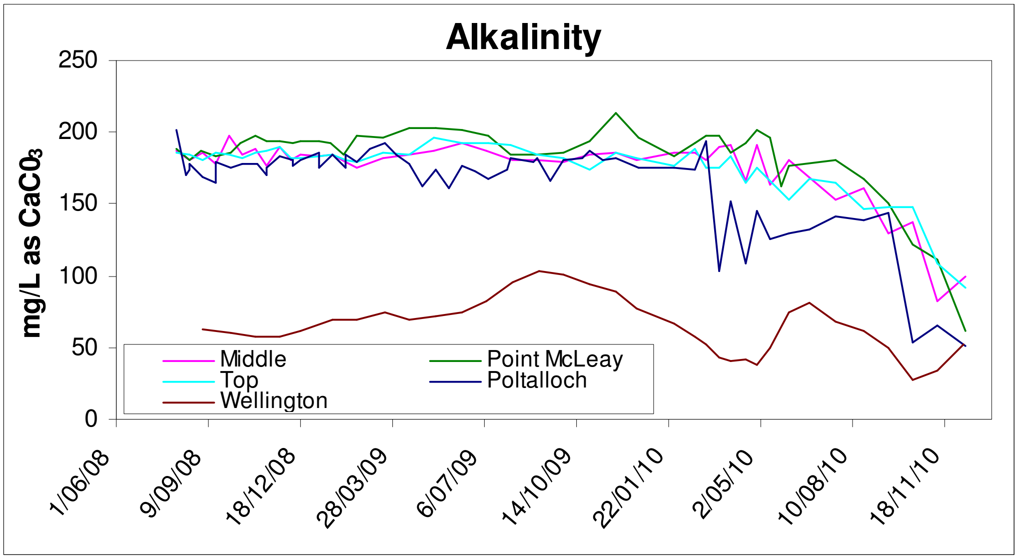


Figure 3 – Alkalinity at the Lake Alexandrina ambient monitoring sites

Sulfate:chloride ratio

- The sulfate:chloride ratio is stable in the most of the main lake water body (Middle, Top, Point McLeay sites), but sites in (Wellington), or most influenced by (Poltalloch), the river inflow show elevated ratios (Figure 4). This increased ratio is most likely due to changing river ion composition (e.g. due to dissolving of salts during wetland and floodplain reconnection) rather than acid sulfate soil releases. The water leaving the river channel generally flows in a southerly direction past Poltalloch before mixing with the rest of the lake through wind driven water movement patterns.

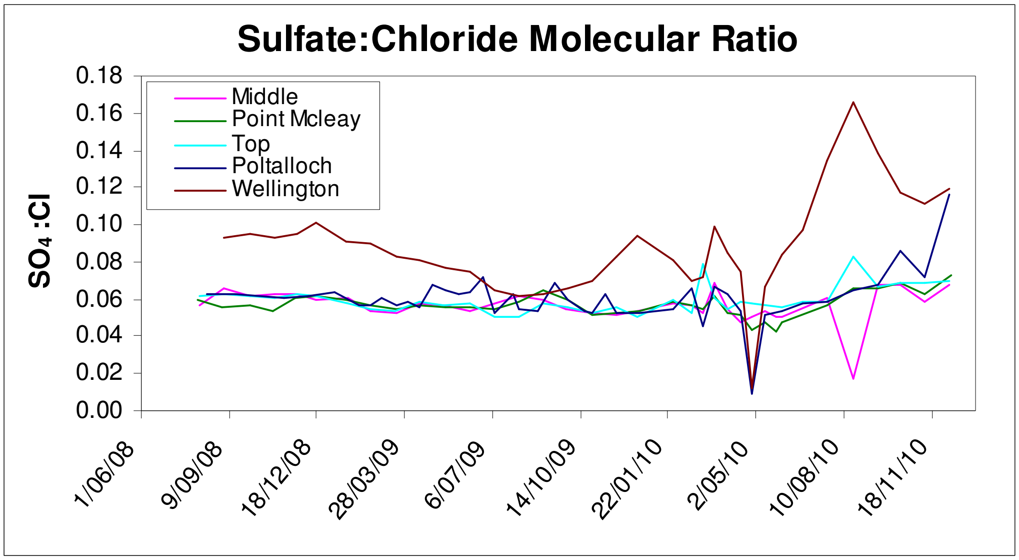


Figure 4 – Sulfate:chloride ratio at the Lake Alexandrina ambient monitoring sites

Salinity (EC)

- Salinity (as measured by electrical conductivity) has continued to decline across Lake Alexandrina to between 1500 and 250 EC (Figure 5). The decline in salinity is due to continued high Murray-Darling Basin inflows and export of accumulated salt through the barrages.

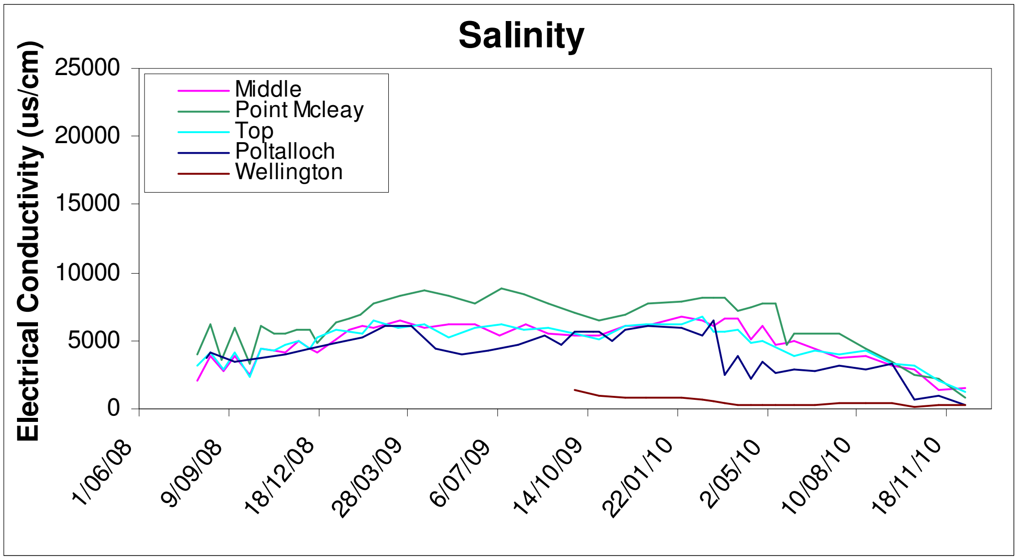


Figure 5 – Salinity at the Lake Alexandrina ambient monitoring sites

Turbidity

- Turbidity continues to be variable and at high levels within Lake Alexandrina (Figure 6). The inflowing flood waters contain high levels of suspended particles, and wind events causing resuspension and redistribution of sediment in the Lower Lakes.

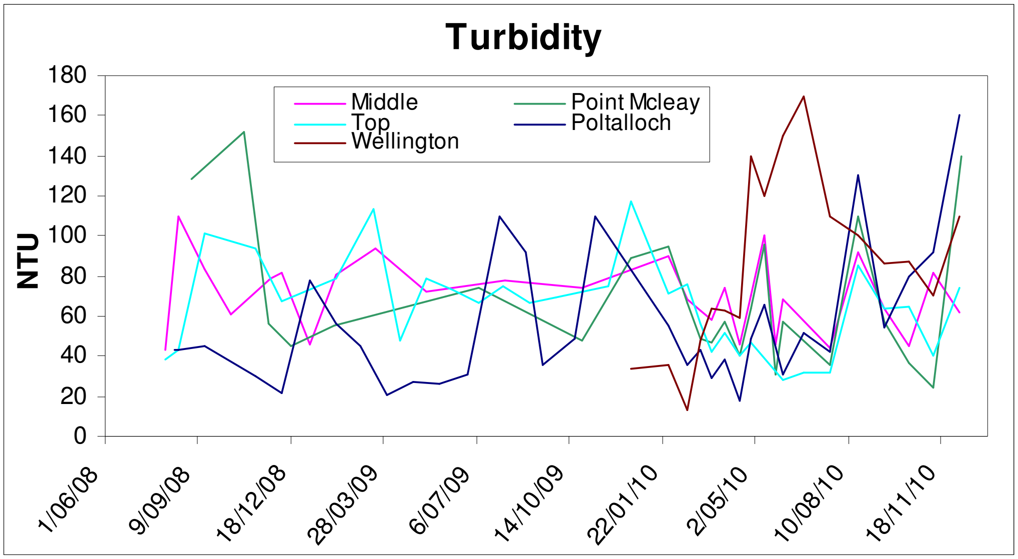


Figure 6 – Turbidity at the Lake Alexandrina ambient monitoring sites

Nutrients (total nitrogen and phosphorus)

- Total nitrogen and phosphorus levels are relatively stable within Lake Alexandrina (see Figures 7 and 8). As the large floodwater inflows dilute and replace the existing lake water, nutrient levels are expected to trend towards that of the river. This is particularly apparent for total nitrogen (Figure 7) with most sites recording similar nutrient concentrations to the Wellington site. Total phosphorus levels increased in the river inflows near the end of 2010, likely due to runoff of soil and fertiliser off the wider Murray-Darling Basin catchment. Total phosphorus levels in the rest of the Lower Lakes became more similar to the river concentrations over 2010. Nutrient levels in the Lower Lakes continue to remain above ANZECC guidelines for freshwater ecosystems (<1mg/L TN, <0.025 mg/L TP).

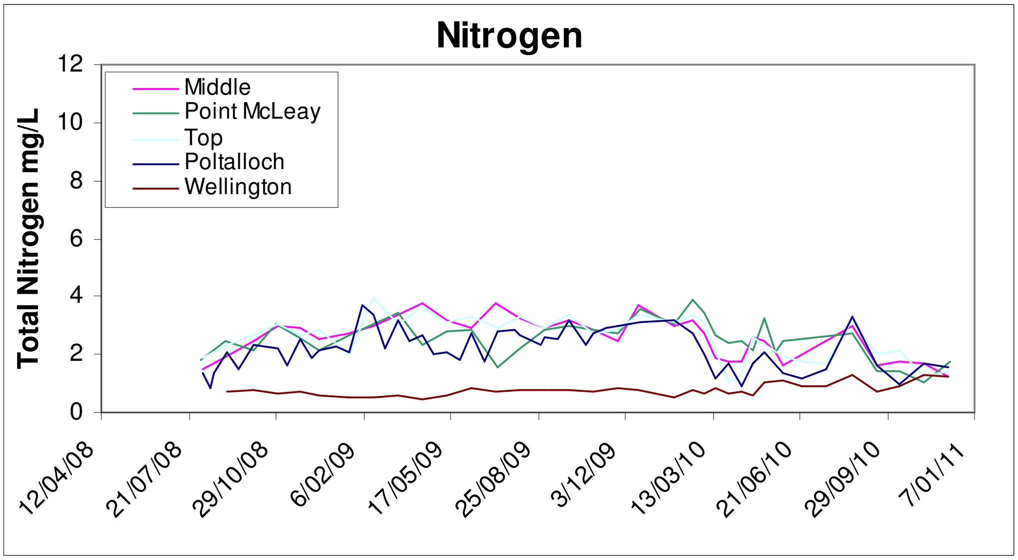


Figure 7 – Total nitrogen in Lake Alexandrina

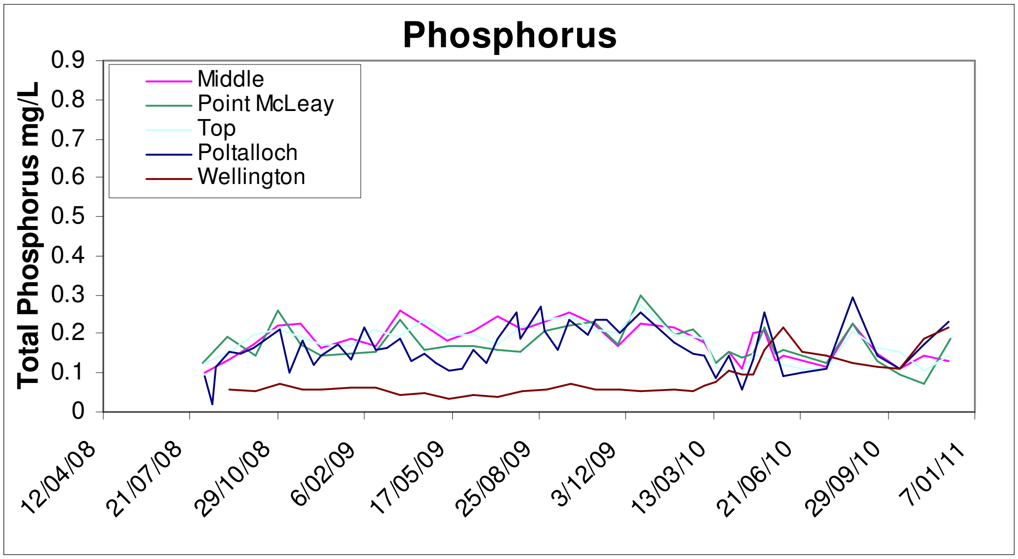


Figure 8 – Total phosphorus in Lake Alexandrina

Chlorophyll a (algae)

- Chlorophyll *a* continues to remain relatively stable and still in excess of ANZECC guidelines (<15 µg/L) indicating a highly nutrient enriched (hyper-eutrophic) system (Figure 9). Chlorophyll levels are much lower in the river inflow (Wellington site) highlighting the increased algal productivity once water enters the Lower Lakes. Although chlorophyll *a* levels in Lake Alexandrina remain high, no potentially toxic blue-green algal blooms are present. This will continue to be monitored over the coming summer months.

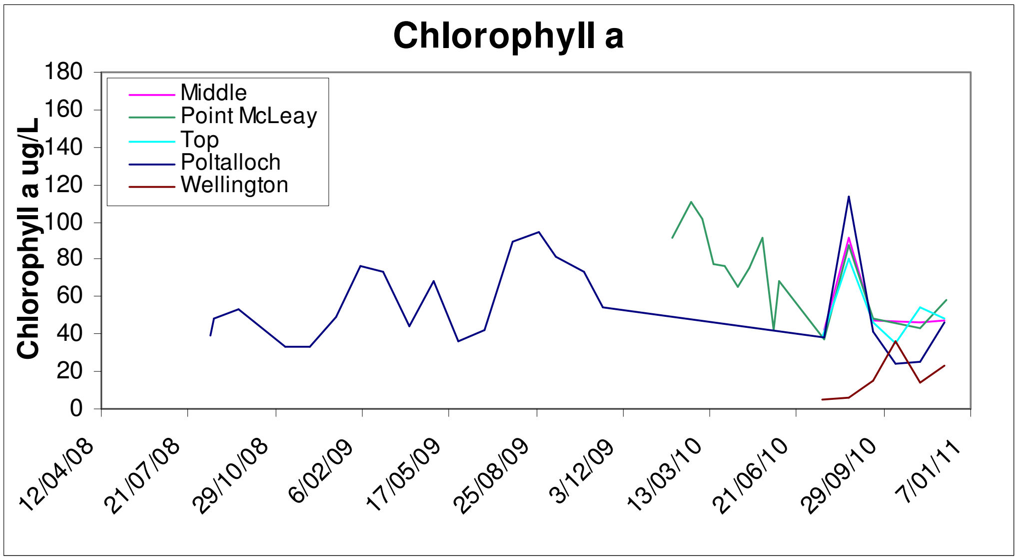


Figure 9 – Chlorophyll *a* in Lake Alexandrina

Metals

- Total aluminium and iron concentrations within Lake Alexandrina have decreased at most sites over December (Figures 10 and 11) This appears to be related to variable flood water concentrations rather than lake system processes as concentrations in the lakes tend to track those in the river (Wellington site).

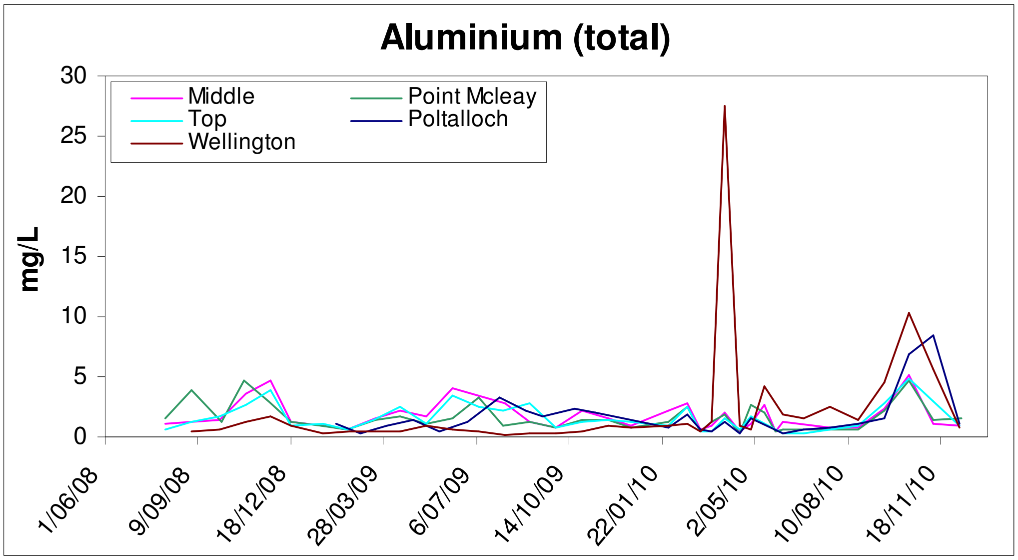


Figure 10 – Total aluminium in Lake Alexandrina

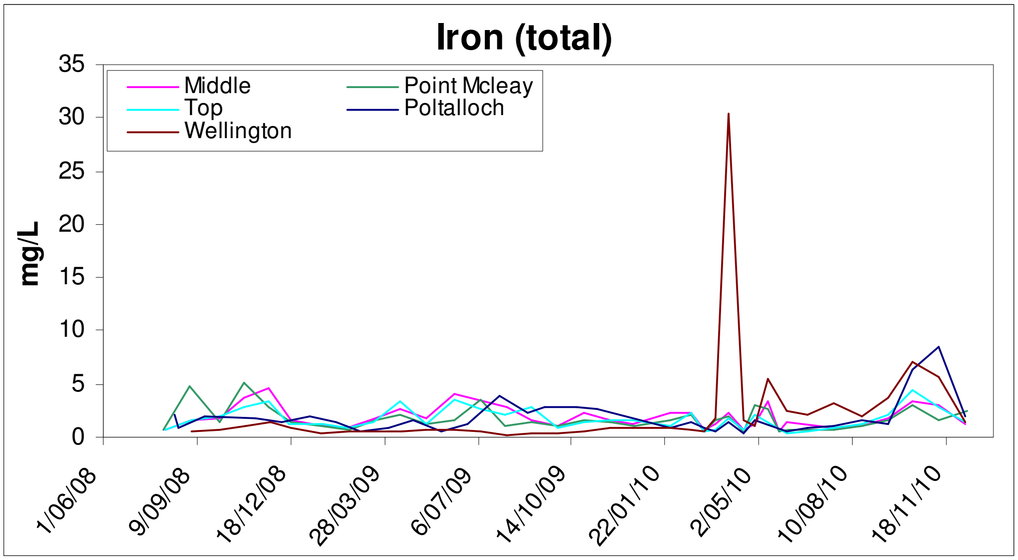


Figure 11 – Total iron in Lake Alexandrina

Lake Albert Water Quality

Ambient water quality monitoring results are discussed below for selected sites and parameters in Lake Albert. While the Lake Albert Opening site is not part of the ambient program (but rather part of monitoring for the previous pumping program) it is included at present to assist in interpretation of water quality data in the northern lake region. In mid September (starting 19/9/10), the Narrung bund was partially breached and so monitoring data after then will reflect changes due to inflows from Lake Alexandrina.

pH

- pH levels are stable and within ANZECC guideline levels (pH 6.5-9.0) at all sites in Lake Albert (Figure 12).

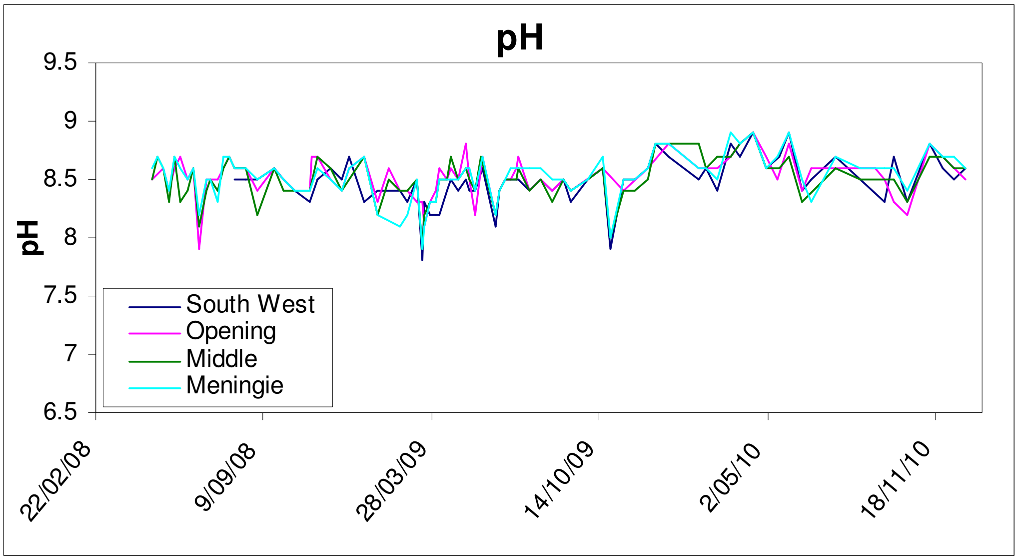


Figure 12 – pH at the Lake Albert ambient monitoring sites

Alkalinity

- Lake Albert alkalinity is relatively stable and remains at high and similar levels at all sites apart from the Opening (Figure 13). The alkalinity patters are similar to those for salinity (see Figure 15), suggesting the trends are influenced by water inputs and mixing patterns. The Opening site is the one most influenced by inflows of lower alkalinity Lake Alexandrina water. It is likely that the alkalinity will continue to decline across Lake Albert with further mixing with Lake Alexandrina water.

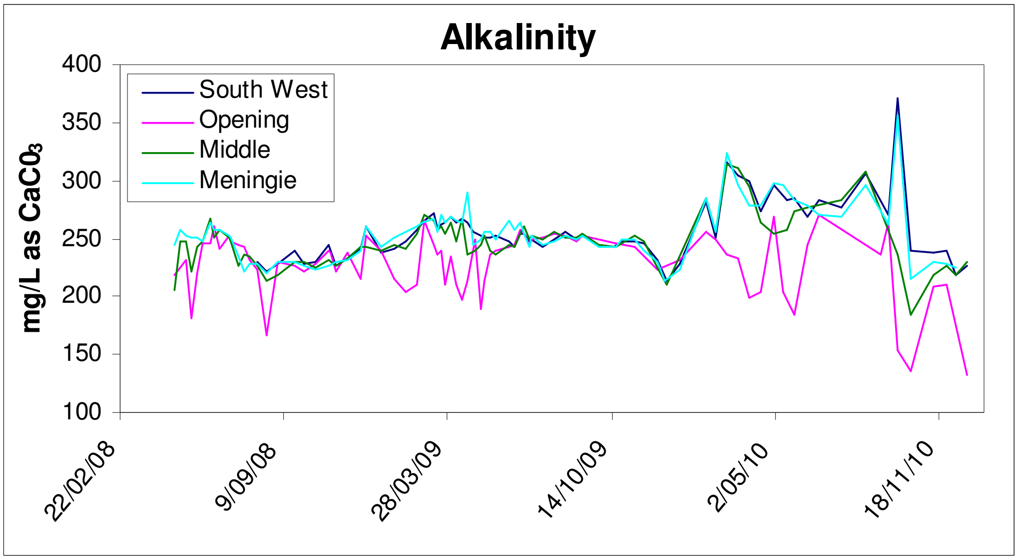


Figure 13 – Alkalinity at the Lake Albert ambient monitoring sites

Sulfate:chloride ratio

- The sulfate:chloride ratio continues to be variable at all sites (Figure 14). but is not showing an increasing trend that would suggest widespread acid sulfate soil influences.

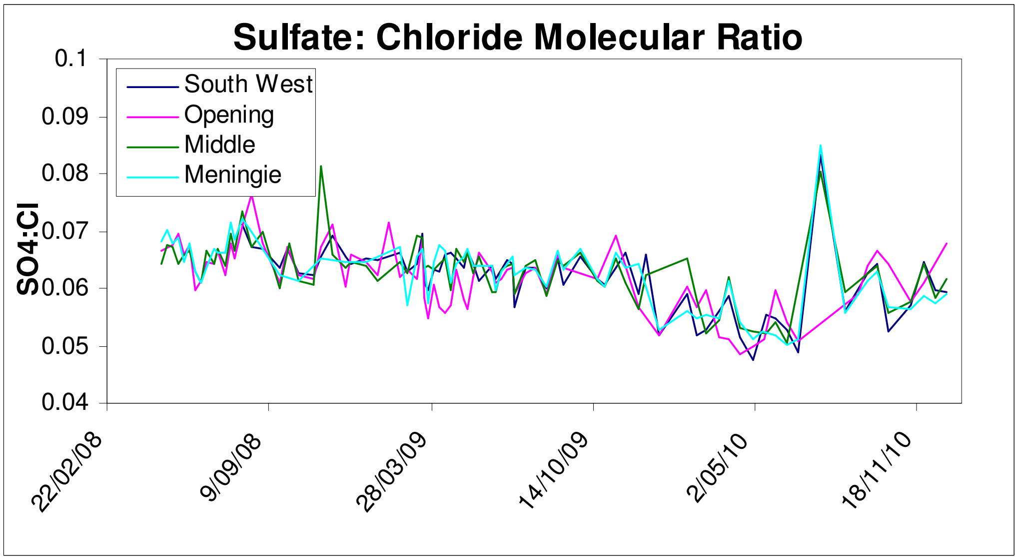


Figure 14 – Sulfate:chloride ratio at the Lake Albert ambient monitoring sites

Salinity (EC)

- Salinity has continued to decline at all sites but still remains high (between 2900 and 8000 µS/cm) compared to pre-drought levels (Figure 15). Further inflow and mixing of water from Lake Alexandrina are expected to reduce salinities further across Lake Albert, however it is unlikely salinities will return to pre drought levels (<1600 µS/cm) for some time due to the limited water exchange between the two lakes.

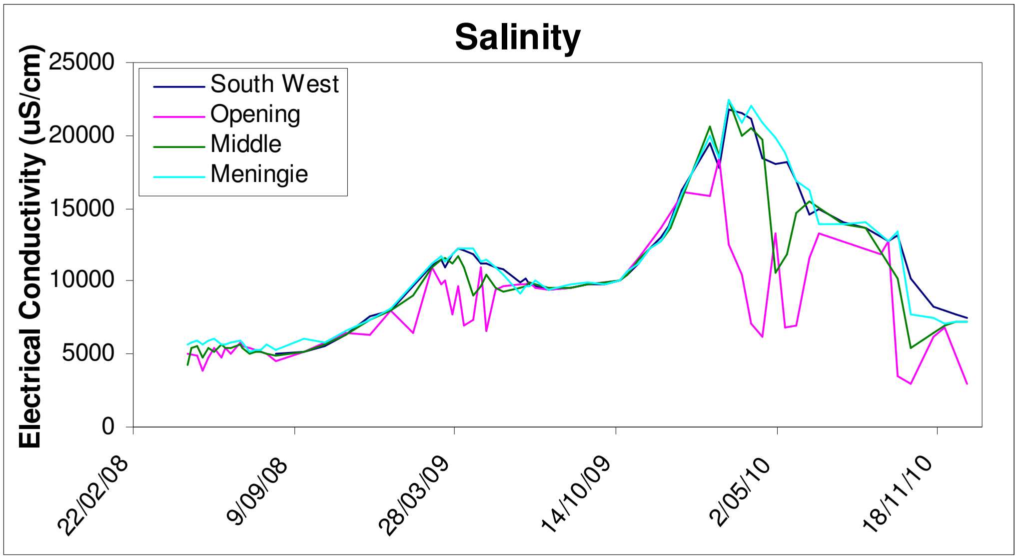


Figure 15 – Salinity at the Lake Albert ambient monitoring sites

Turbidity

- Turbidity in Lake Albert has continued to show variability (Figure 16). Increased water levels mean that less resuspension of sediments occurs during wind events but turbidity continues to remain high compared to historical levels.

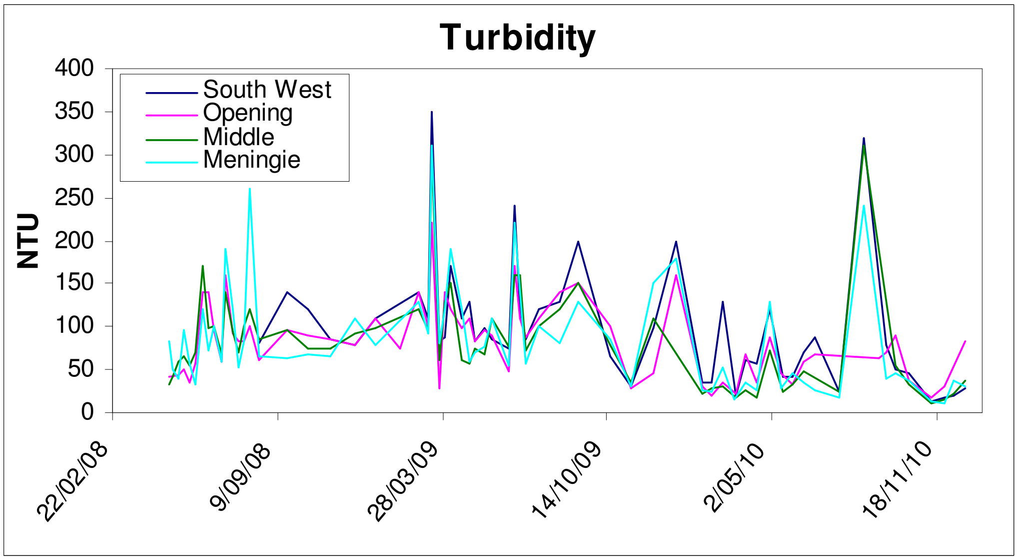


Figure 16 – Turbidity at the Lake Albert ambient monitoring sites

Nutrients (total nitrogen and phosphorus)

- Total nitrogen and total phosphorus levels stabilised during December following the dilution as the lake refilled after partial removal of the Narrung embankment in September (Figures 17 and 18). Nutrient levels have returned to comparable levels to historic data however continue to be in excess of the ANZECC guidelines for freshwater ecosystems (<1mg/L TN, <0.025 mg/L TP).

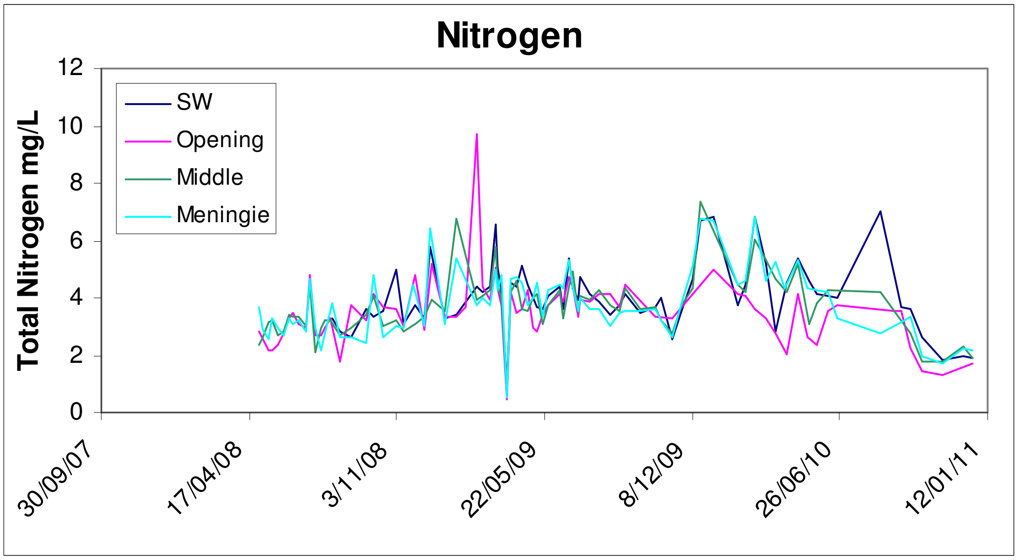


Figure 17 – Total Nitrogen in Lake Albert

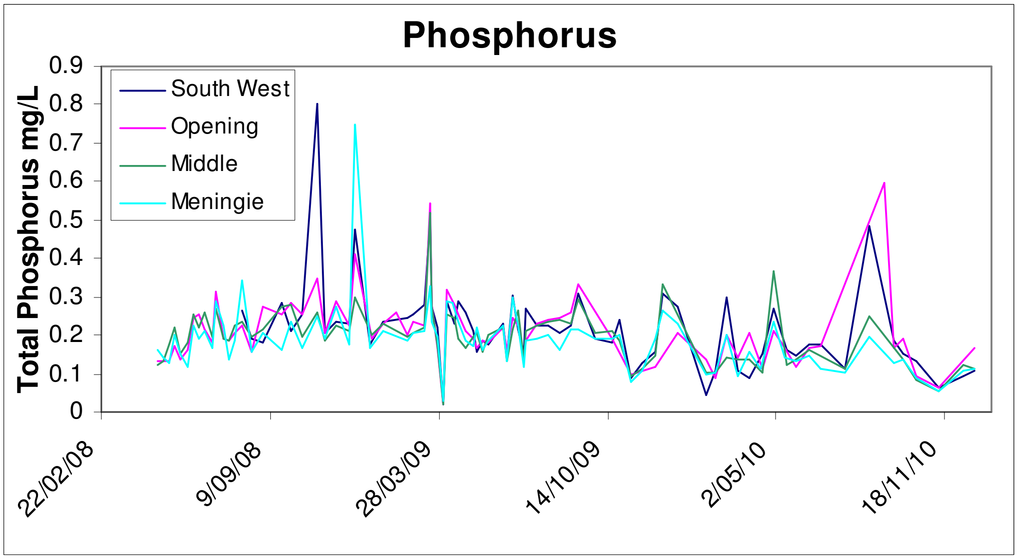


Figure 18 – Total phosphorus in Lake Albert

Chlorophyll a (algae)

- Chlorophyll *a* has decreased over recent months and is comparable to historic data for Lake Albert (Figure 19). This is likely due to dilution and some limited flushing of Lake Albert following reconnection with Lake Alexandrina. However these levels continue to be in excess of the ANZECC guidelines (>15 µg/L) and indicate a nutrient enriched system. No toxic blue-green algal species have been identified at present.

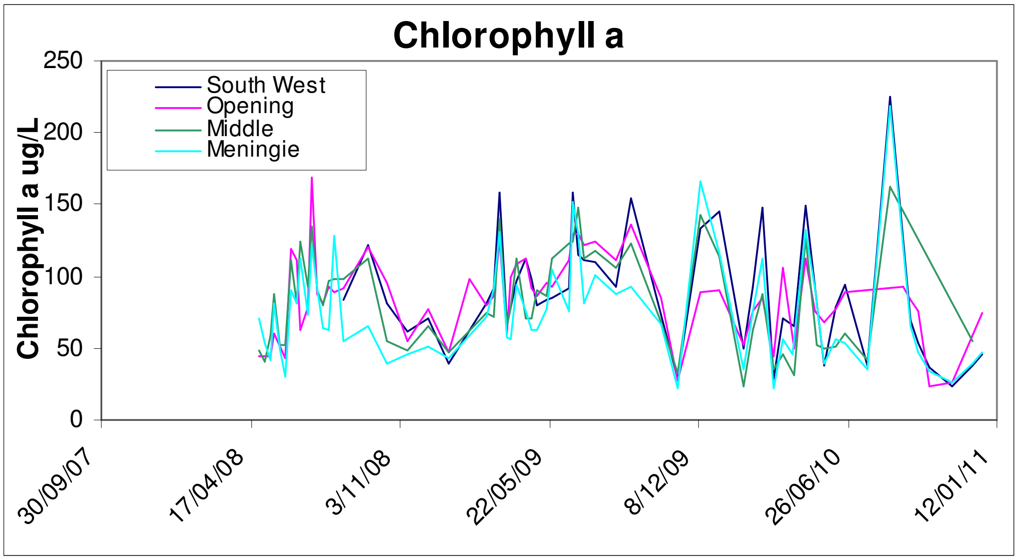


Figure 19 – Chlorophyll *a* in Lake Albert

Metals

Total aluminium and iron concentrations within Lake Albert (Figures 20 and 21) have remained low and stable since water levels have been maintained at historic pool level. There has likely been less resuspension of sediment (containing metals) and lower flux from exposed acidic sediments at these higher water levels. The increase in total iron observed at the Opening site during December is comparable with levels recorded from Lake Alexandrina and likely due to input through the narrows

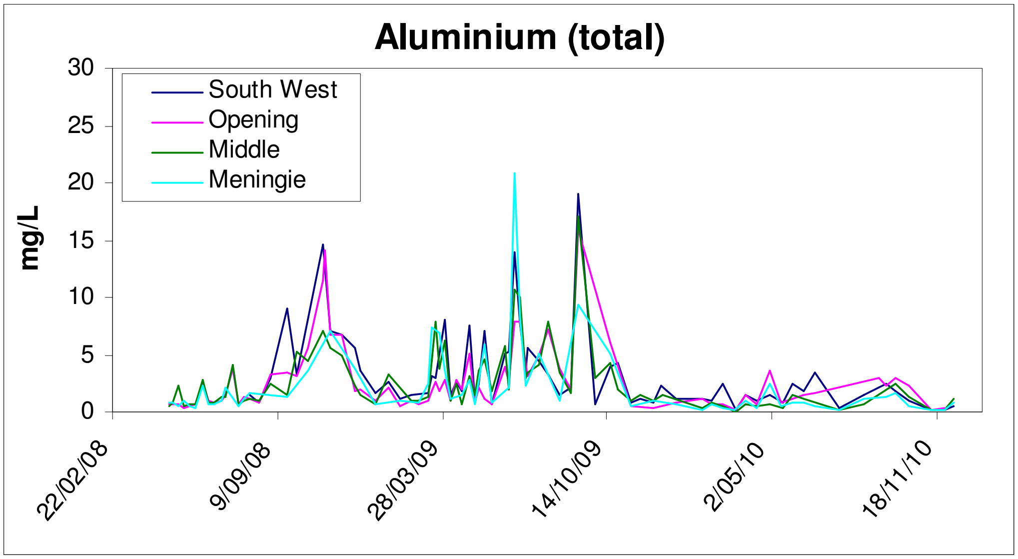


Figure 20 – Total aluminium in Lake Albert

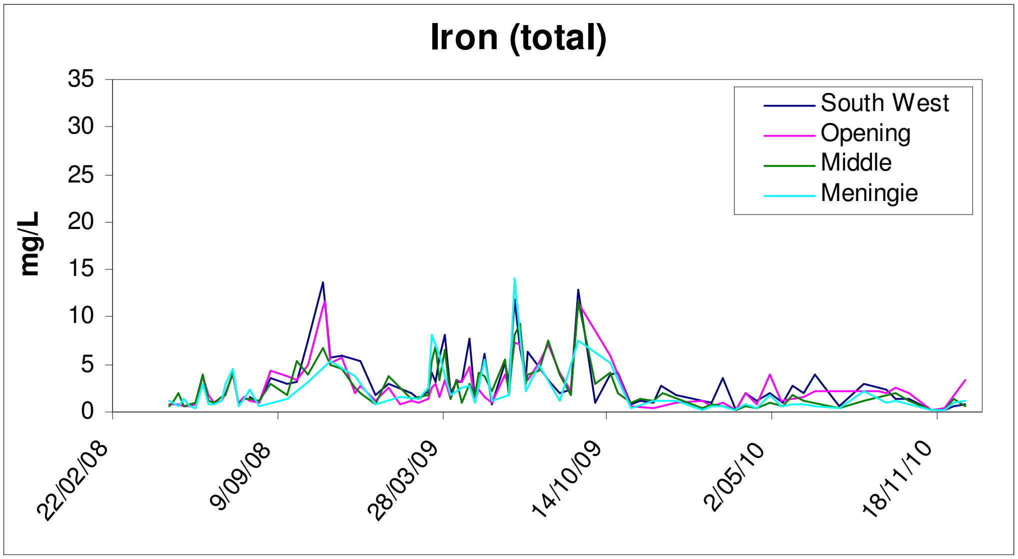


Figure 21 – Total iron in Lake Albert

Goolwa Channel and Tributaries Water Quality

Ambient and event-based water quality monitoring results are discussed for selected sites and parameters in the Goolwa Channel and tributaries region (see Figures 1 and 22 for site locations). Due to the nature of the monitoring program both the ambient and event-based sites have been included in this section to compare data collected over the month. In late September (starting 26/9/10), the Goolwa regulator near Clayton was partially breached and so monitoring data after then will reflect changes due to inflows from Lake Alexandrina.

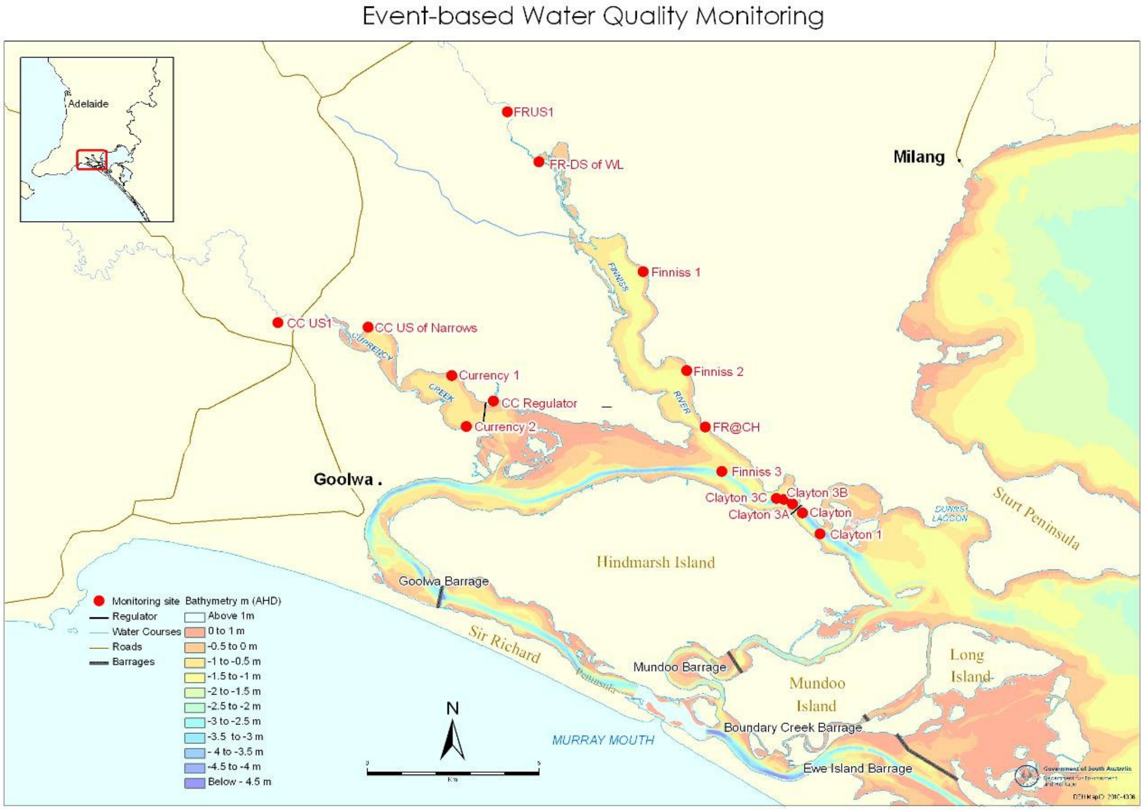


Figure 22 – Goolwa Channel and tributaries ambient and event-based monitoring sites

pH

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

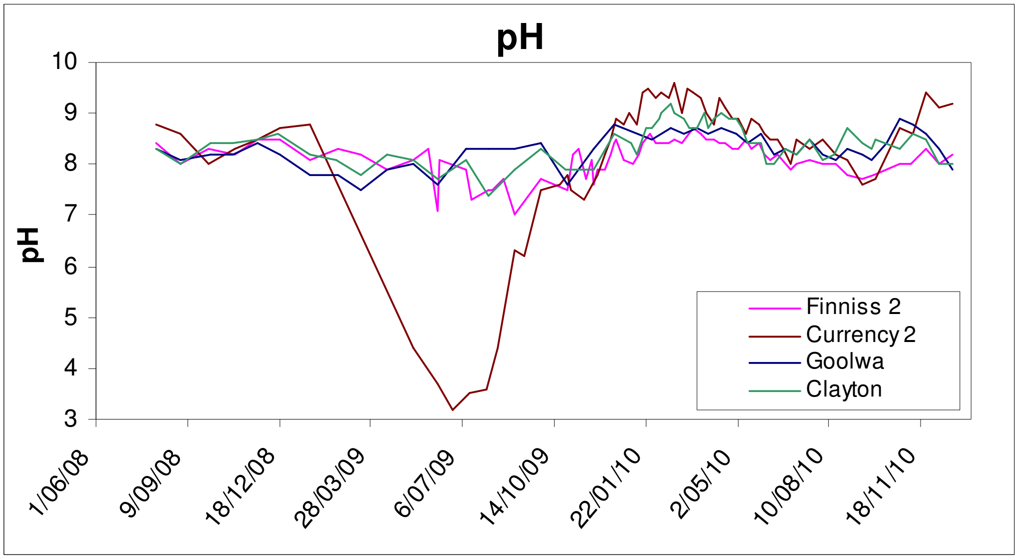


Figure 23 – pH at the Tributary monitoring sites

Alkalinity

- Alkalinity at all of the Goolwa Channel and tributaries sites has decreased over the latter part of 2010 (Figure 24). This is likely due to reconnection with Lake Alexandrina and mixing with the lower alkalinity flood water. As water continues to flow through the Goolwa Channel past the tributaries to the Murray Mouth it is expected that there will be some further mixing, dilution and reduction of alkalinity.

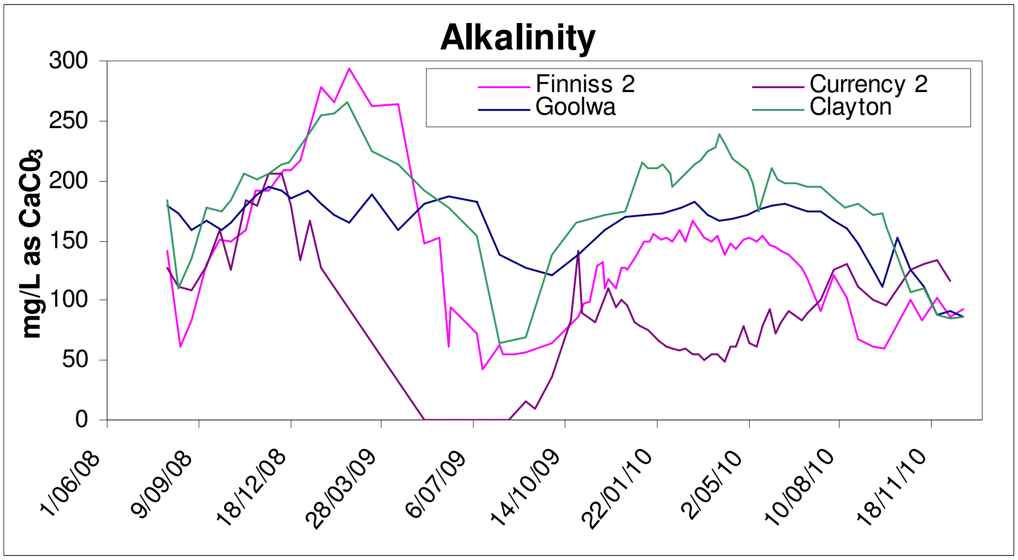


Figure 24 – Alkalinity at the Goolwa Channel and Tributaries monitoring sites

Sulfate:chloride ratio

- The sulfate:chloride ratio is similar at most sites and does not show any increasing trends that would suggest widespread acid sulfate soil inputs (Figure 25).

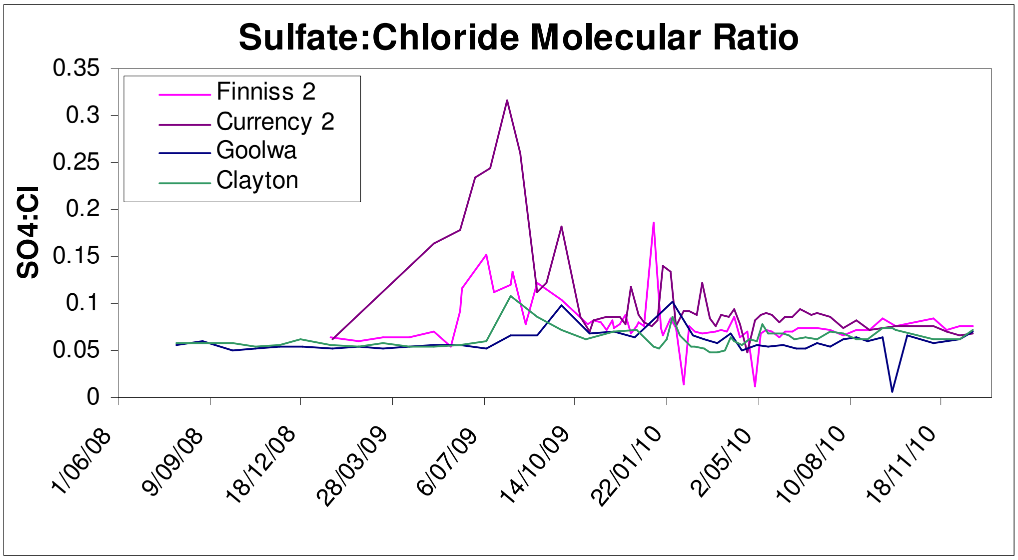


Figure 25 – Sulfate:chloride molecular ratio at the Goolwa Channel and Tributaries monitoring sites

Salinity (EC)

- Salinity continues to remain low and decreasing at all sites (Figure 26). Salinity is expected to continue to decrease over coming months as further water is released through the Goolwa Barrage. Salinity at the Currency 2 site remains higher than the other sites due to the presence of the Currency regulator preventing mixing with the low salinity flood waters.

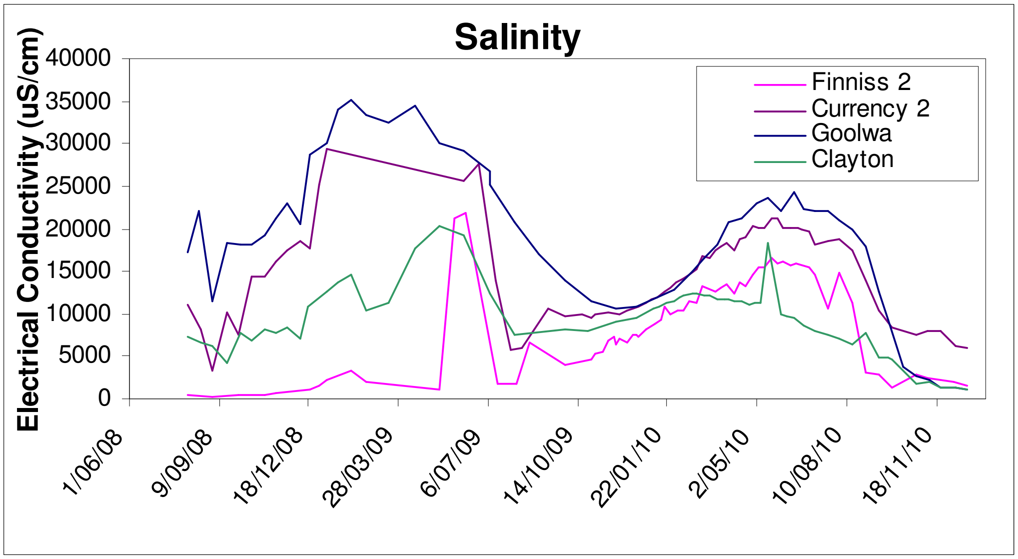


Figure 26 – Salinity at the Goolwa Channel and Tributaries monitoring sites

Turbidity

- Turbidity is variable in the Goolwa Channel and Tributaries sites (Figure 27). As expected since the partial breech in the regulator has taken place turbidity has become more similar to that in Lake Alexandrina (see Figure 6). Turbidity within the Goolwa Channel is expected to remain high as the more turbid floodwaters flow through the lakes. The lower turbidity at the Currency 2 site is likely due to the presence of the Currency regulator preventing mixing with the more turbid flood waters.

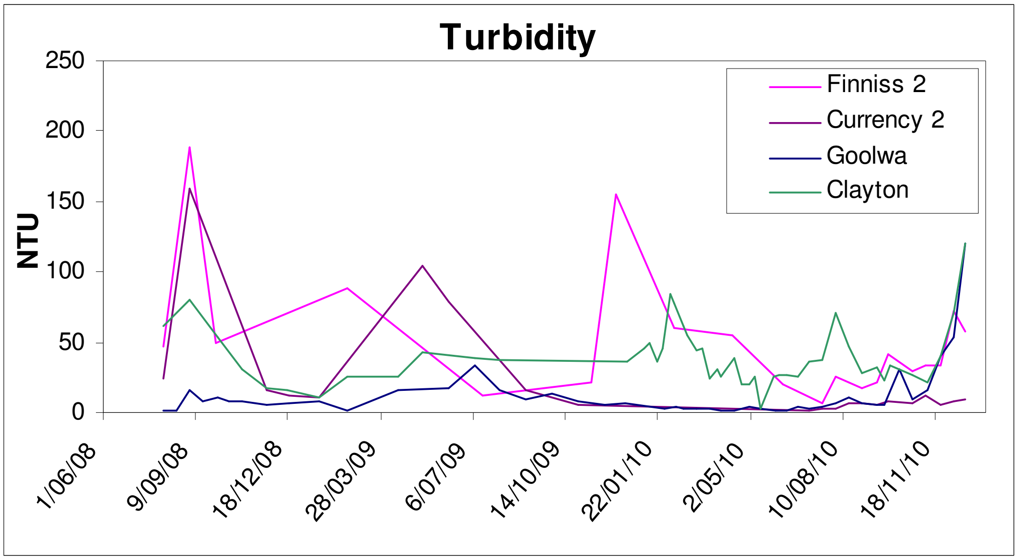


Figure 27 – Turbidity at the Goolwa Channel and Tributaries monitoring sites

Nutrients (total nitrogen and phosphorus)

- Nutrient levels remain relatively stable in the Goolwa Channel and tributaries (Figures 28 and 29). Nutrient trends in this region are currently driven by flood water inflow composition and mixing processes in Lake Alexandrina (Figures 7 and 8). Nutrient levels continue remain above ANZECC guidelines for freshwater ecosystems (<1mg/L TN, <0.025 mg/L TP).

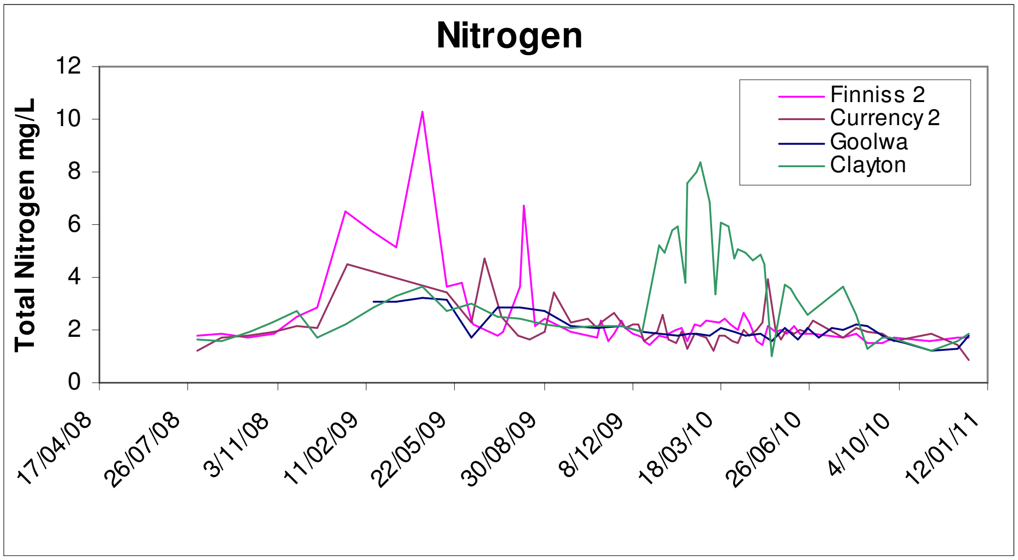


Figure 28 – Total Nitrogen at the Goolwa Channel and Tributaries monitoring sites

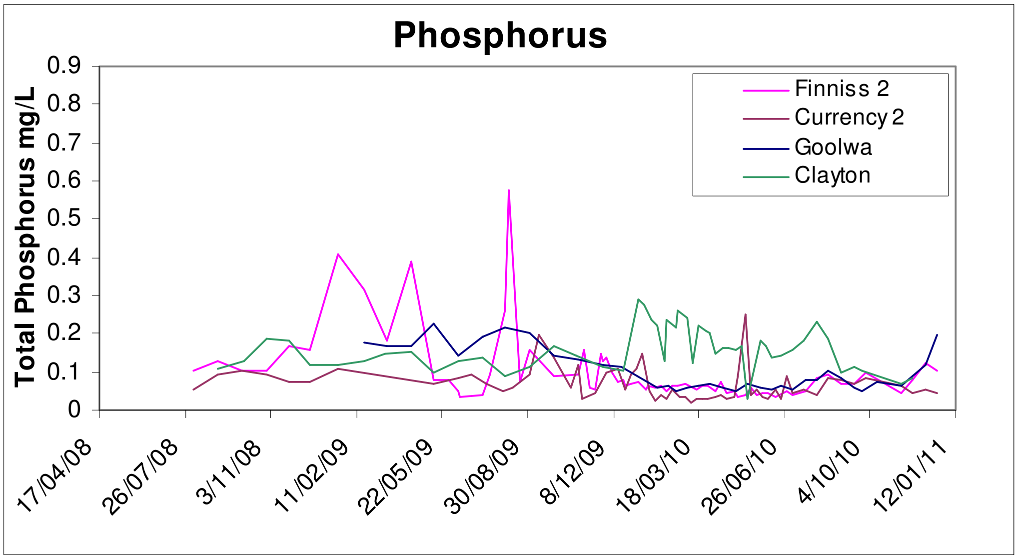


Figure 29 – Total phosphorus at the Goolwa Channel and Tributaries monitoring sites

Chlorophyll (algae)

- Chlorophyll *a* continues to be variable at the Goolwa Channel and tributaries sites (Figure 30). Increases in chlorophyll *a* have been observed over December in the Goolwa Channel sites (Clayton and Goolwa) this could be due to warmer water temperatures and large areas of slow moving shallow water providing ideal conditions for algal growth of the fringing areas surrounding these sites.

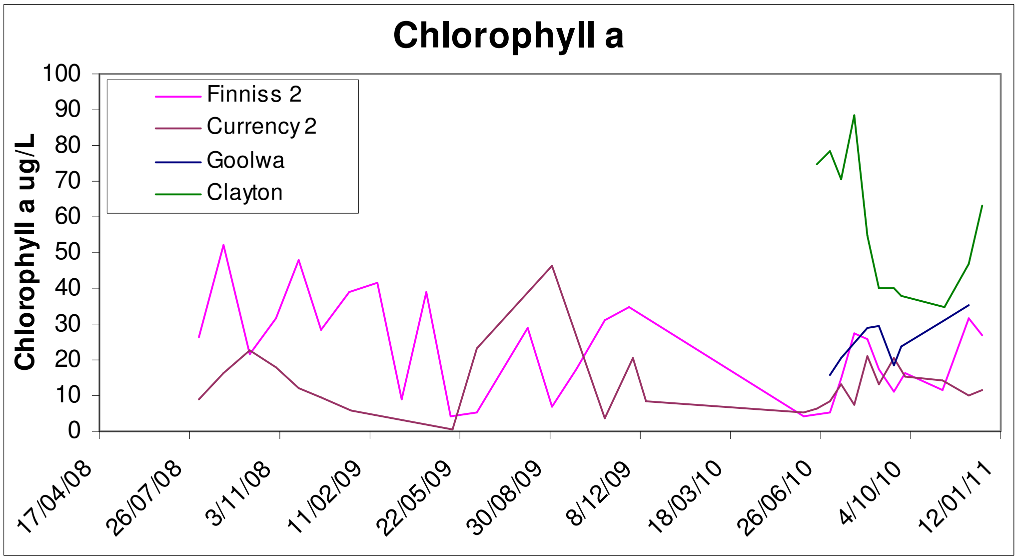


Figure 30 – Chlorophyll *a* at the Goolwa Channel and Tributaries monitoring sites

Metals

Total aluminium and iron concentrations within the tributaries continue to remain relatively low compared to the 2008–2009 drought period (Figures 31 and 32).

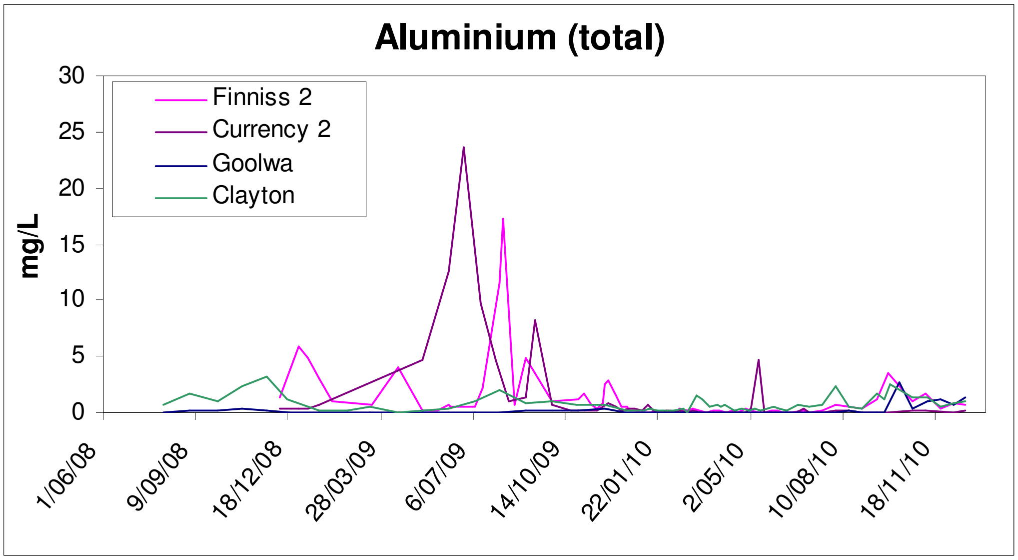


Figure 31 – Total aluminium at the Goolwa Channel and Tributaries monitoring sites

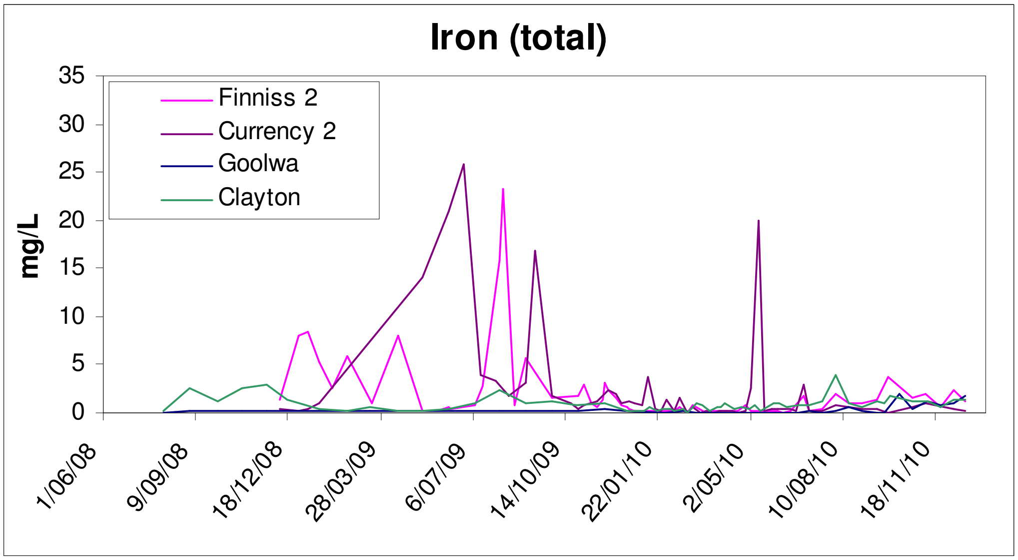


Figure 32 – Total iron at the Goolwa Channel and Tributaries monitoring sites

Event-based monitoring

Event-based water quality sampling is undertaken in selected regions that have experienced acidification or were at risk of acidification (Figure 33). The selection of sites was based upon previous acid sulfate soil risk assessments, 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. Previously this information has been used to determine the need for management actions, such as limestone dosing, which reduces the acidity hazard and mitigates further metal release.

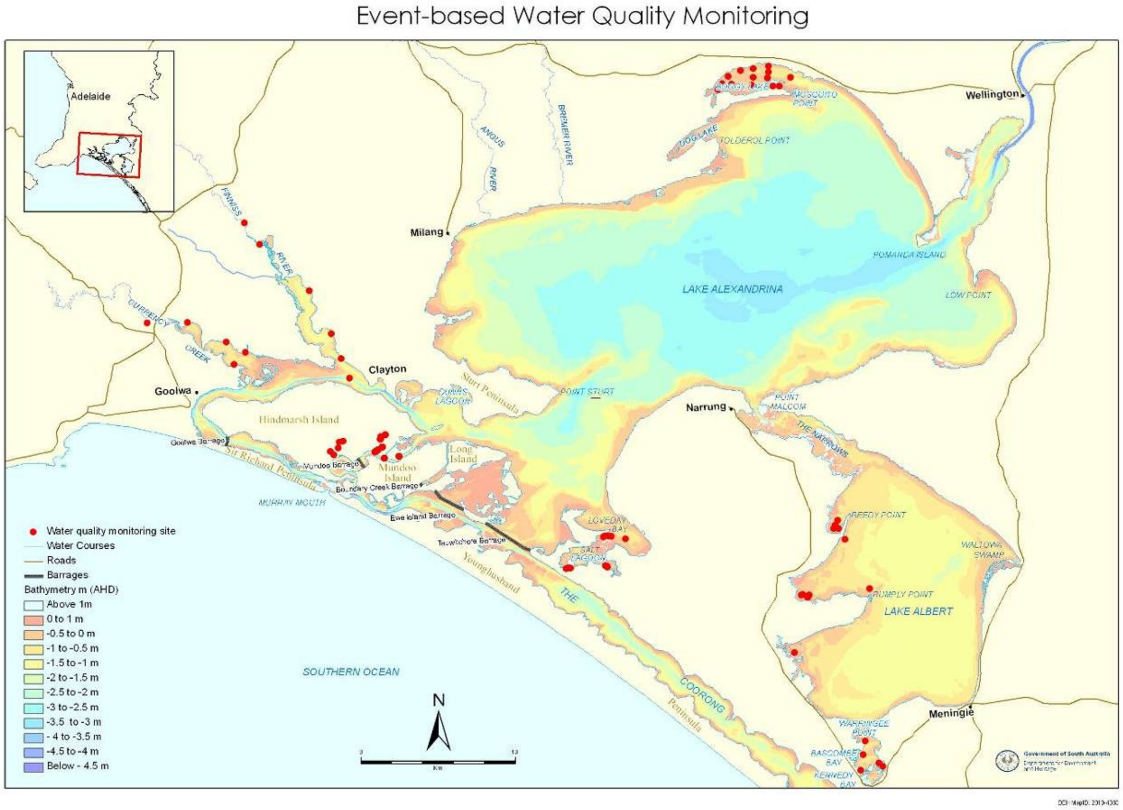

Event-based Water Quality Monitoring

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

Boggy Lake

Figure 34 shows a map of sampling locations in Boggy Lake with water quality results from selected sites shown in Figure 35. Limestone dosing, improved water levels and flow into Lake Alexandrina since September have enabled the pH and Alkalinity within Boggy Lake to recover and stabilise to satisfactory levels within guideline and trigger values. (Figure 35). However the salinity within Boggy Lake (≈2500 EC) has stabilised well above that seen in Lake Alexandrina (between 750 – 1500 EC). This is primarily due to limited mixing owing to the flow dynamics of the area. Boggy Lake although much smaller in area and volume is exhibiting similar patterns to Lake Albert even with a large connection to the fresher Lake Alexandrina water the mixing process is slow and primarily driven by large wind events. As we continue to see fresh water inflows and mixing into this region it is expected that the salinity will continue to decline.

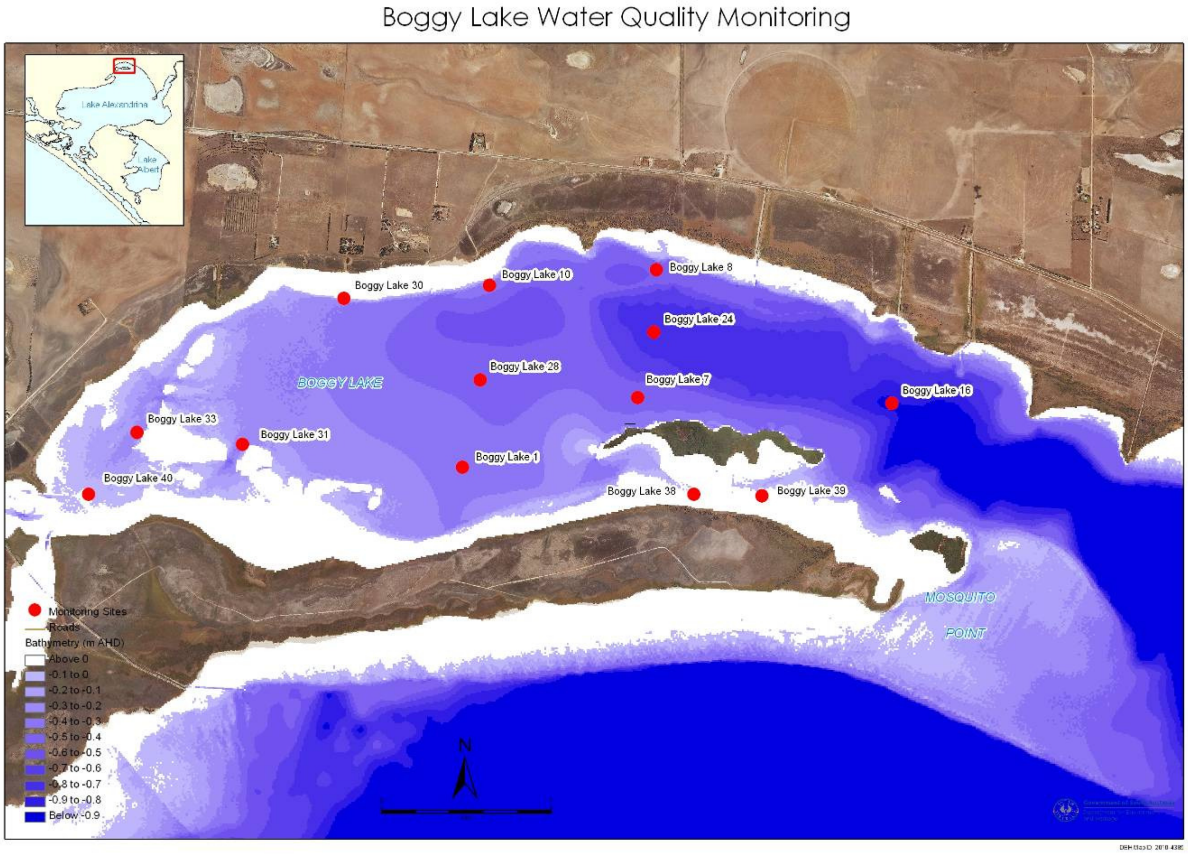


Figure 34 – Map of Boggy Lake monitoring sites

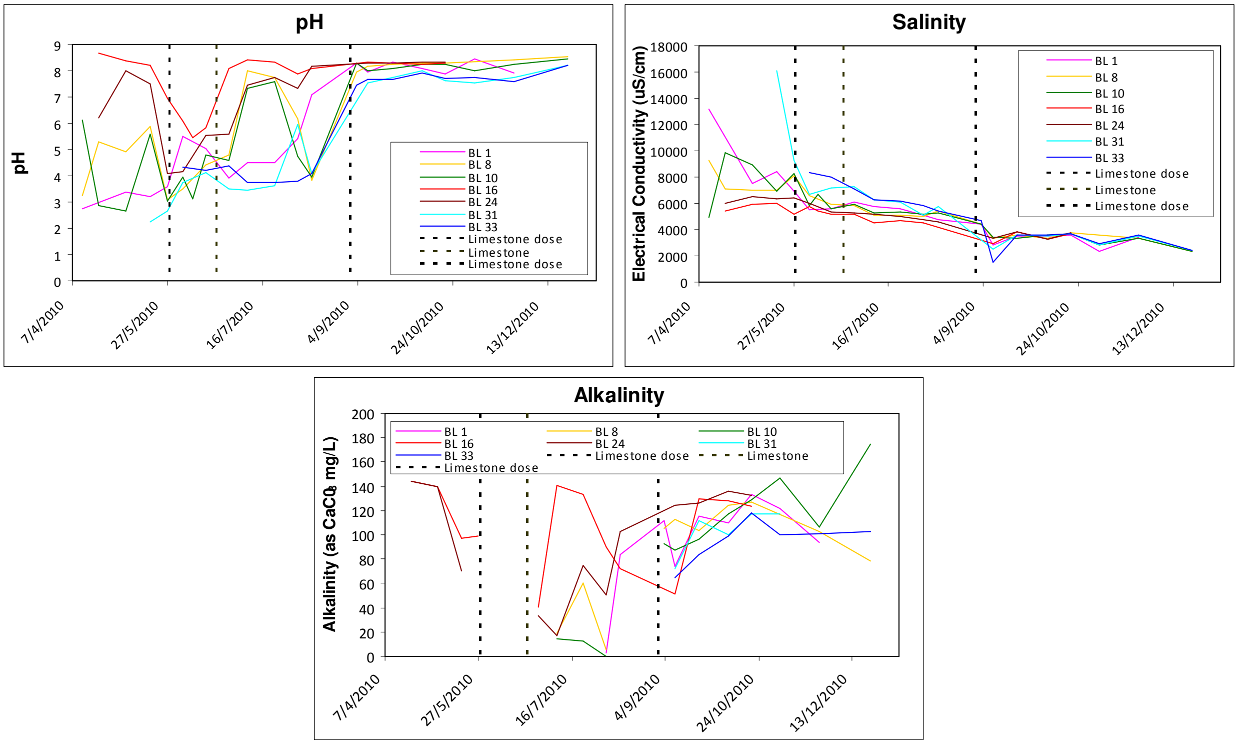


Figure 35 –Boggy Lake water quality results

Narrung Narrows

Figure 36 and 37 show the Narrung Narrows sample sites and water quality results respectively. Sites within the Narrung Narrows have been monitored since the Narrung bund was breached in August 2010. Since this time the pH has remained relatively stable and within ANZECC guidelines for the protection of freshwater organisms (between 6.5 and 9). However there was a noticeable decrease in pH immediately after the breach took place, this can be attributed to the initial inflow and dilution with Lake Alexandrina water. A similar trend can be observed in both the alkalinity and salinity graphs showing the dip recorded immediately after the breach. Additionally it can be observed that sites located in the eastern end of the channel (Narrows 16 and 19) have significantly higher alkalinities and salinity (alkalinity > 100 mg/L and salinity > 3000 µS/cm) as compared to those sites located in the western end of the channel (Narrows 7, 8 and 10 with alkalinity < 75 mg/L and salinity < 1000 µS/cm) which exhibit similar water chemistry as seen in Lake Alexandrina (see Figures 3 and 5). This suggests that as Lakes Alexandrina and Albert have refilled and reached equilibrium water exchange between the lakes is somewhat limited and dependent on wind driven water level changes and seiching through the Narrows.

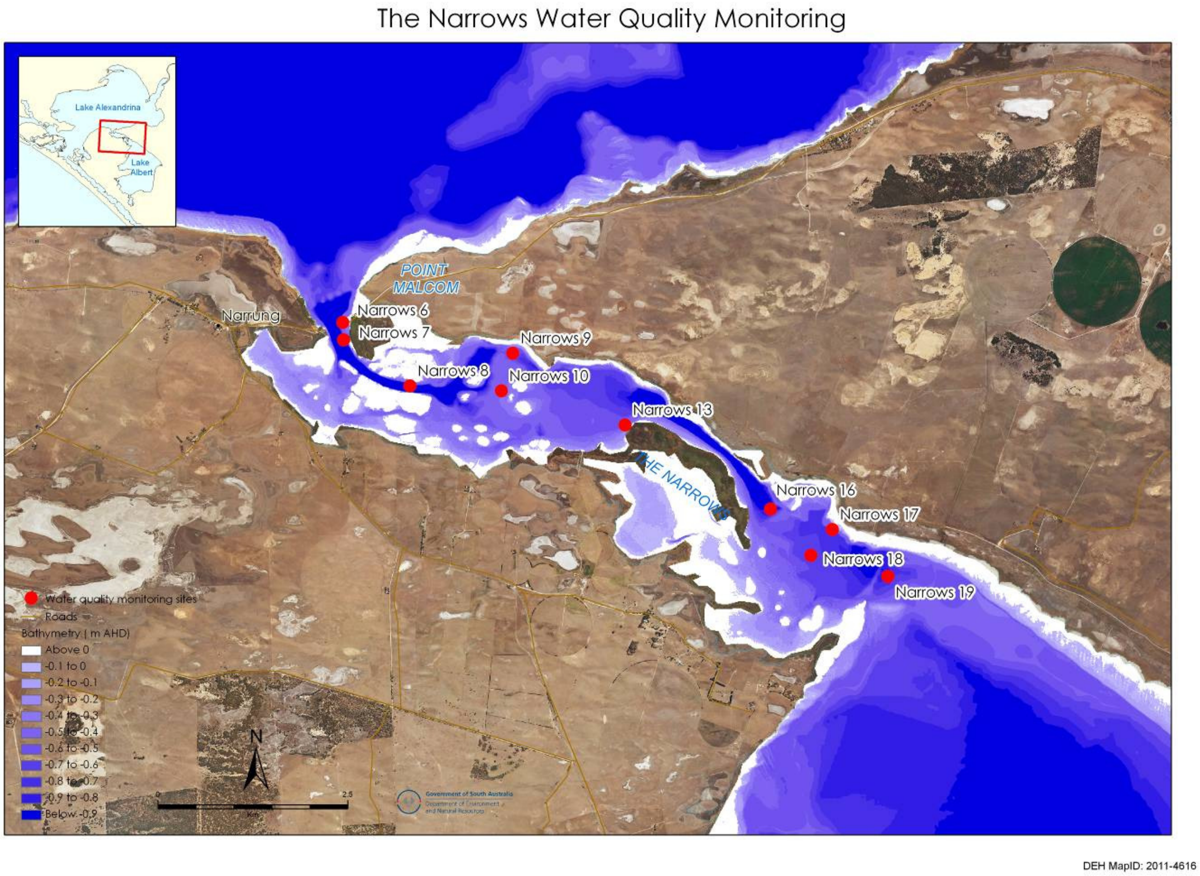


Figure 36 – Map of Narrung Narrows sample sites

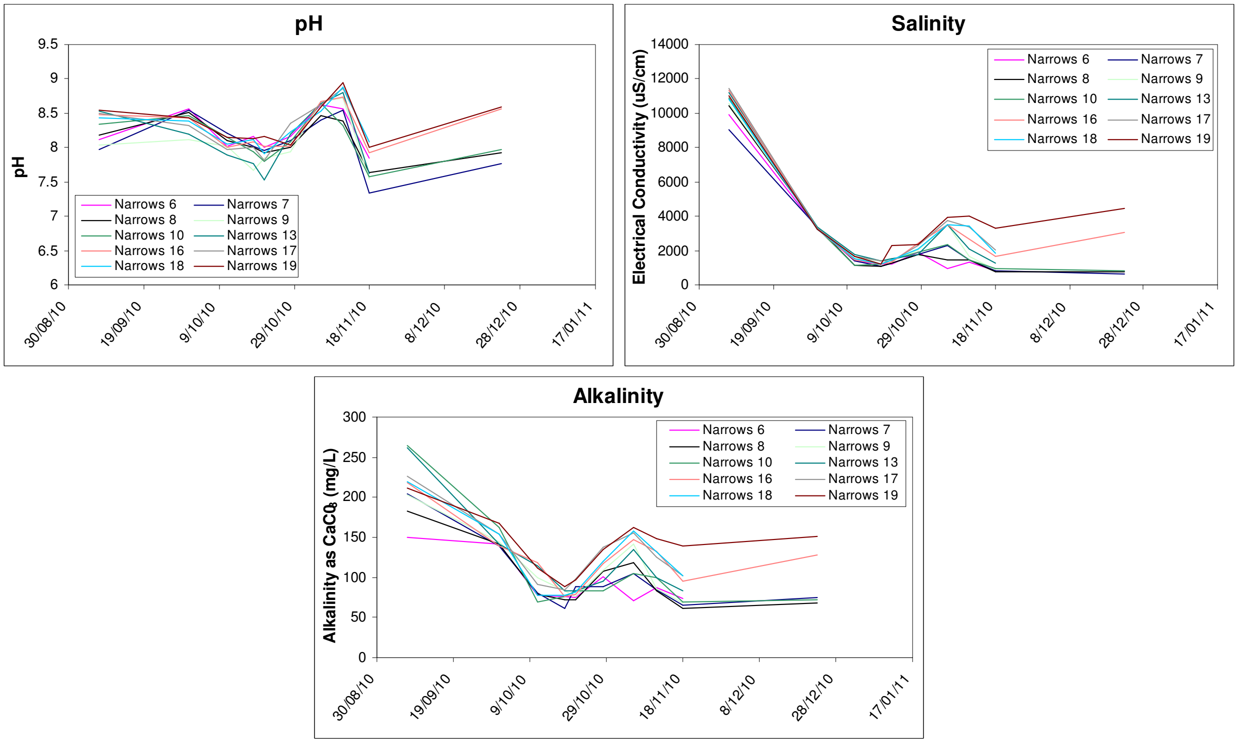
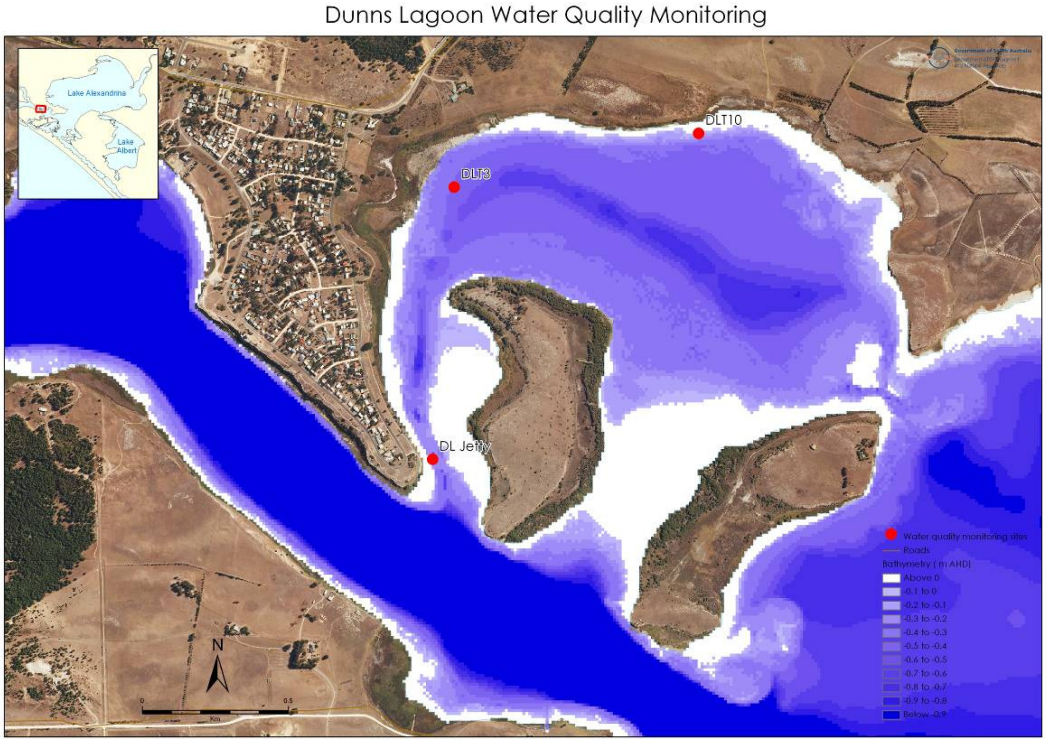


Figure 37 – Narrung Narrows water quality results

Dunn's Lagoon

Figure 38 shows a map of sampling locations in Dunn's Lagoon with water quality results from selected sites shown in Figure 39. pH and alkalinity fluctuated in Dunn's Lagoon as rewetting and refilling took place but have now stabilised. Salinity within Dunn's lagoon has continued to decrease due to continued flushing and exchange with lower salinity Lake Alexandrina water.


Dunns Lagoon Water Quality Monitoring

DEH MapID: 2011-4617

Figure 38 – Map of Dunn's sample site

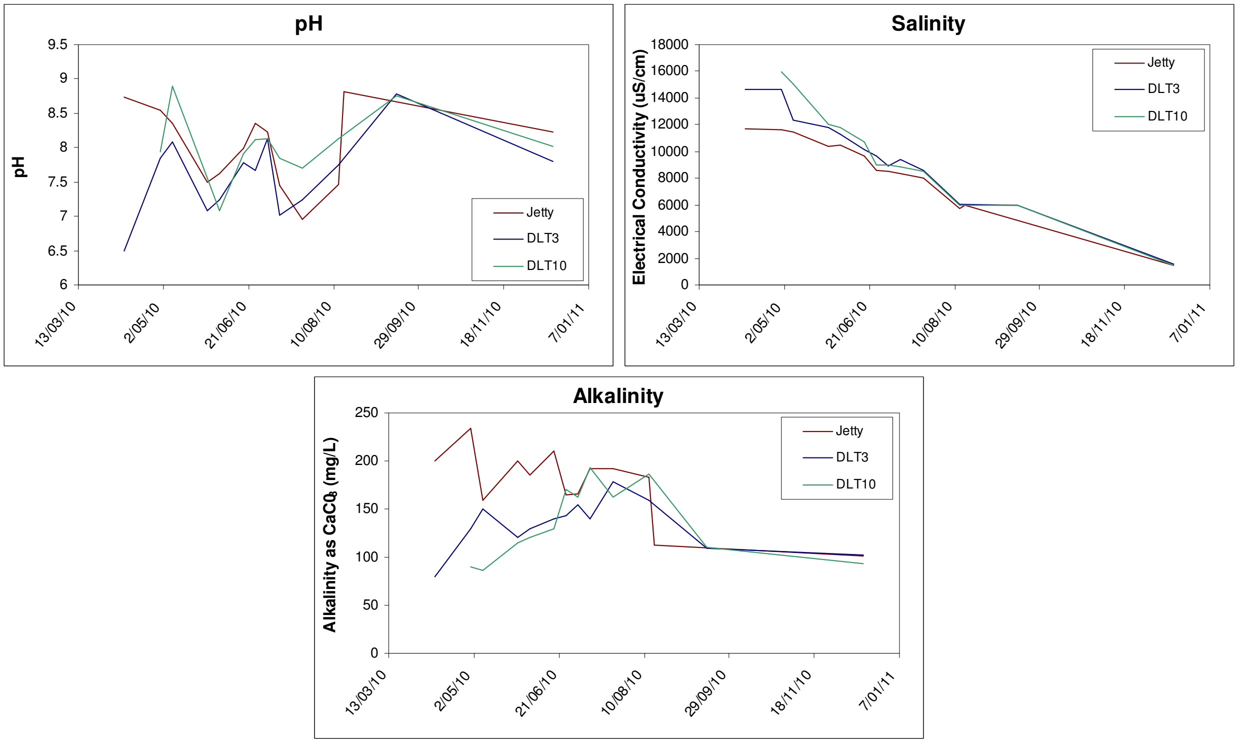


Figure 39 – Dunn's Lagoon water quality results

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