Lower Lakes and Tributaries

Water Quality Report

Ambient and Event-based Monitoring

Report 28, June 2011

Government of South Australia
Department of Environment and Natural Resources

EPA South Australia

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Observations at a Glance

- ***Salinity remains stable and at low levels across Lake Alexandrina due to dilution from river inflows and export of salt through the barrages***
- ***Salinity levels still remain elevated in Lake Albert compared to historical values***
- ***pH and alkalinity continue to remain satisfactory at all sites in the main lake water bodies***
- ***The large salinity spike recorded within the Goolwa Channel and Tributaries, and at Boggy and Hunter's Creek was a result of a king tide during May. As the tidal levels dropped the salinity was flushed out, however small salinity pockets remain and levels are yet to return to pre event levels.***

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 and Tribuatries. 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, acidity, salinity, and sulfate:chloride, 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* $CaCO_3$

***Acidity** is a measure of the presence of acid and soluble metals (positively charged) in a solution. Under normal stable conditions there should be no acidity present in waters sampled. Measured acidity is often a by product of oxidised acid sulfate soils and an indicator to their presence in the soil profile.*

***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).*

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

***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.*

***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 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).

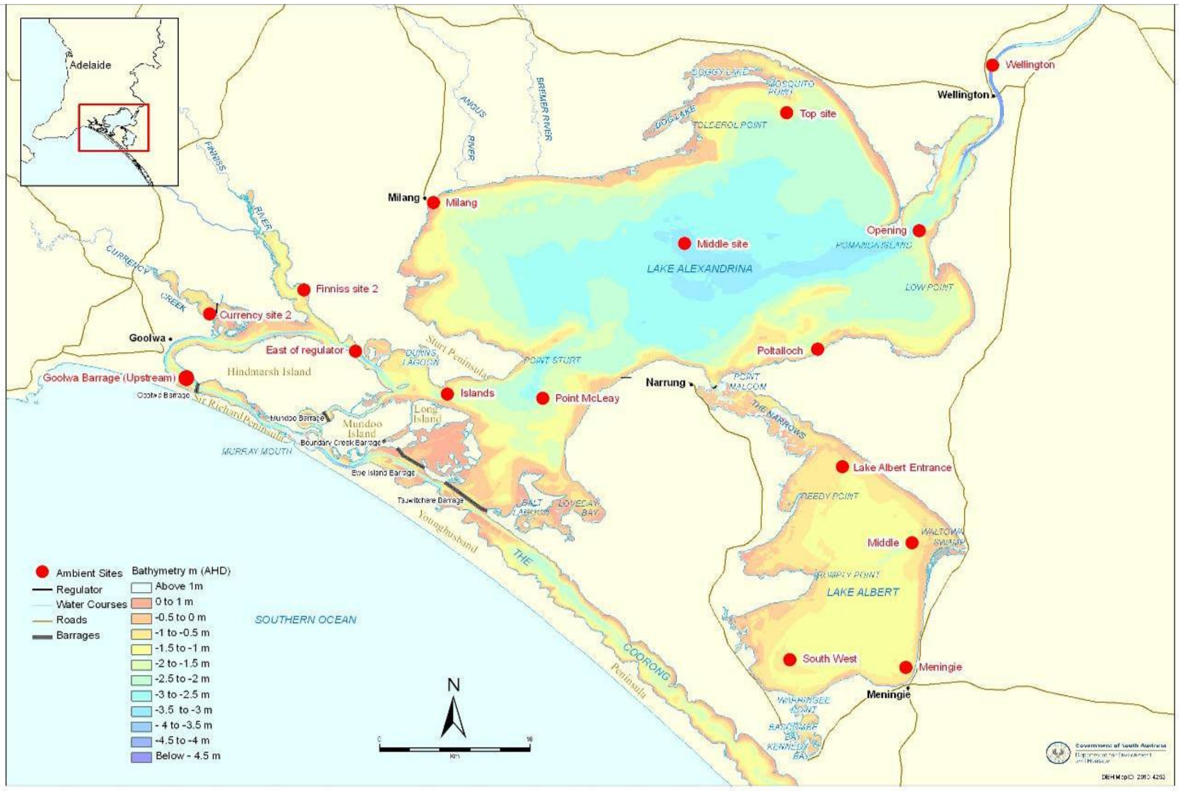


Figure 1 –Lower Lakes and Tributaries ambient monitoring sites

Lake Alexandrina Water Quality

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 Murray (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. Figure 2 shows the recent water levels in Lake Alexandrina.

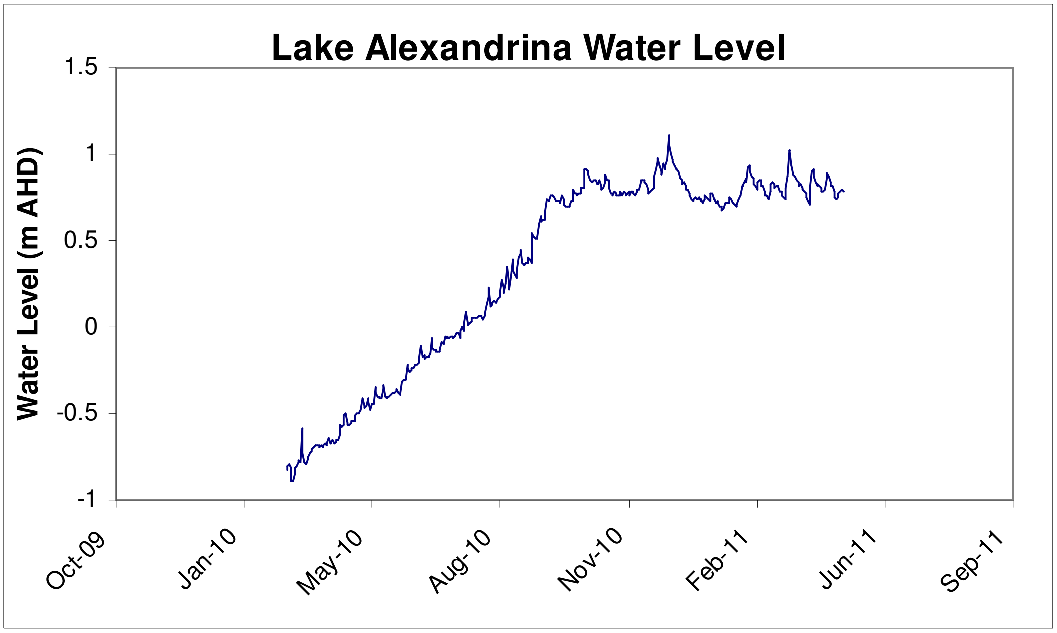


Figure 2 – Water level in Lake Alexandrina

pH

- pH levels in Lake Alexandrina (Figure 3) have increased at all sites during June despite a decline at the Wellington site within the River Murray. These fluctuations could be attributed to natural Lake processes with association to water inflows into Lake Alexandrina. All sites remain within ANZECC guideline levels (pH 6.5-9.0).

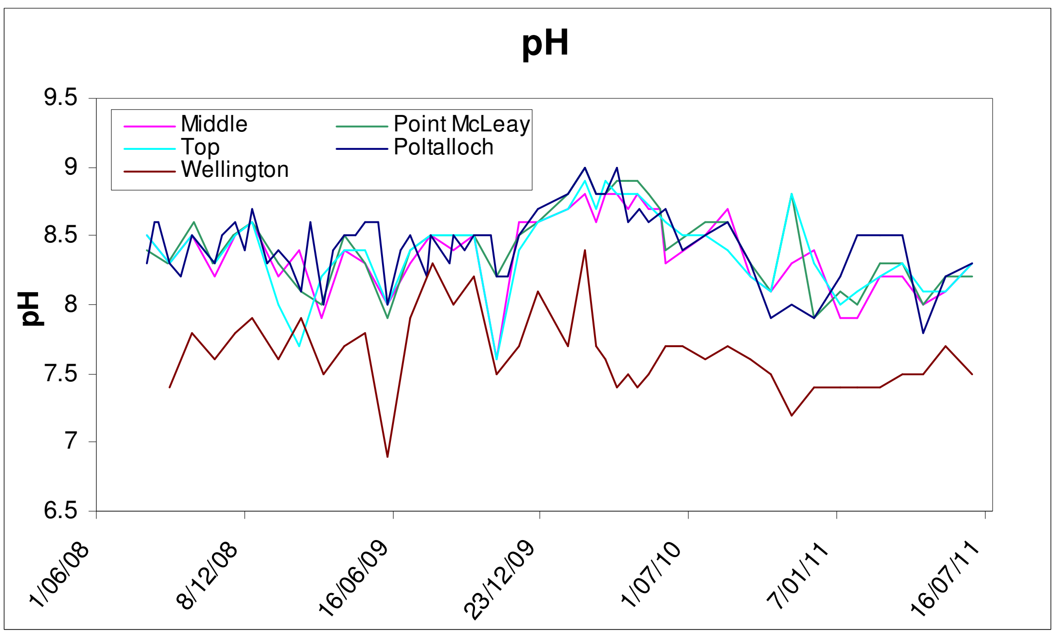


Figure 3 – pH at the Lake Alexandrina ambient monitoring sites

Alkalinity

- Alkalinity levels within Lake Alexandrina have remained stable throughout June (Figure 4). Levels remain relatively uniform for all sites indicating that the Lake is well mixed and exhibiting. Alkalinity at the River Murray (Wellington site) followed the trend of pH recording a slight decline during June this is likely due to upstream fluctuations and in flows.

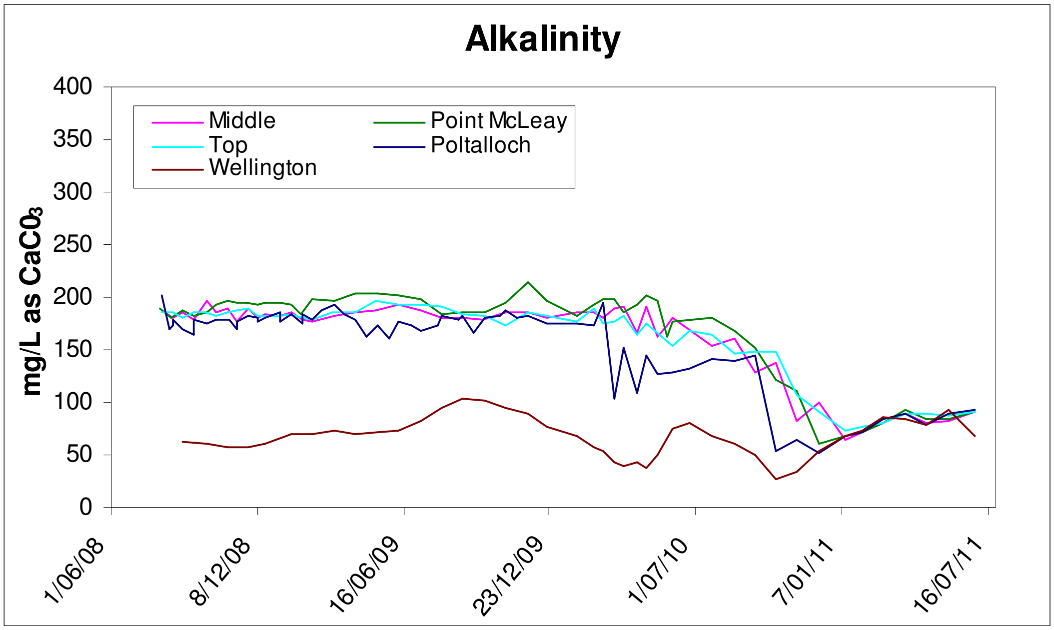


Figure 4 – Alkalinity at the Lake Alexandrina ambient monitoring sites

Sulfate:chloride ratio

- The sulfate:chloride ratio (Figure 5) has remained stable for most Lake Alexandrina sites in June with the exception of the site at Wellington which showed a significant increase. This increase shows a significant rise in the sulfate concentration compared to the chloride concentrations indicating increased sulfate input. Although the increase seems significant it is likely caused by a draw down event like releases from upstream wetlands.

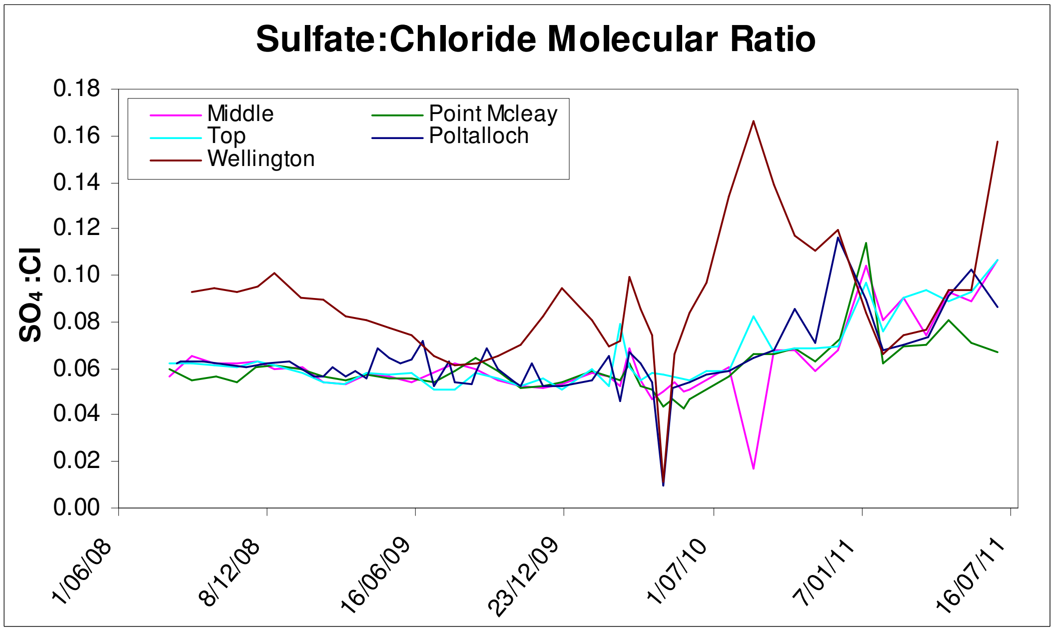


Figure 5 – Sulfate:chloride ratio at the Lake Alexandrina ambient monitoring sites

Salinity (EC)

- Salinity (as measured by electrical conductivity) levels have stabilised at consistent and low levels right across Lake Alexandrina (Figure 6). The high Murray-Darling Basin inflows and export of accumulated salt through the barrages have driven the reduction and subsequent stabilisation of salinity within the lake. The exception to this is the increase recorded at point McLeay this can be attributed to the salt water intrusion through the barrages as a result of some large tides and strong winds pushing seawater back up into the Goolwa Channel through the barrages.

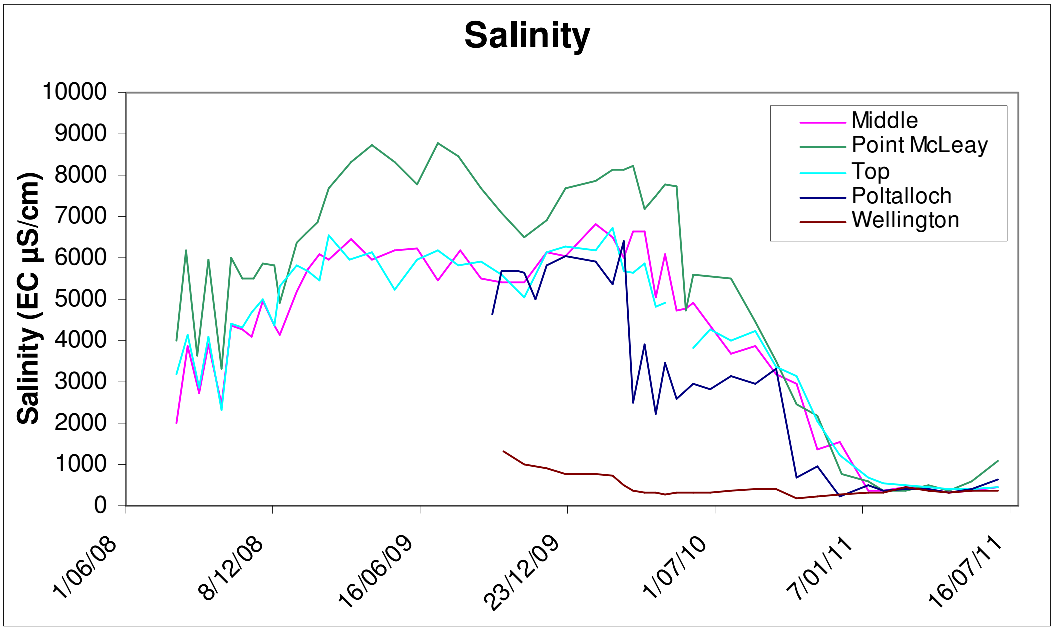


Figure 6 – Salinity at the Lake Alexandrina ambient monitoring site

Turbidity

- Turbidity within Lake Alexandrina decreased at all sites with the exception of the Wellington site in the June sampling. Wellington also remains much more turbid than the lakes (Figure 7). Changes in turbidity levels across Lake Alexandrina are primarily influenced by wind strength and direction at the time of sampling which influences the amount of sediment resuspension from the lake bed.

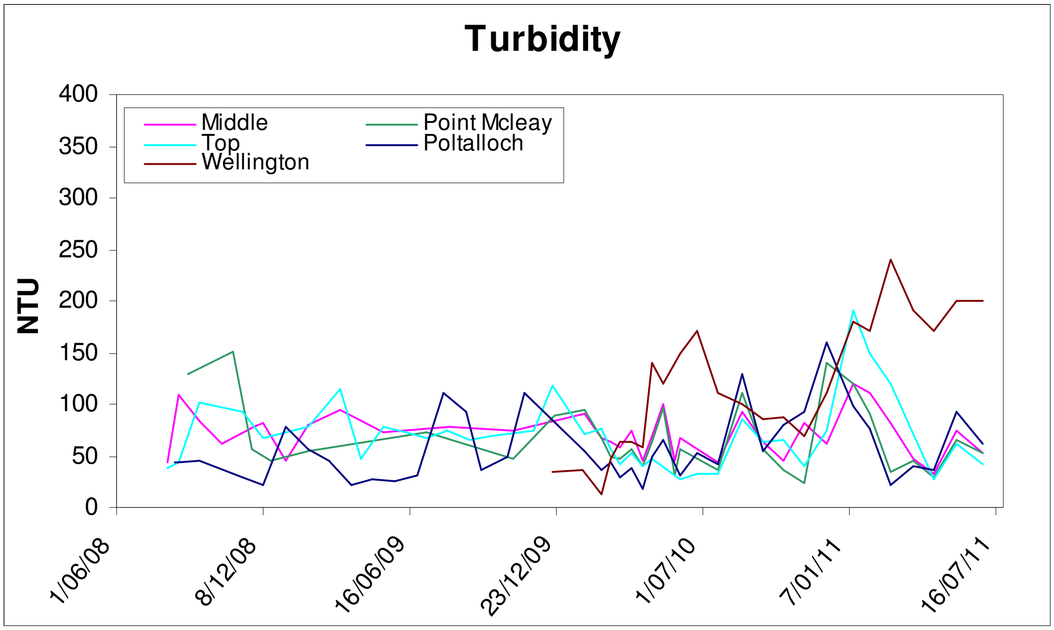


Figure 7 – Turbidity at the Lake Alexandrina ambient monitoring sites

Nutrients (total nitrogen and phosphorus)

- Total nitrogen and phosphorus levels within Lake Alexandrina remain stable with a slight decrease at all sites during June (Figures 8 and 9). Levels remain above ANZECC guidelines for freshwater ecosystems (<1mg/L TN, <0.025 mg/L TP). Total nutrient concentrations within Lake Alexandrina appear largely driven by the high lake flushing rate, with levels reflecting that of the river inflow (Wellington site).

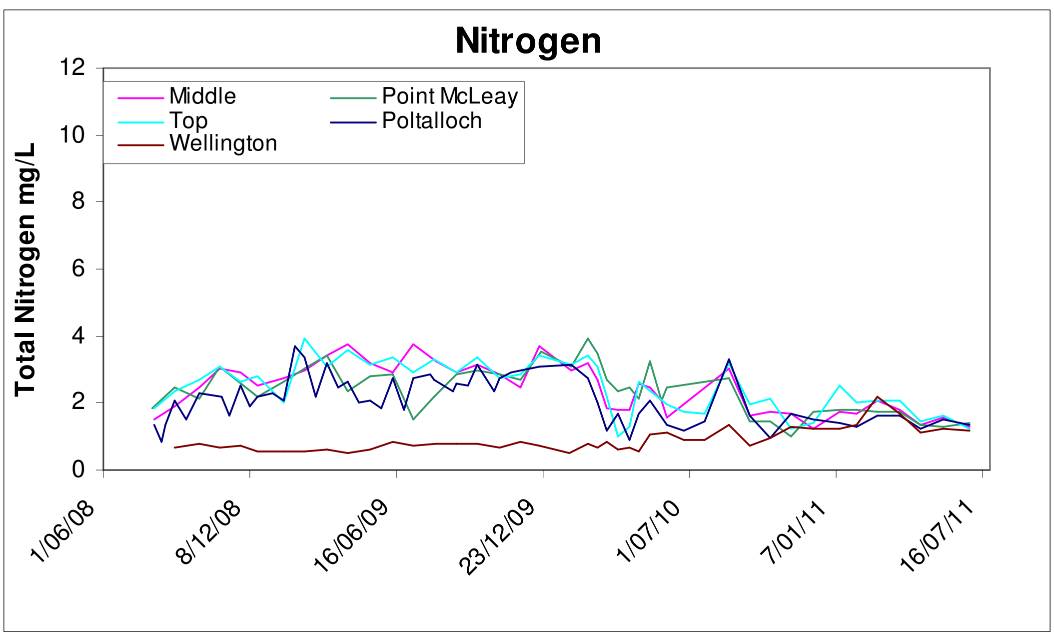


Figure 8 – Total nitrogen at the Lake Alexandrina ambient monitoring sites

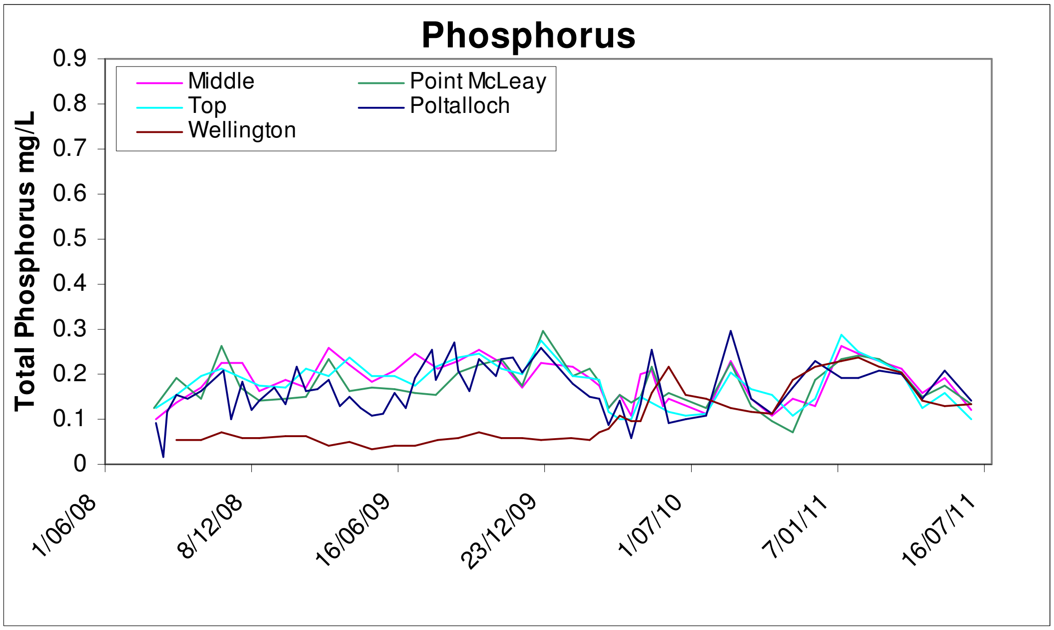


Figure 9 – Total phosphorus at the Lake Alexandrina ambient monitoring sites

Chlorophyll a (algae)

- Chlorophyll *a* in Lake Alexandrina decreased at all sites in June (Figure10). Cooler conditions and fewer hours of daylight will slow primary productivity and algal growth within Lake Alexandrina. Despite this Chlorophyll *a* levels remain above ANZECC guidelines (15ug/L) and Lake Alexandrina is considered hyper eutrophic.

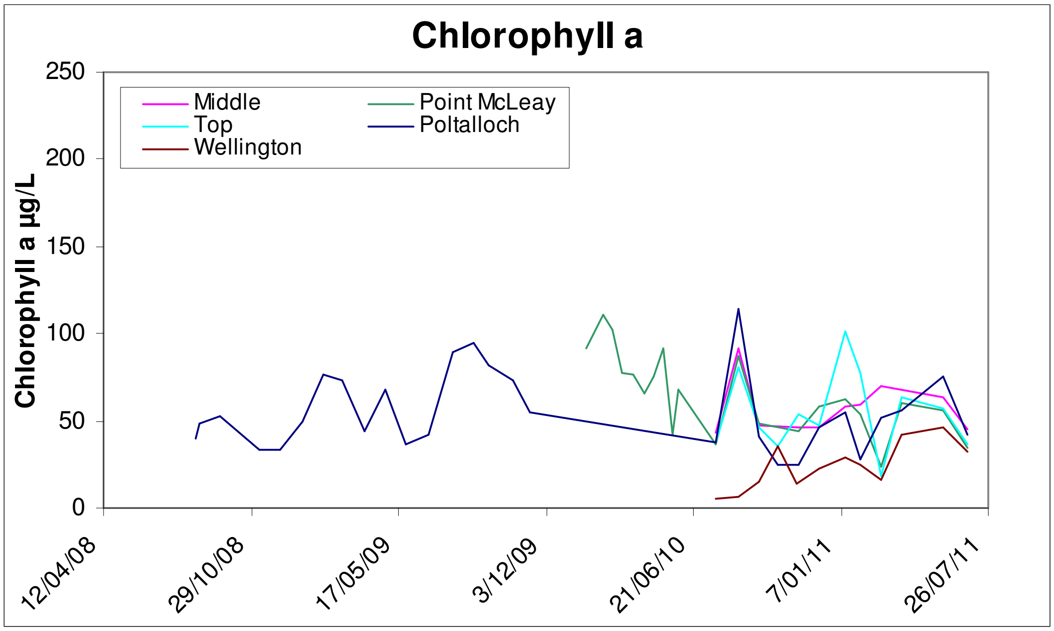


Figure 10 – Chlorophyll *a* at the Lake Alexandrina ambient monitoring sites

Metals

- Total aluminium and total iron levels within Lake Alexandrina remain stable but with a slight decrease across all sites (Figures 11 and 12). At present, lake metal concentrations appear to be more related to variable floodwater concentrations than lake geochemical processes.

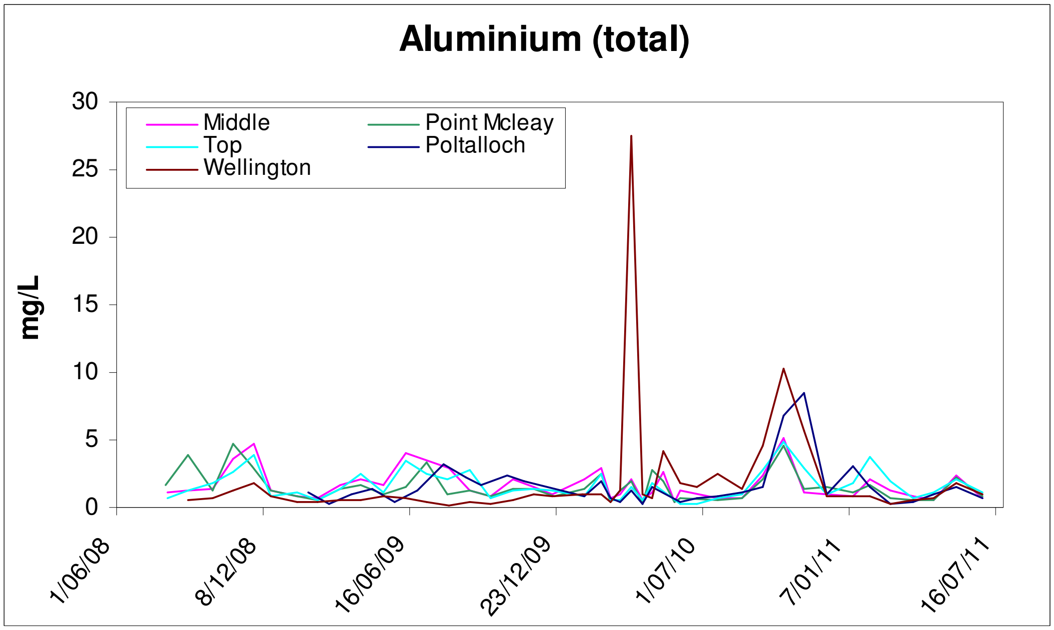


Figure 11 – Total aluminium at the Lake Alexandrina ambient monitoring sites

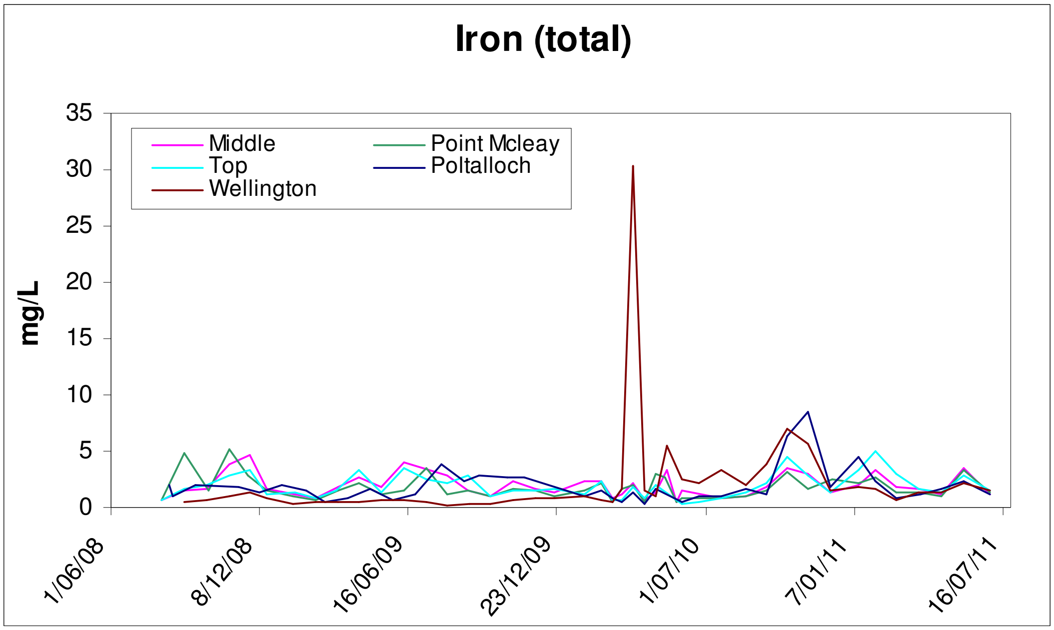


Figure 12 – Total iron at the Lake Alexandrina ambient monitoring sites

Lake Albert Water Quality

Ambient water quality monitoring results are discussed below for selected sites and parameters in Lake Albert. In mid September (starting 19/9/10), the Narrung bund was partially breached and monitoring data after this reflects changes due to inflows from Lake Alexandrina. Figure 13 shows the water level as measured in Lake Albert from March 2010. The figure clearly shows the rapid rise in water levels following removal of the regulator and recent managed Lake Alexandrina water level fluctuations designed to pulse/pump water and export salt from Lake Albert.

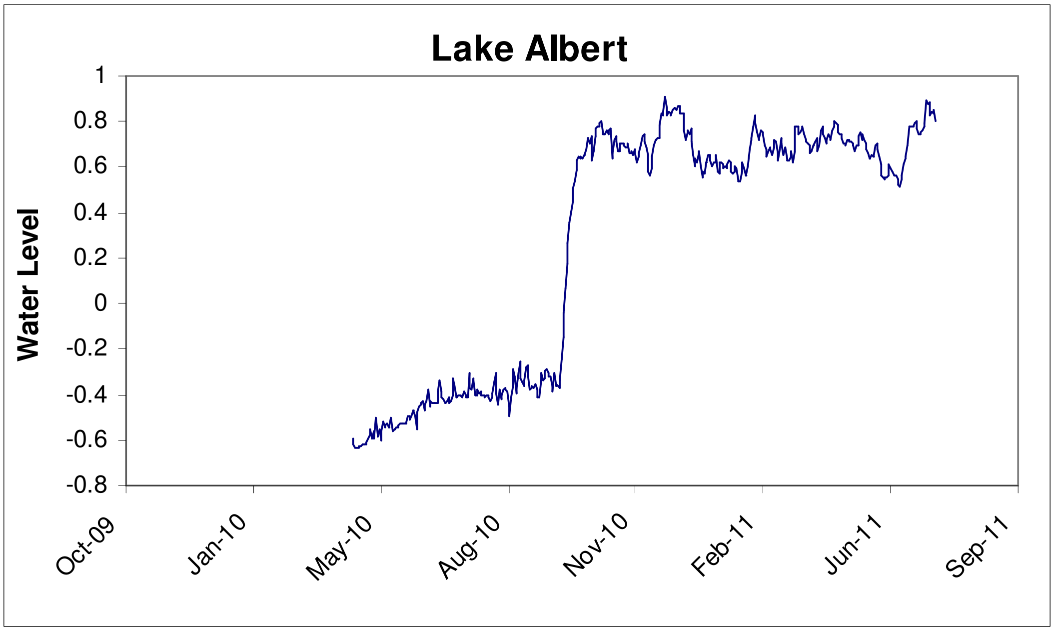


Figure 13 – Water level in Lake Albert

pH

pH levels in Lake Albert decreased slightly for most sites (Figure 14) but remain within ANZECC guideline levels (pH 6.5-9.0).

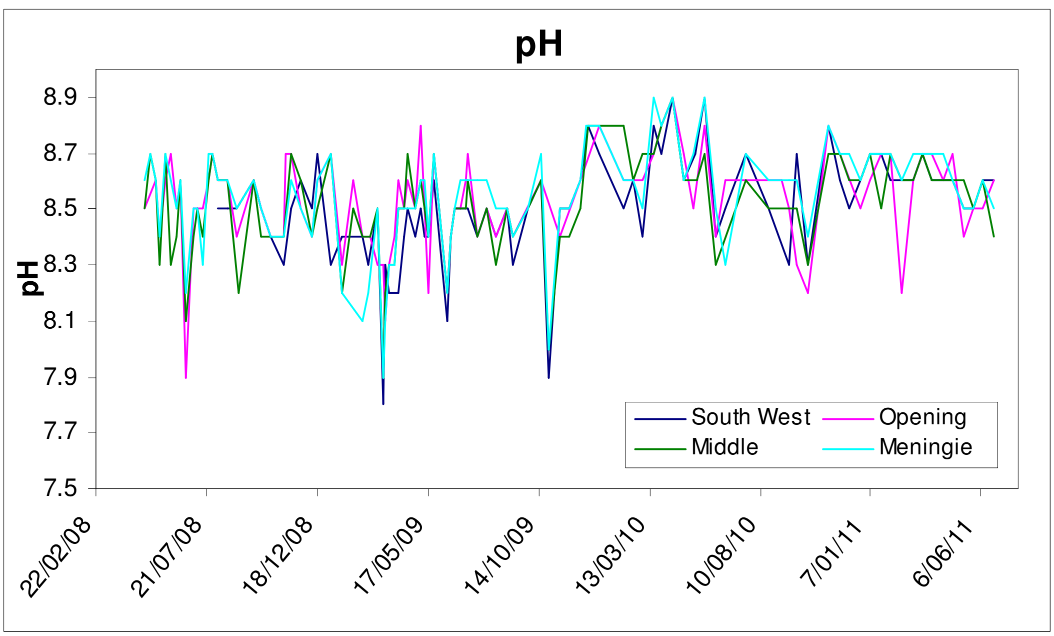


Figure 14 – pH at the Lake Albert ambient monitoring sites

Alkalinity

- Alkalinity within Lake Albert remained stable across most sites during June with the exception of the Opening site which continued to show significant variability in levels (Figure 15). The Opening site is the most influenced by inflow of lower alkalinity water from Lake Alexandrina and thus experiences more variability in concentrations.

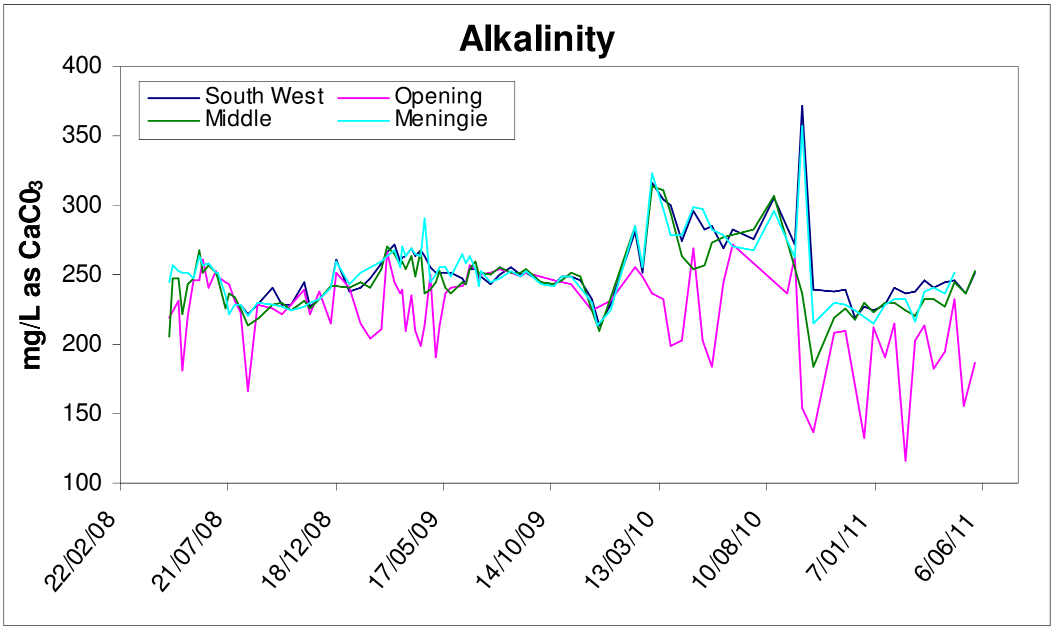


Figure 15 – Alkalinity at the Lake Albert ambient monitoring sites

Sulfate:chloride ratio

- The sulfate:chloride ratio has remained stable across all Lake Albert sites with only the Opening site showing any variation (Figure 16). This indicates that the lake system is not experiencing any additional sulfate inputs which come from the presence of acid sulfate soils and water movement through acidic soil profiles.

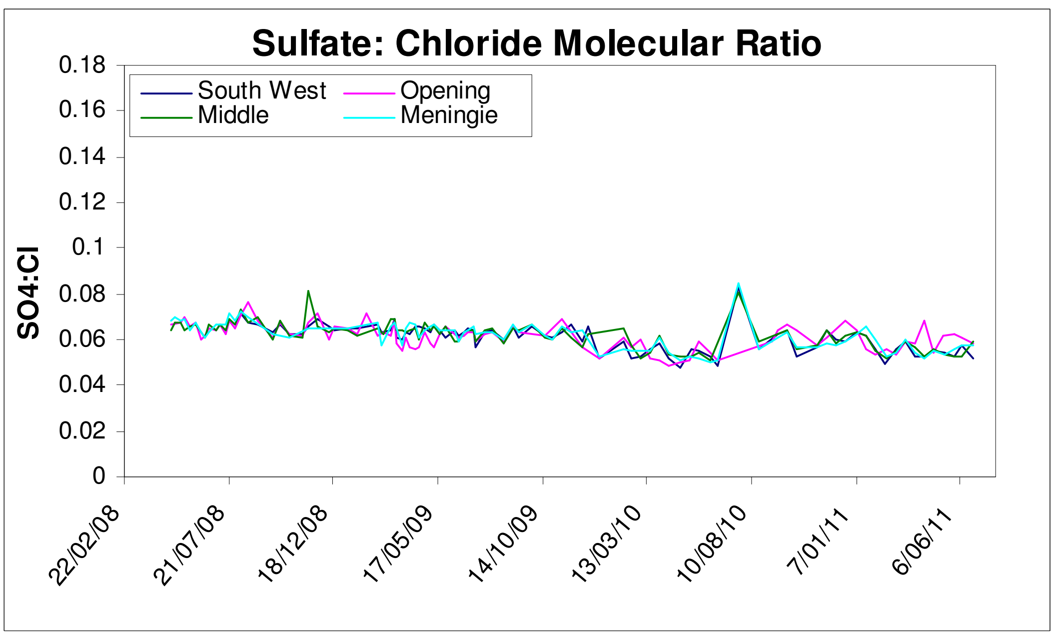


Figure 16 – Sulfate:chloride ratio at the Lake Albert ambient monitoring sites

Salinity (EC)

- Salinity levels continues to decrease across most sites in June but still remain high (between 2900 and 7000 µS/cm) compared to historical averages of <1600 µS/cm (Figure 17). The Opening site continues to show the most variability in salinity levels as it is influenced by inflows from Lake Alexandrina primarily driven by wind direction and water level manipulations, as seen in Figure 14. The full removal of the Narrung bund and further inflows and mixing of water from Lake Alexandrina are expected to reduce salinities across Lake Albert, however it is unlikely salinities will return to pre-drought levels for some time due to the limited water exchange between the two lakes.

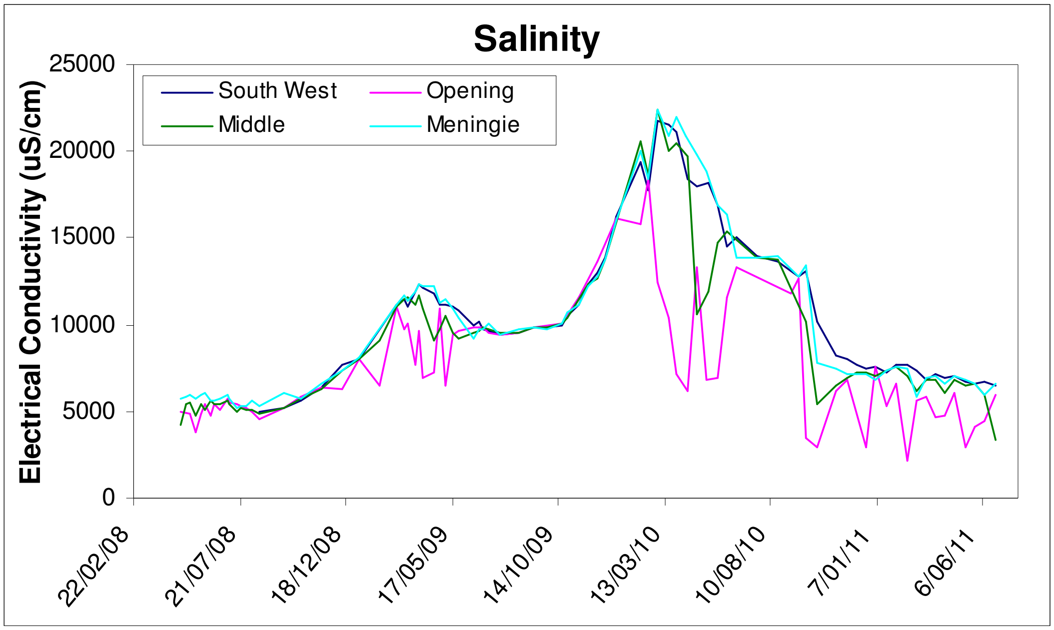


Figure 17 – Salinity at the Lake Albert ambient monitoring sites

Turbidity

- Turbidity in Lake Albert has remained stable but continues on an upward trend across all sites in June (Figure 18). This could be due to an increase in highly turbid Lake Alexandrina inflows, or possibly an increase in wind events during autumn. Changes in turbidity levels across Lake Albert are primarily influenced by wind strength and direction at the time of sampling which influences the amount of sediment resuspension from the lake bed.

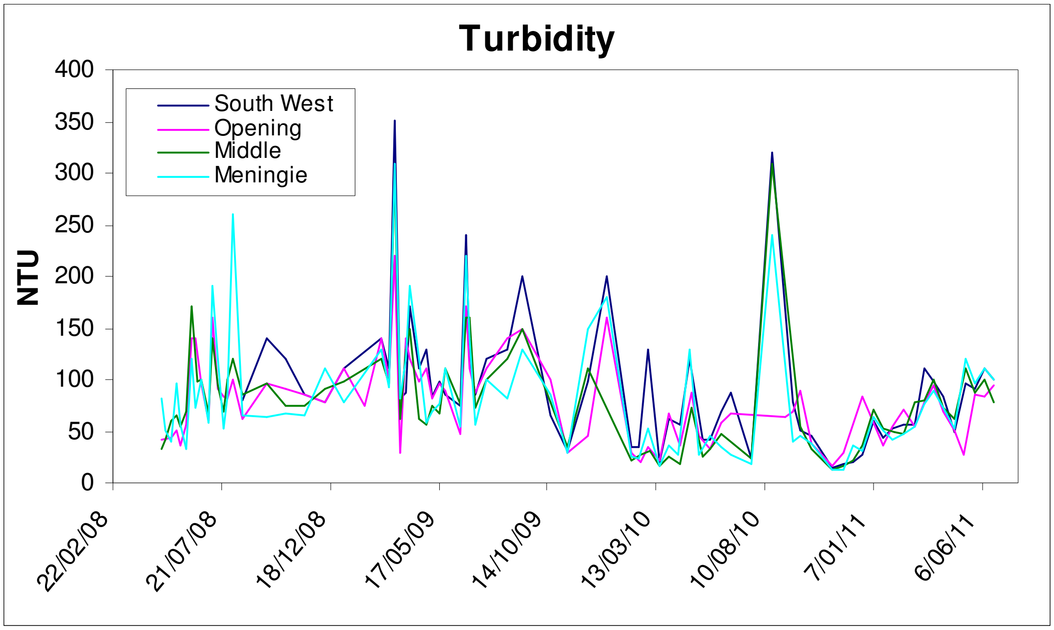


Figure 18 – Turbidity at the Lake Albert ambient monitoring sites

Nutrients (total nitrogen and phosphorus)

- Total nitrogen and phosphorus levels have remained stable across most Lake Albert sites during June (Figures 19 and 20). Nutrient levels are comparable to historic data, however continue to be in excess of the ANZECC guidelines for freshwater ecosystems (<1mg/L TN, <0.025 mg/L TP).

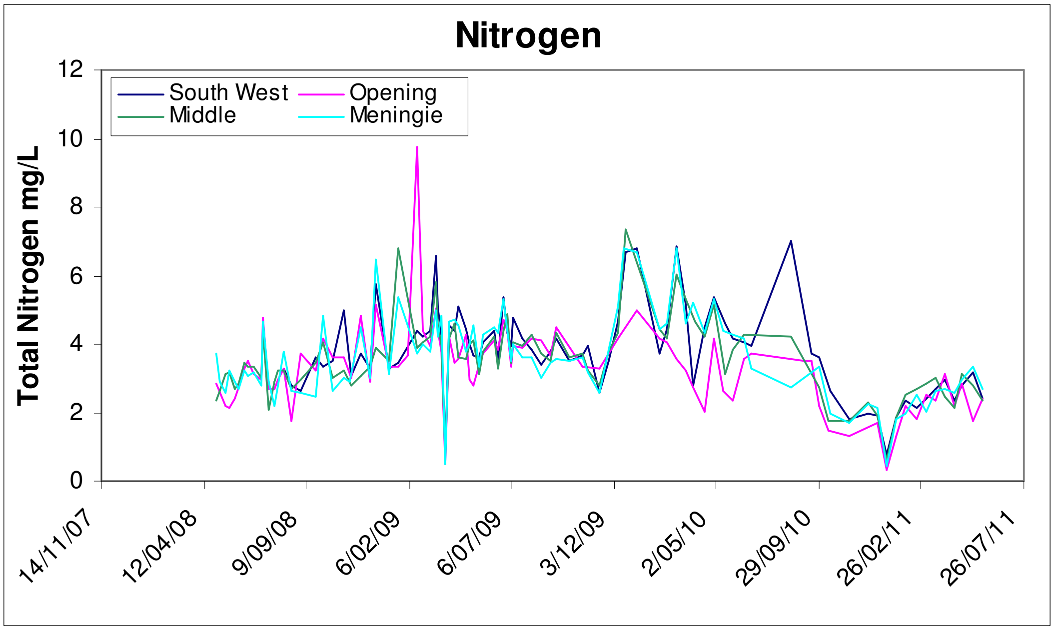


Figure 19 – Total Nitrogen at the Lake Albert ambient monitoring sites

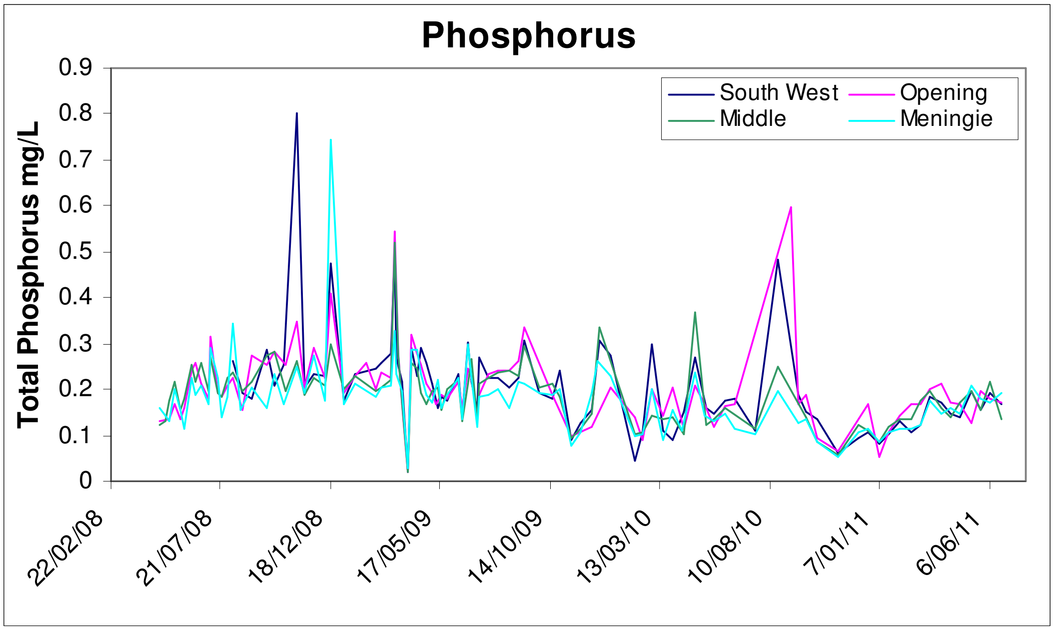


Figure 20 – Total phosphorus at the Lake Albert ambient monitoring sites

Chlorophyll a (algae)

- Chlorophyll *a* for Lake Albert has remained stable overall at most sites, however levels remain well in excess of ANZECC guidelines (>15 µg/L considered hyper-eutrophic) and indicate a nutrient enriched system (Figure 21). This is a result of shorter days and cooler temperatures limiting the amount of primary production.

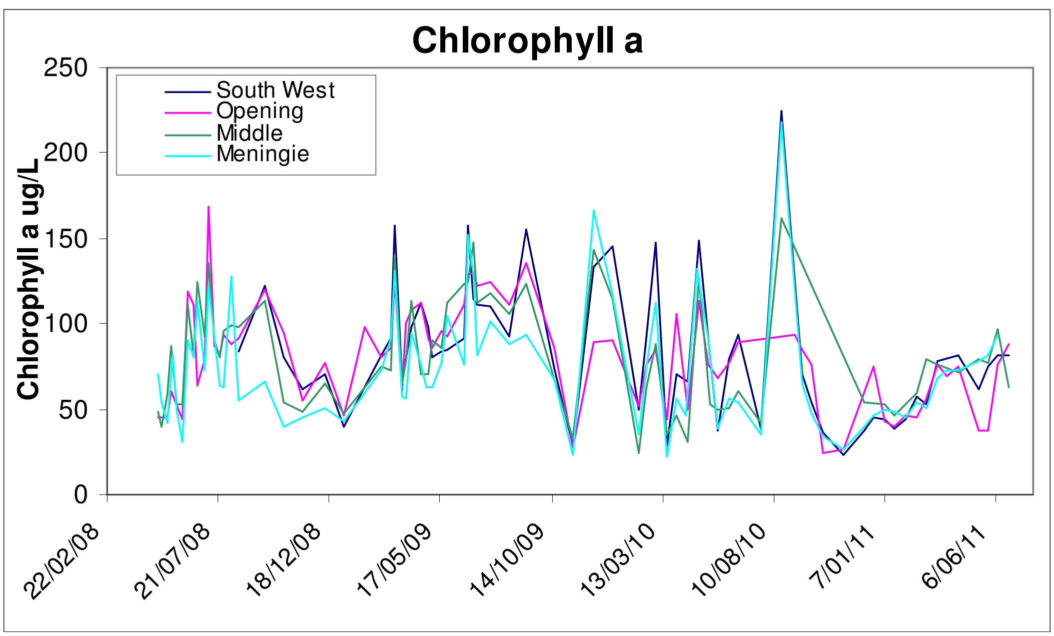


Figure 21 – Chlorophyll *a* at the Lake Albert ambient monitoring sites

Metals

Total aluminium and iron concentrations within Lake Albert remain at low levels but have slightly decreased at all sites during June (Figures 22 and 23).This is likely due to increased settling of sediment (containing metals), consistent with the slightly lower turbidities shown in Figure 18.

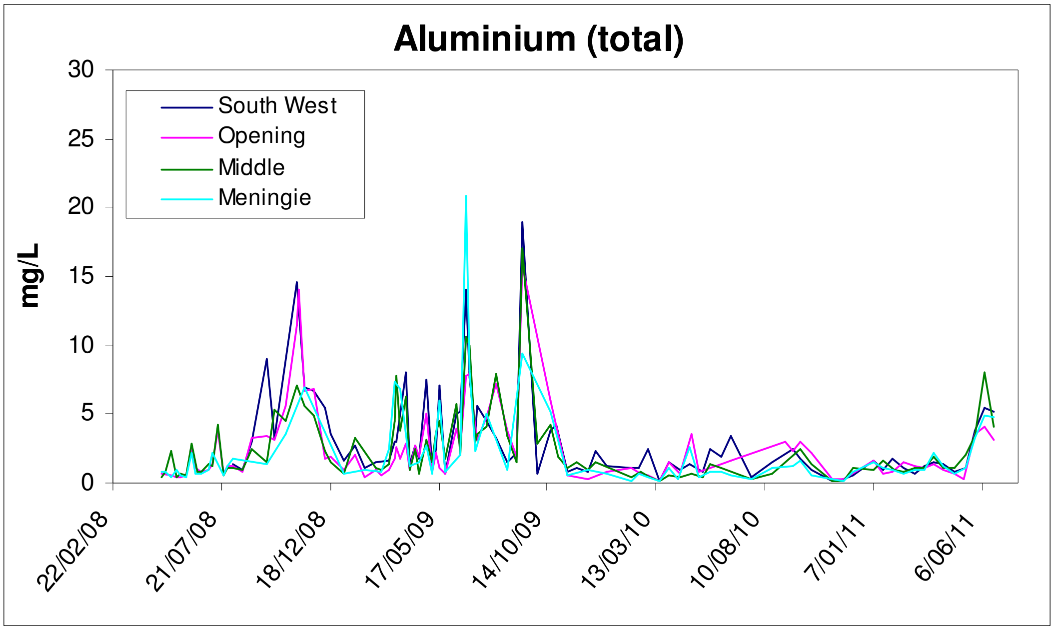


Figure 22 – Total aluminium at the Lake Albert ambient monitoring sites

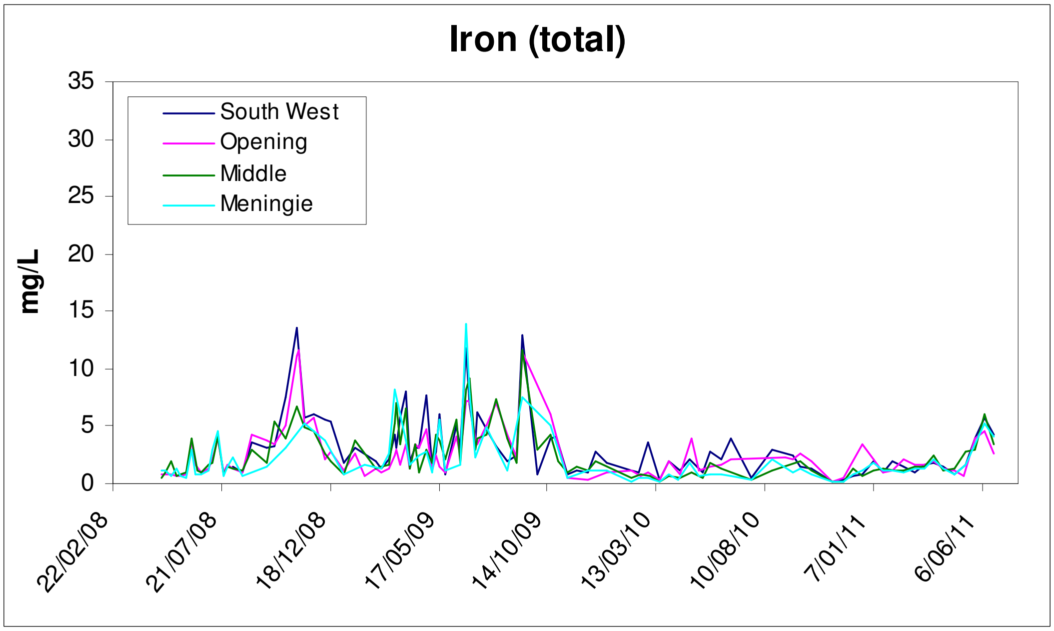


Figure 23 – Total iron at the Lake Albert ambient monitoring sites

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 24 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 2010 (starting 26/9/10), the Goolwa regulator near Clayton was partially breached so monitoring data after this will reflect changes due to inflows from Lake Alexandrina. The water level in this region is shown in Figure 25.

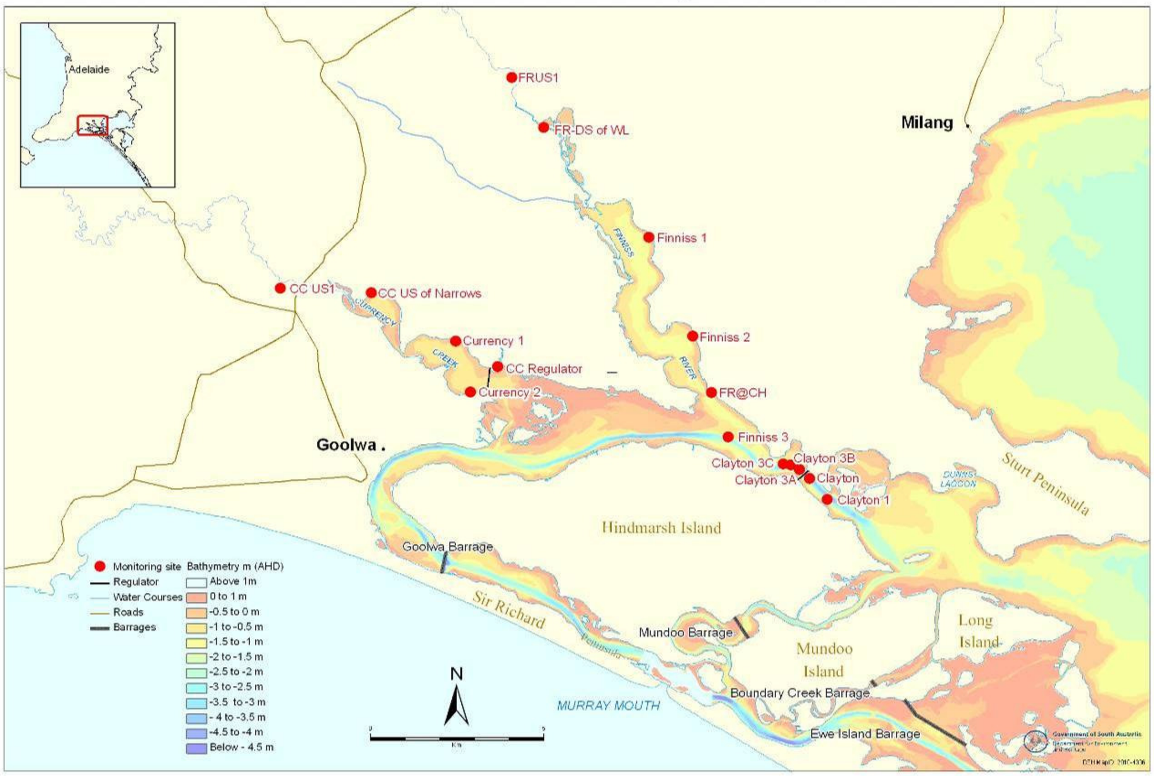


Figure 24 – Goolwa Channel and Tributaries ambient and event-based monitoring sites

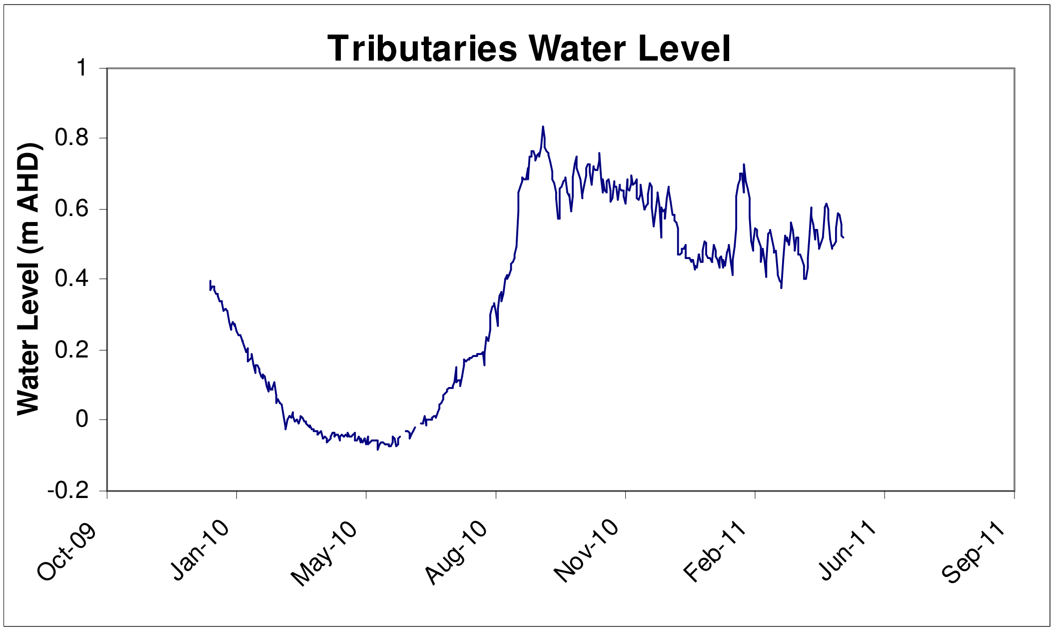


Figure 25 – Water level in the tributaries

pH

- pH levels at all sites in the Goolwa Channel and Tributaries region have remained quite stable and within ANZECC guideline values (pH 6.5-9.0) since water levels have increased in the region (Figure 26).

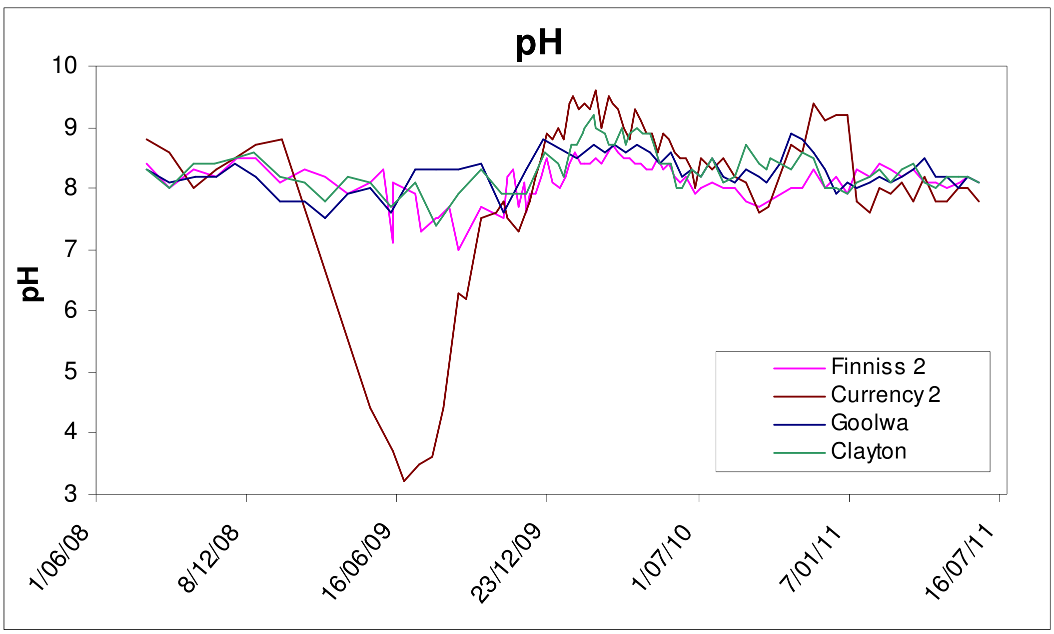


Figure 26 – pH at the Goolwa Channel and Tributaries monitoring sites

Alkalinity/Acidity

- Alkalinity levels at all of the Goolwa Channel and Tributaries sites remain stable with Currency 2 recording the highest levels (See Figure 27). Laboratory results (not displayed) have indicated there are consistent and low levels of acidity within Currency Creek and Finniss River. This is likely due to diffusion of acidity from the underlying acid sulfate soils sediments that were exposed during the 2007-2009 drought. Alkalinity and near neutral pH conditions are present in conjunction with the acidity. This will continue to be monitored closely over the coming months.

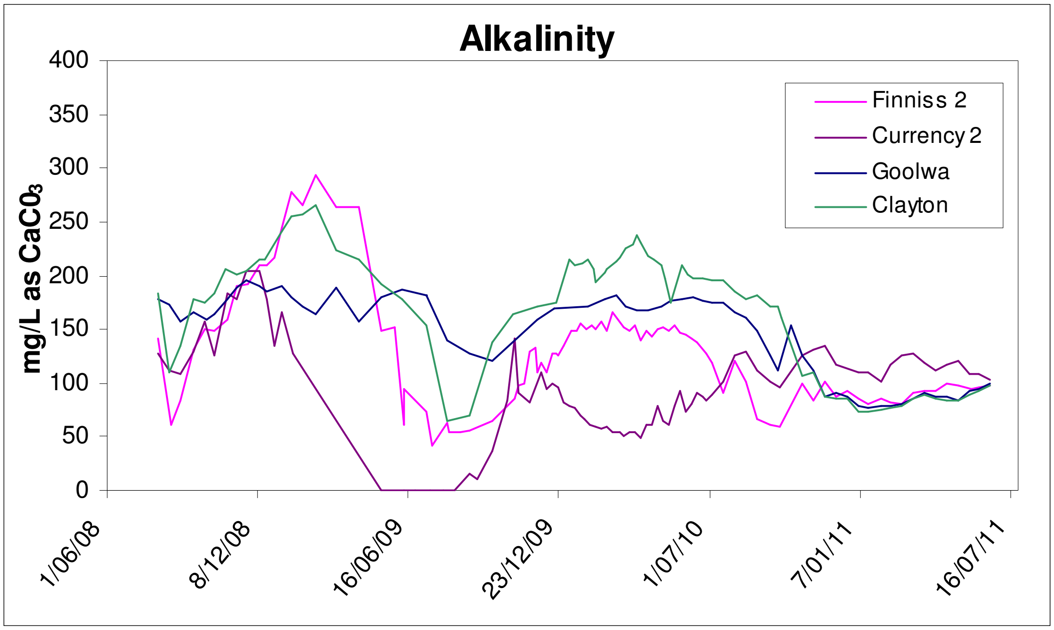


Figure 27 – Alkalinity at the Goolwa Channel and Tributaries monitoring sites

Sulfate:chloride ratio

- The sulfate: chloride ratio has stabilised with some minor decreases observed in June (Figure 28) which may relate to sulfate reduction processes on previously acidified sediments (compare to 2009 acidification period where elevated ratios occurred). This process, if it is occurring, is beneficial in remediating the submerged acidic sediments.

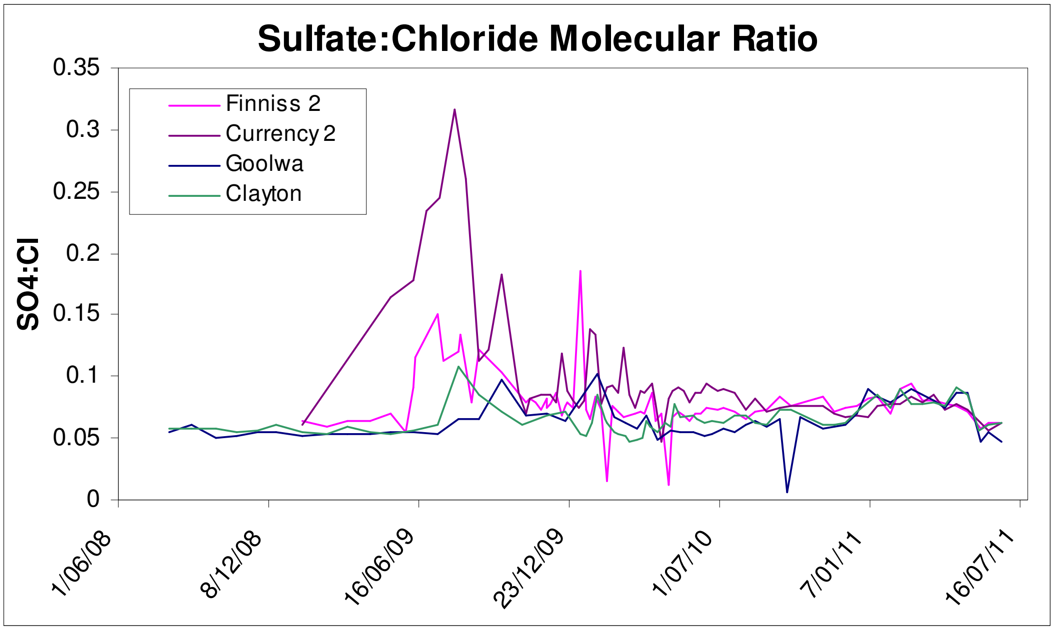


Figure 28 – Sulfate:chloride molecular ratio at the Goolwa Channel and Tributaries monitoring sites

Salinity (EC)

- Salinity levels spiked in June in the Goolwa Channel (Figure 29) This is a result of a king tide event pushing salt water through the open barrages into the Goolwa Channel. All of the other sites besides Goolwa stabilised but continue to remain elevated. This is especially the case at the Currency 2 site which is likely due to the regulator preventing mixing and flows from leaving Currency Creek.

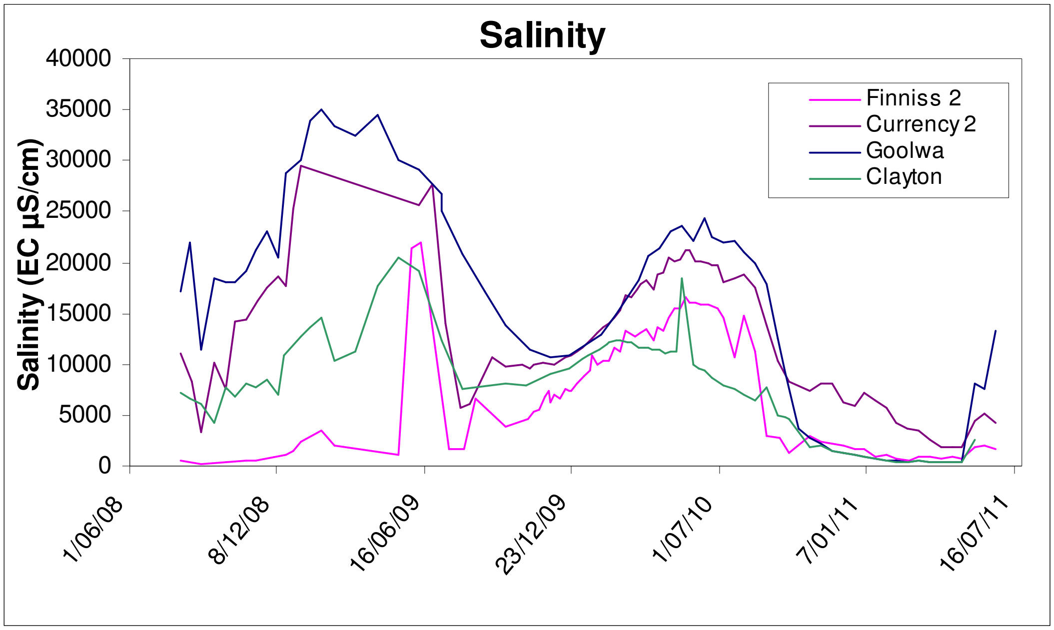


Figure 29 – Salinity at the Goolwa Channel and Tributaries monitoring sites

Turbidity

- Turbidity levels at the Clayton and Tributaries sites (Figure 30) have all increased. Currency 2 still remains lower than other Tributaries sites which may be as result of increased settling of particles behind the (partly submerged) Currency Creek regulator.

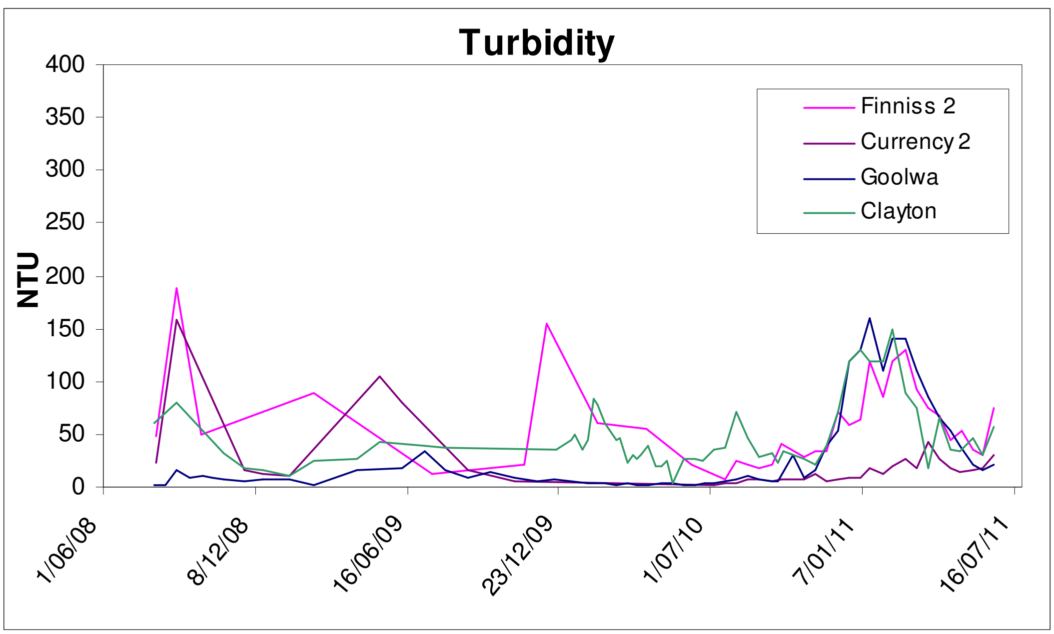


Figure 30 – Turbidity at the Goolwa Channel and Tributaries monitoring sites

Nutrients (total nitrogen and phosphorus)

- Total nitrogen and phosphorous levels continued to increase at all sites during June (Figures 31 and 32). This is likely due to winter rain run off transporting nutrients to the Goolwa Channel and Tributaries Nutrient levels throughout the Goolwa Channel and Tributaries appear to be coming more uniform. The exception to this is the Goolwa site which appears to be exhibiting the effects of the salt water intrusion and lower nutrient levels. Nutrient levels continue to remain above ANZECC guidelines for freshwater ecosystems (<1mg/L TN, <0.025 mg/L TP).

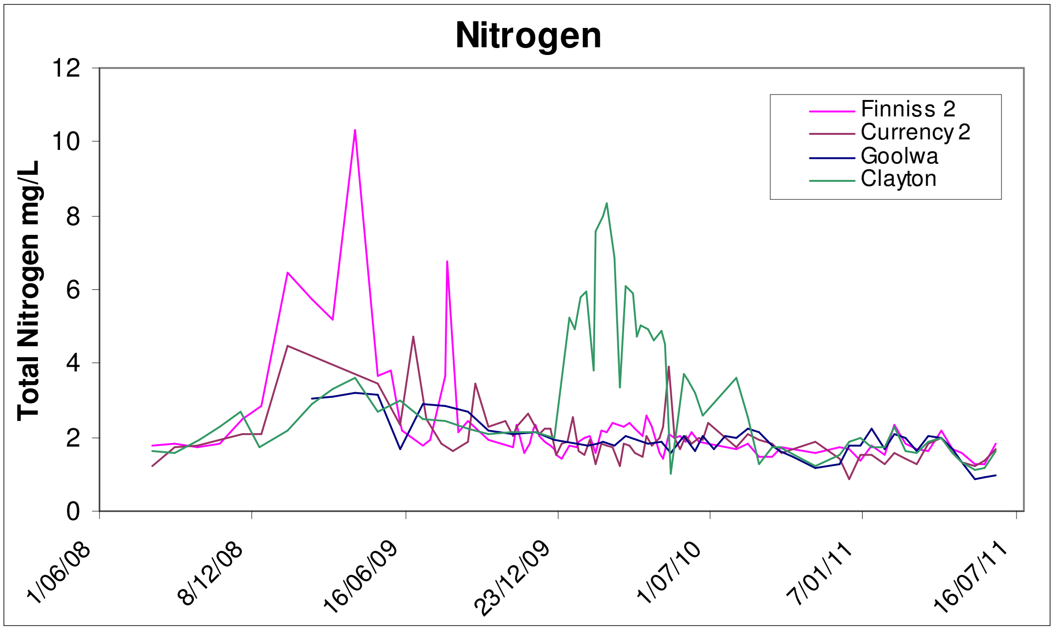


Figure 31 – Total Nitrogen at the Goolwa Channel and Tributaries monitoring sites

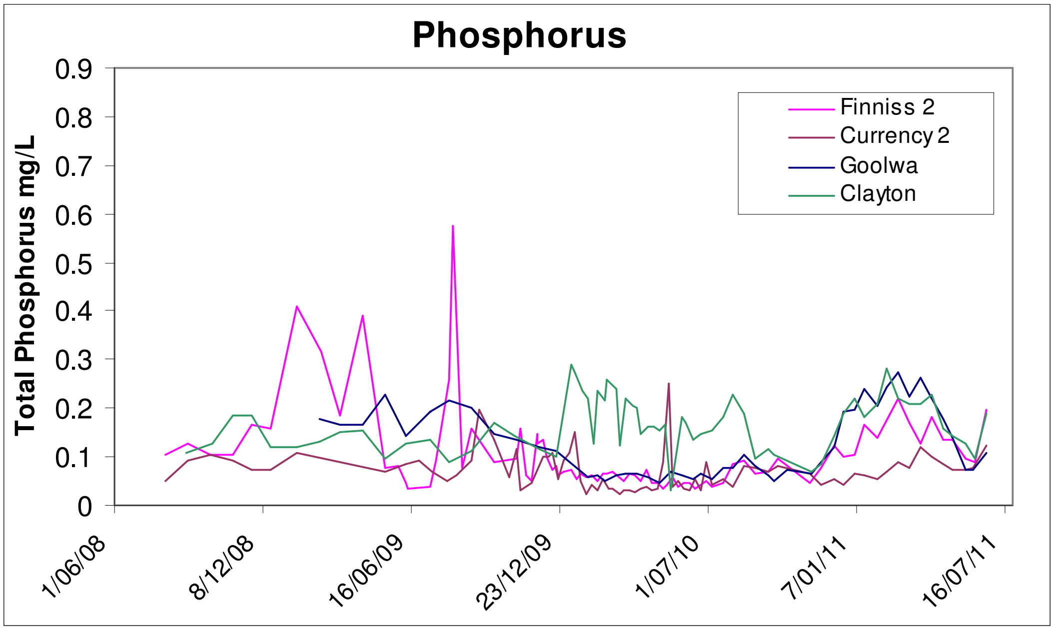


Figure 32 – Total phosphorus at the Goolwa Channel and Tributaries monitoring sites

Chlorophyll a (algae)

- Chlorophyll *a* increased within the Goolwa Channel and the Tributaries during June at most sites (See Figure 33). Cooler conditions and fewer hours of daylight are likely slowing primary productivity and algal growth. Despite this Chlorophyll *a* levels remain above ANZECC guidelines (15ug/L) which is considered hyper eutrophic

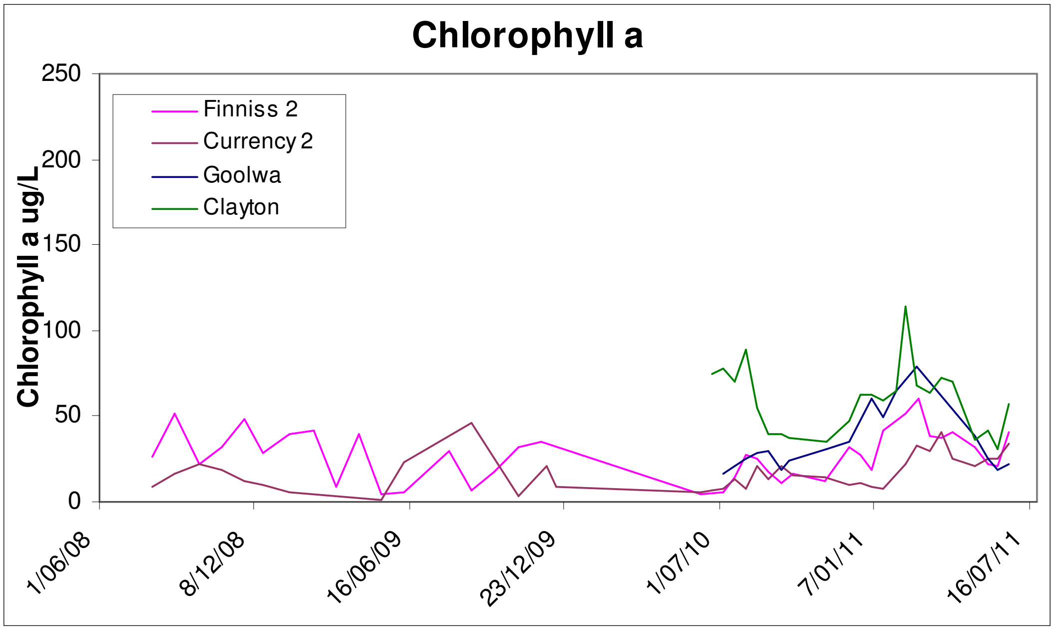


Figure 33 – Chlorophyll *a* at the Goolwa Channel and Tributaries monitoring sites

Metals

- Total aluminium and iron concentrations within the Goolwa Channel and Tributaries have remained stable during June. The exception to this is the Finniss 2 site which has exhibited an increase of both aluminium and iron levels, this is likely a result of rainfall and runoff in the catchment mobilising metals into the Finniss River (Figures 34 and 35). Levels remain relatively low compared to the drought period of 2008-2009 when large areas of acid sulfate soils were exposed. High lake flushing rates are likely contributing to the recent stable metal results in this region.

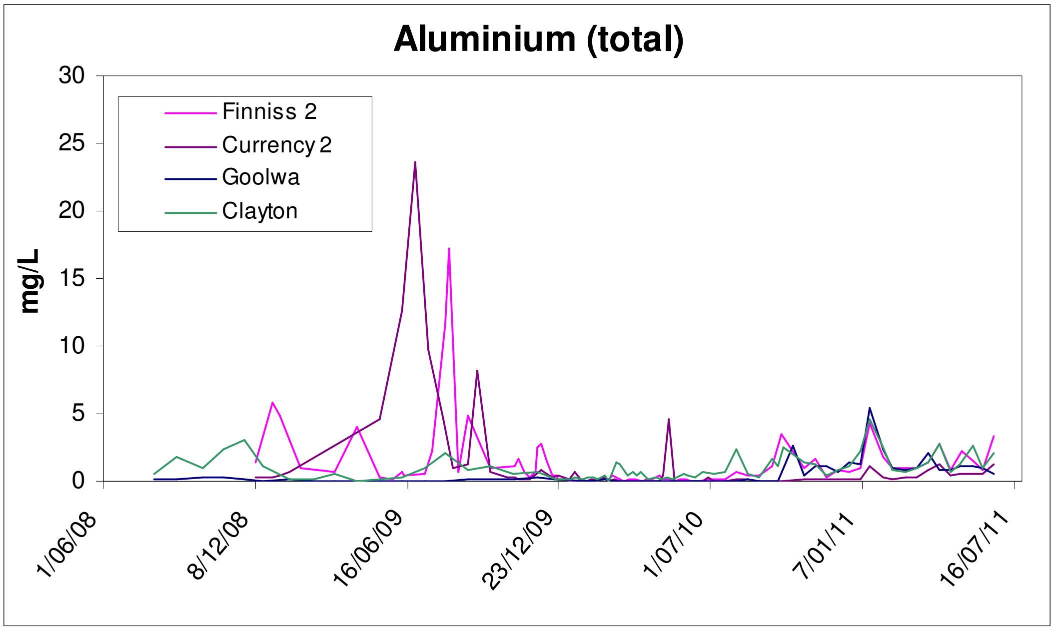


Figure 34 – Total aluminium at the Goolwa Channel and Tributaries monitoring sites

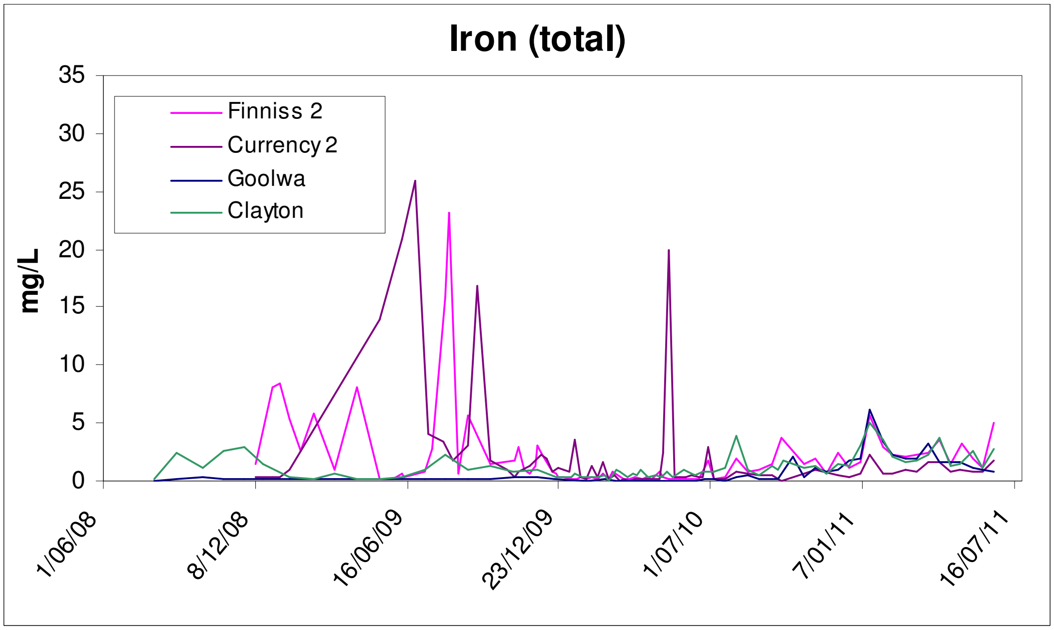


Figure 35 – Total iron at the Goolwa Channel and Tributaries monitoring sites

Event-based monitoring

Event-based water quality sampling is undertaken in regions that have experienced acidification or were at risk of acidification (Figure 36). 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 occurred in Currency Creek, Finniss River and Boggy Lake, Lake Alexandrina in 2009 and 2010. Limestone dosing reduces the acidity hazard and mitigates further metal release.

Event-based sampling is also presently undertaken in the Narrung Narrows to better understand the water exchange between the two lakes and from water level manipulation by opening and shutting the barrages (see Figure 37 for sites).

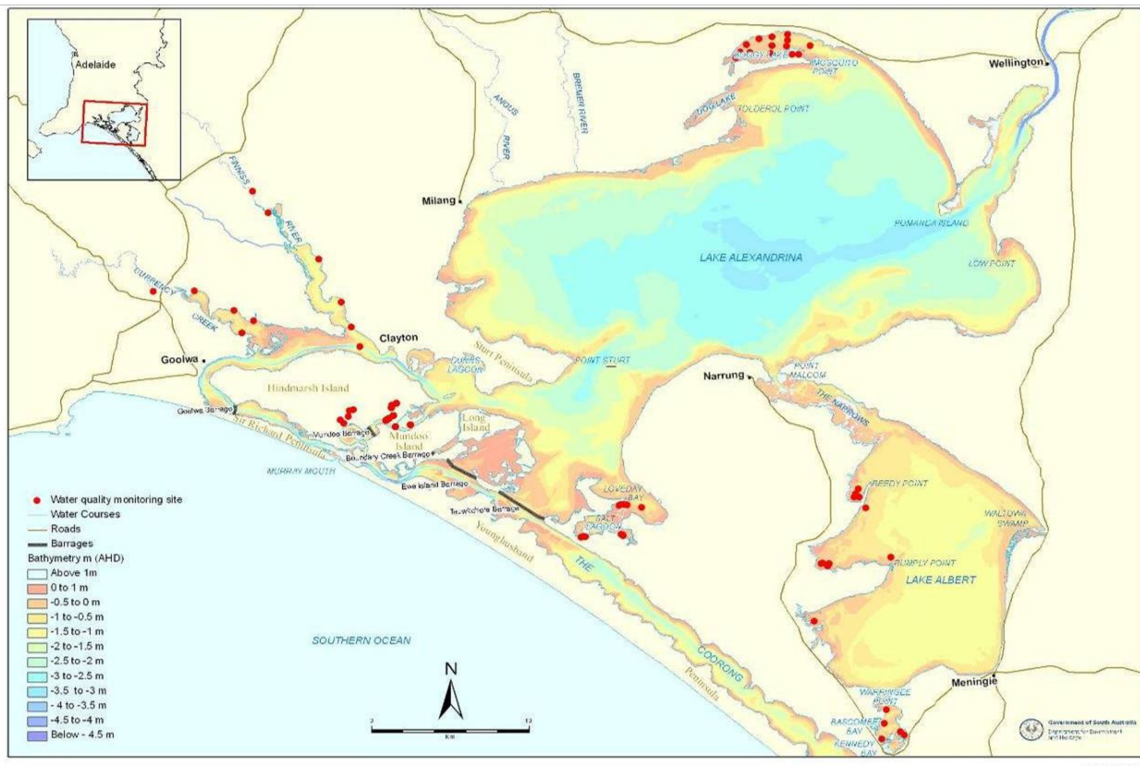
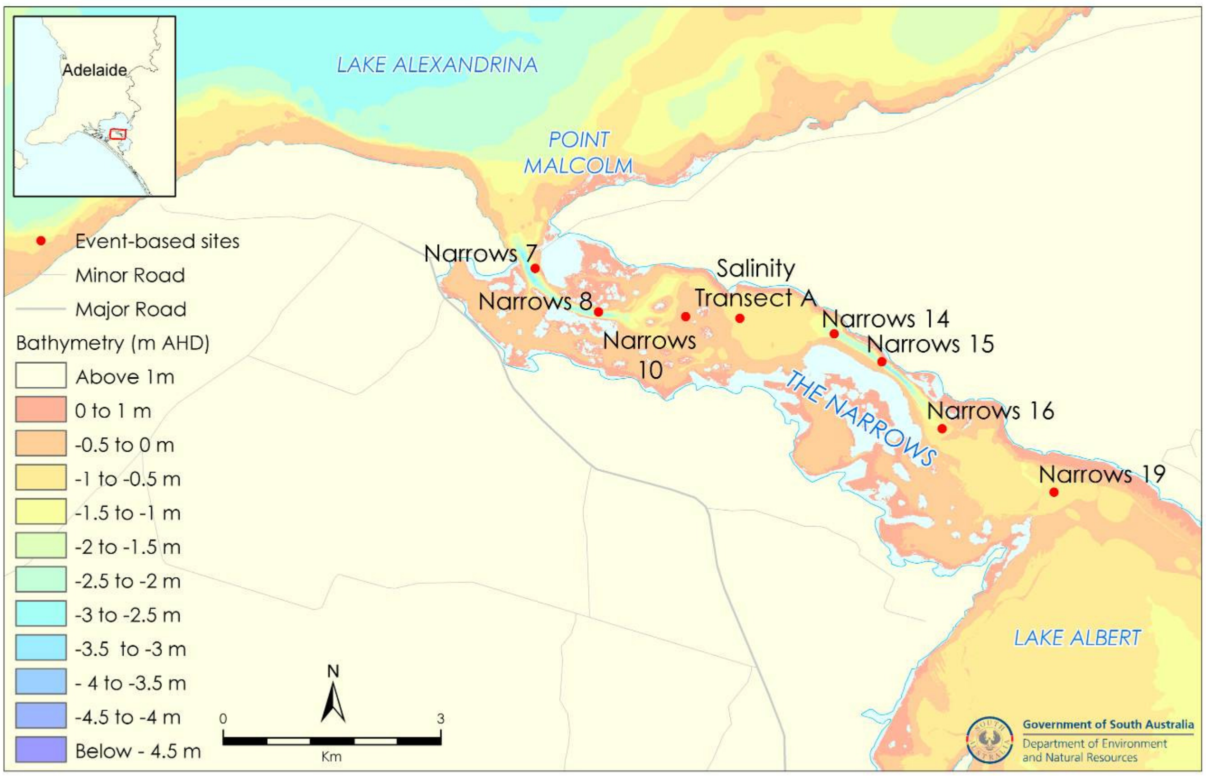


Figure 36 – Event-based water quality monitoring sites

Narrung Narrows Water Quality

Figure 37 shows the various sample sites for the Narrung Narrows separating Lake Alexandrina from Lake Albert. Sites within the Narrung Narrows have been monitored since the Narrung bund was breached in September 2010. pH levels, alkalinity and salinity within the narrows fluctuated greatly during June (Figure 38). The variability of the Narrung Narrows water quality results is likely a result of the varying wind directions and interactions with flood waters pushing water with lower salinity and alkalinity from Lake Alexandrina into the Narrows. Water level manipulations in Lake Alexandrina are also influencing these trends. Figure 39 is a visual representation of surface conductivity (in µS/cm) along a continuous boat transect through the Narrung Narrows. It displays how on this particular day the Narrung Narrows salinity was quite similar to that in Lake Albert indicating that water was flowing out of Lake Albert.



DEH MapID: 2011-4883

Figure 37 – Narrung Narrows monitoring sites

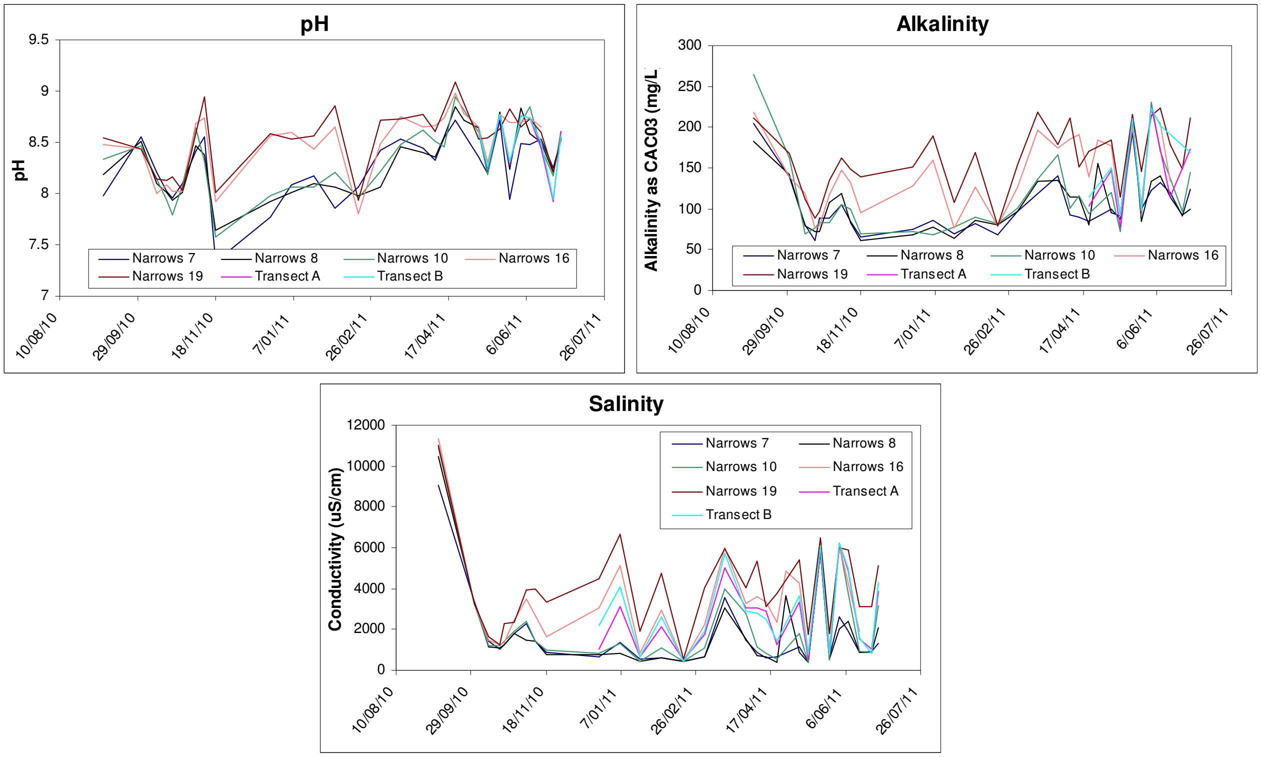


Figure 38 –Narrung Narrows water quality results

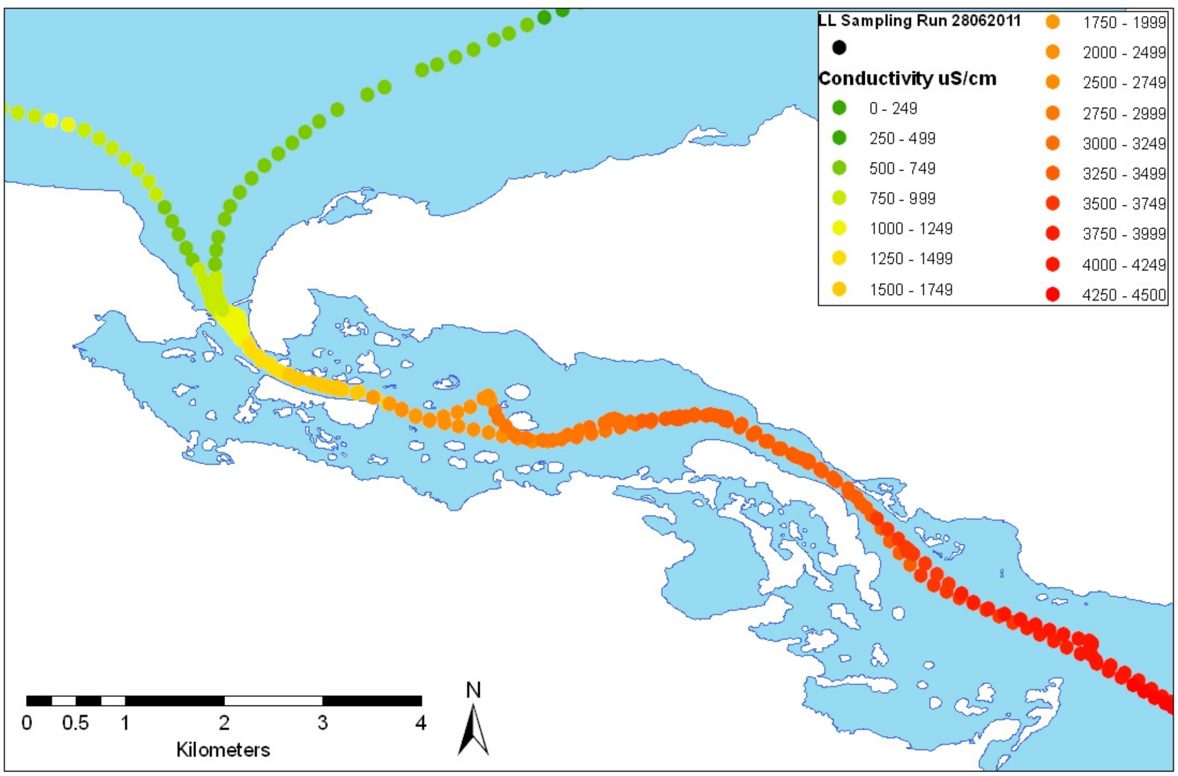
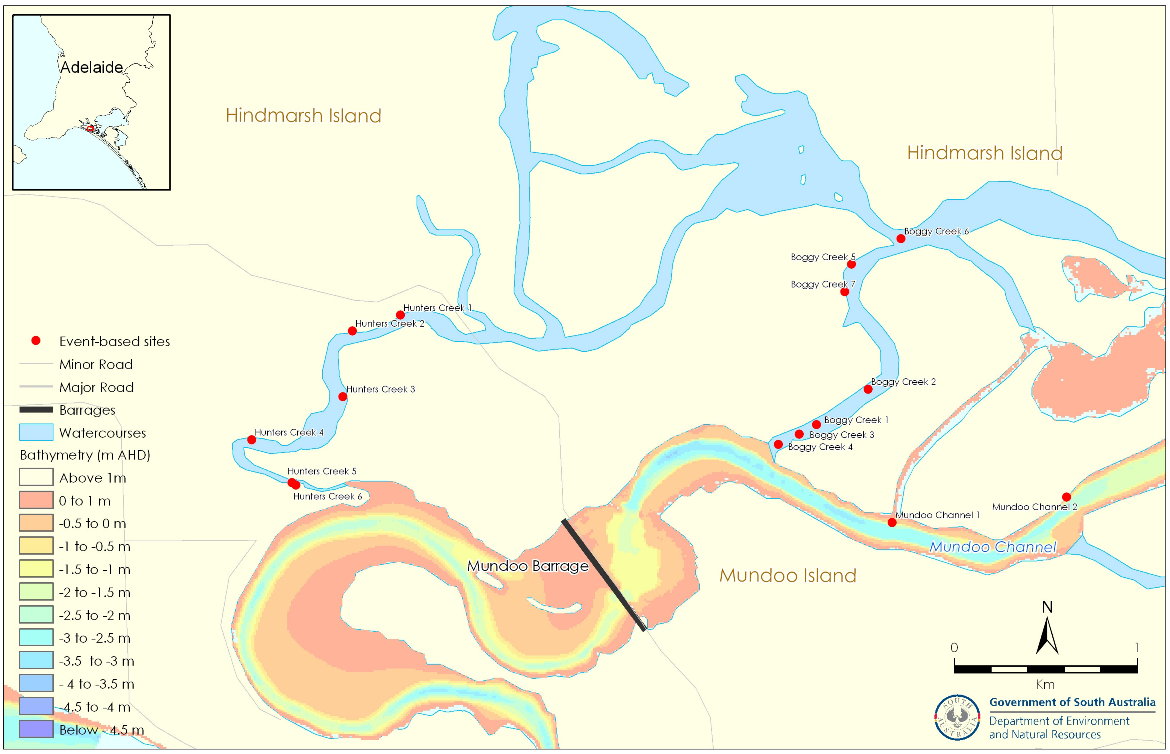


Figure 39 – Narrung Narrows salinity transect (28 June 2011)

Boggy Creek and Hunters Creek Water Quality

Figure 40, 41 and 42 show the Boggy Creek and Hunters Creek sampling sites and water quality results respectively. During the month of June salinity at most sites decreased, however there was still some residual effects from the king tide event which occurred whilst the barrages were open causing a flux of marine water into the Mundoo channel as well as Boggy and Hunters Creek. During June pH and alkalinity remained stable and within ANZECC guidelines throughout Boggy and Hunters Creek (figures 41 and 42), however there continues to be persistent low levels of acidity present at most sites. The acidity is likely from previously exposed acid sulfate soils, with acidity levels remaining low from the current inflows. Boggy and Hunters Creek will be continued to be monitored over the coming months.



DEH MapID: 2011-4846

Figure 40 –Boggy Creek and Hunters Creek site locations

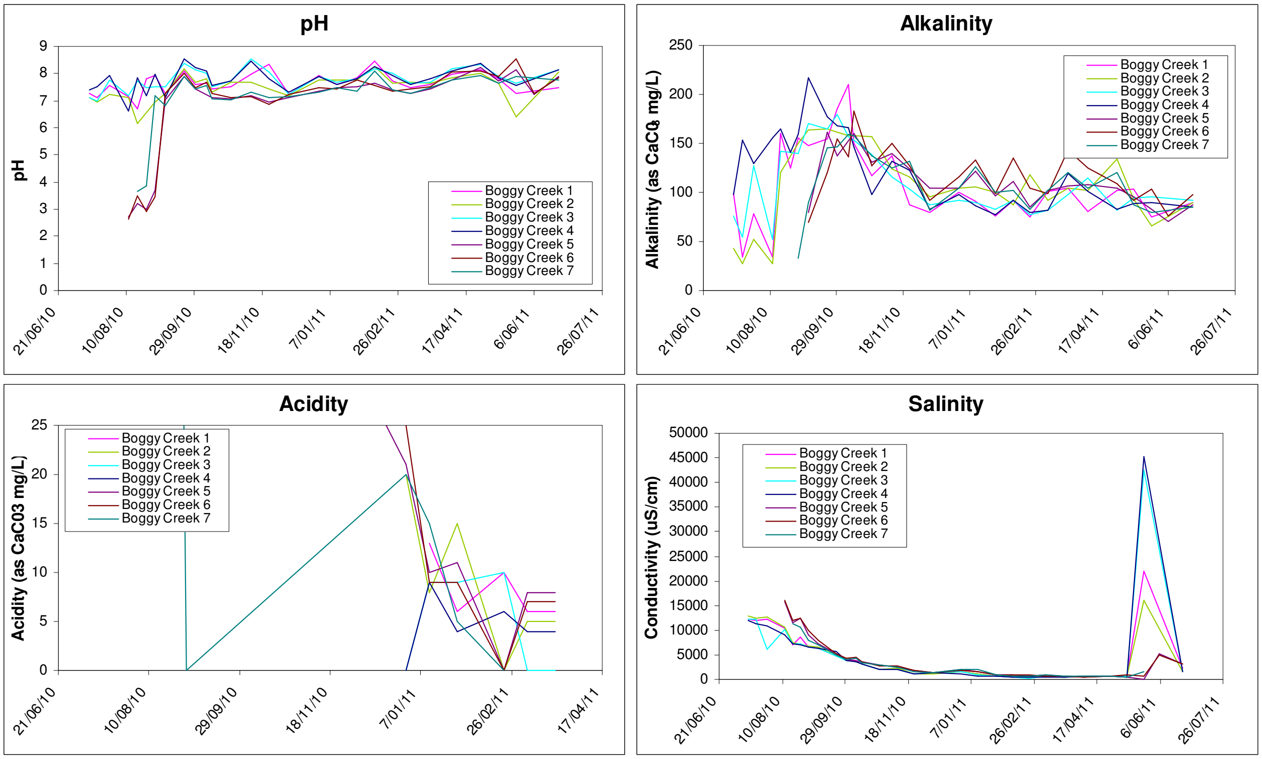


Figure 41 –Boggy Creek water quality results

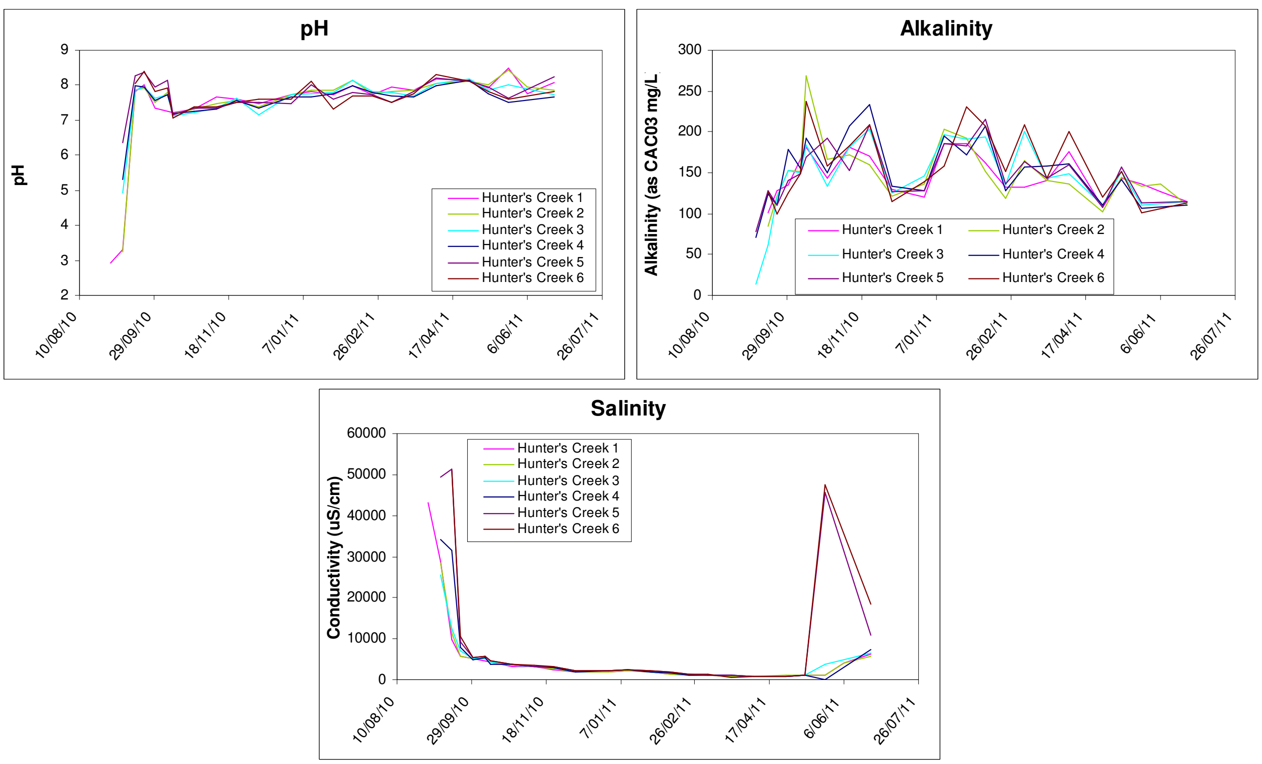


Figure 42 –Hunters Creek water quality results

Further Information

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

- Environment Protection Authority www.epa.sa.gov.au or for specific Lower Lakes data see http://www.epa.sa.gov.au/environmental_info/water_quality/lower_lakes_water_quality_monitoring
- Department of Environment and Natural Resources www.environment.sa.gov.au/cllmm/
- River Murray Data http://data.rivermurray.sa.gov.au/ (real-time data)
- 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