Lower Lakes and Tributaries

Water Quality Report

Ambient and Event-based Monitoring

Report 27, May 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***
- ***A large spike in salinity was recorded within the Goolwa Channel and Tributaries, and at Boggy and Hunter's Creek as a result of a king tide event and open barrages.***

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 $CaCO_3$*

***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 there presence in sediment.*

***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).*

***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*

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

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.

Dissolved Oxygen is a measure of the quantity of oxygen present in water. Oxygen is essential for almost all forms of life Aquatic animals, plants and most bacteria need it for respiration as well as for some chemical reactions. The concentration of dissolved oxygen is an important indicator of the health of the aquatic ecosystem. Persistently low dissolved oxygen (<6 mg/L) will harm most aquatic life.

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).

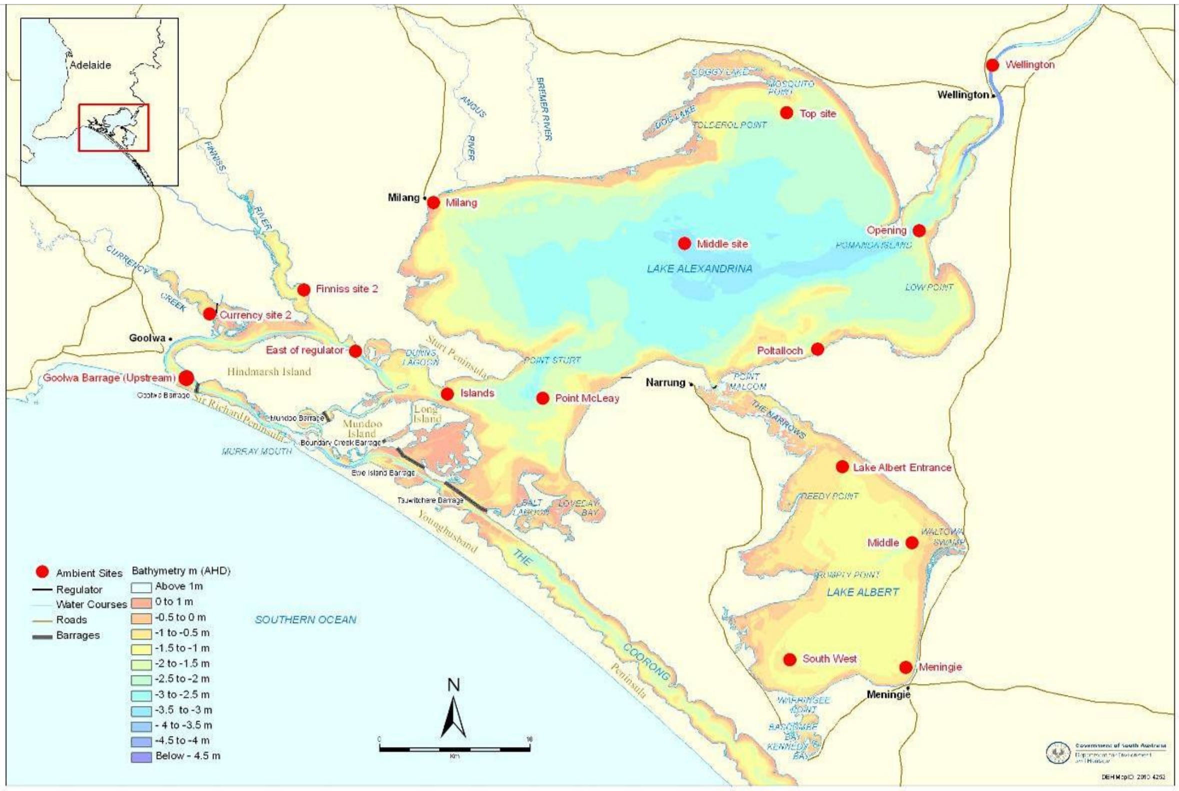

Figure 1 –Lower Lakes and tributaries ambient monitoring sites

Lake Alexandrina

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

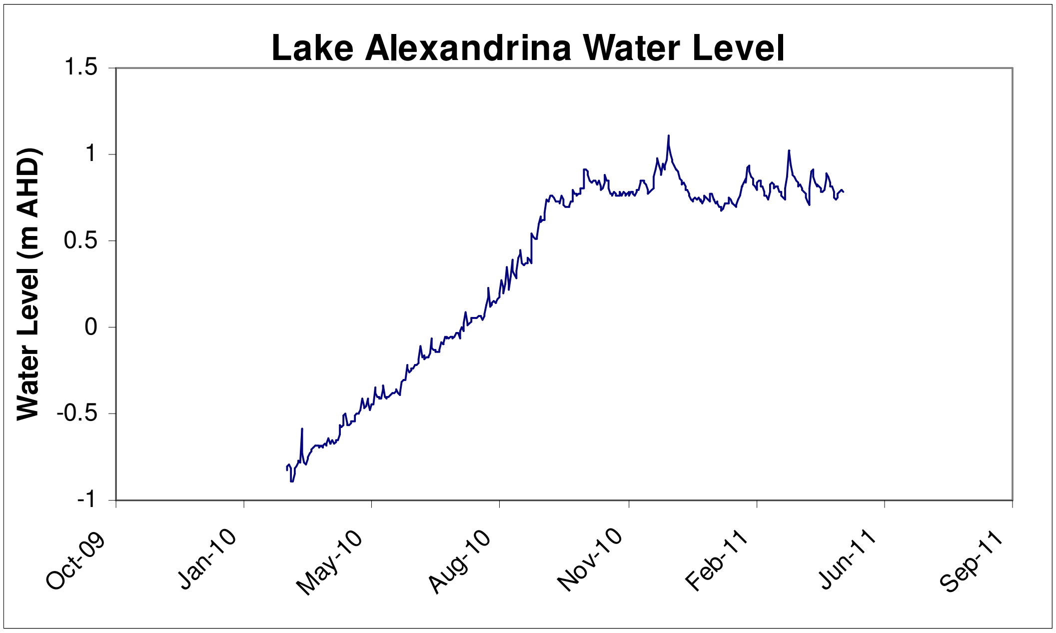

Figure 2 – Water level at the Lake Alexandrina

pH

- pH levels in Lake Alexandrina (Figure 3) have increased at all sites after the decreases recorded in April. These fluctuations appear primarily due to water inflows into Lake Alexandrina. All sites remain within ANZECC guideline levels (pH 6.5-9.0).

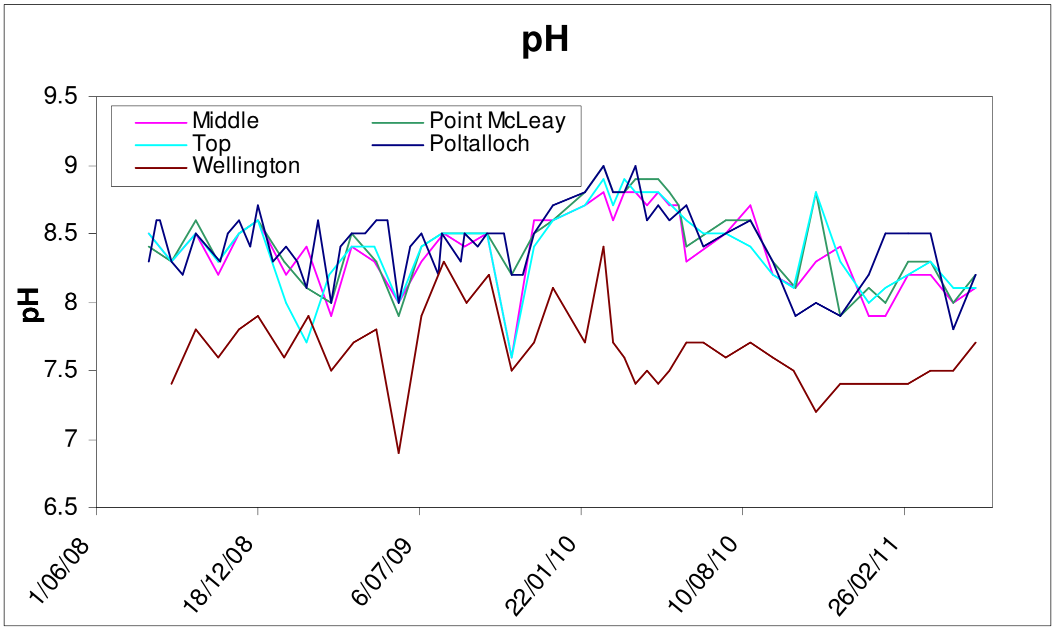

Figure 3 – pH at the Lake Alexandrina ambient monitoring sites

Alkalinity

- Alkalinity levels within Lake Alexandrina have remained stable throughout April (Figure 4). Levels remain relatively uniform for all sites indicating that the Lake is well mixed and exhibiting alkalinity consistent with inflows from the Murray River (Wellington site).

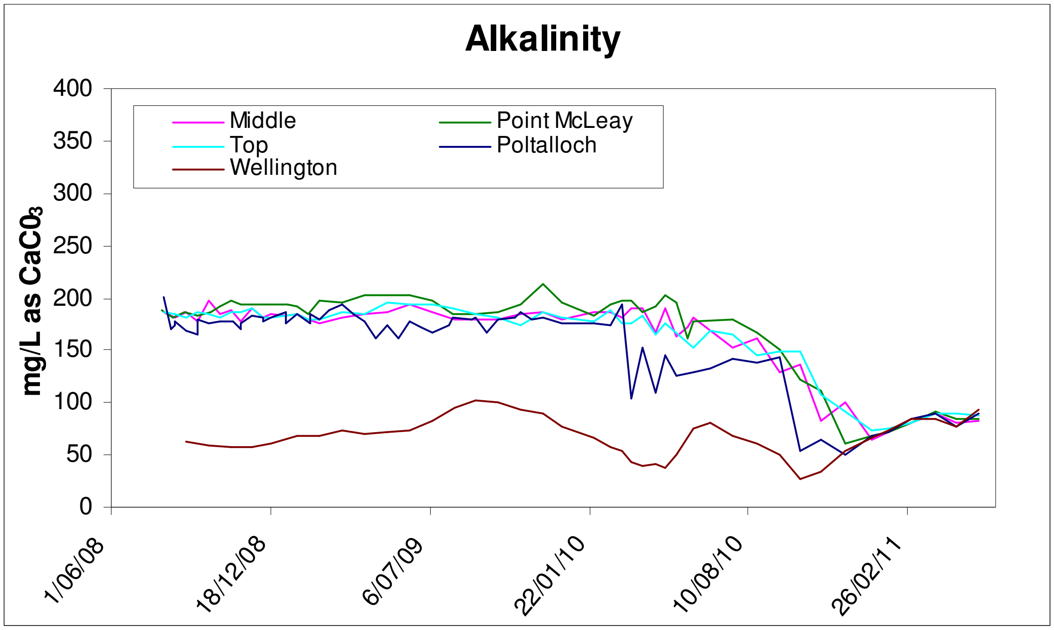

Figure 4 – Alkalinity at the Lake Alexandrina ambient monitoring sites

Sulfate:chloride ratio

- The sulfate:chloride ratio (Figure 5) has remained stable for most Lake Alexandrina sites in May with the exception of Point Mcleay which decreased in May. The levels recorded do not show a trend to indicate any impacts from acid sulfate soils at this time and are consistent with levels recorded in the river at Wellington.

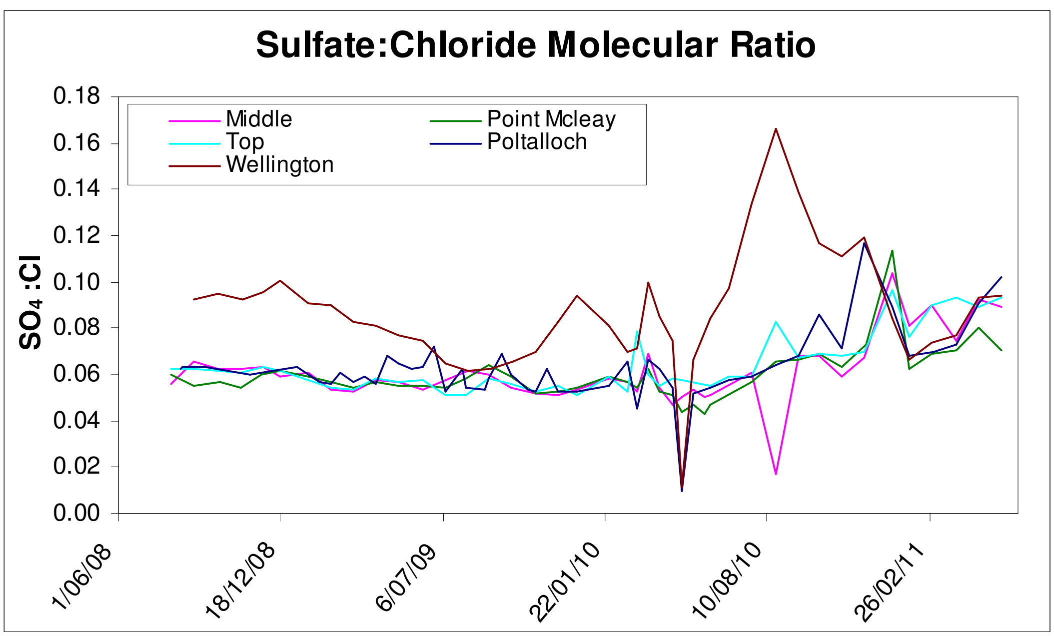

Figure 5 – Sulfate:chloride ratio at the Lake Alexandrina ambient monitoring sites

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.

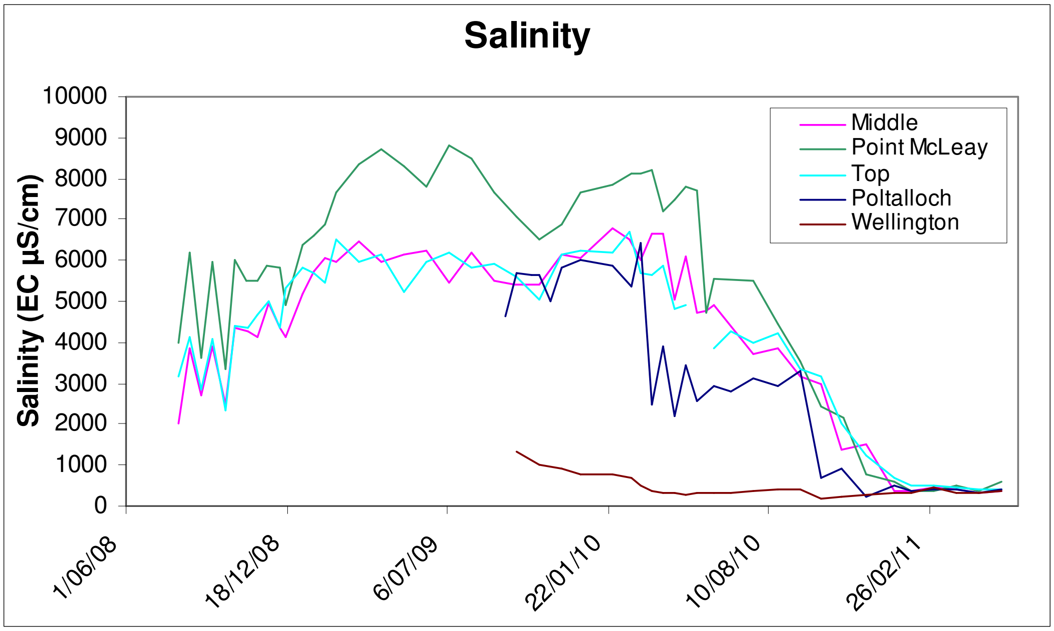

Figure 6 – Salinity at the Lake Alexandrina ambient monitoring site

Turbidity

- Turbidity within Lake Alexandrina increased in the May sampling and the river site (Wellington) is 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.

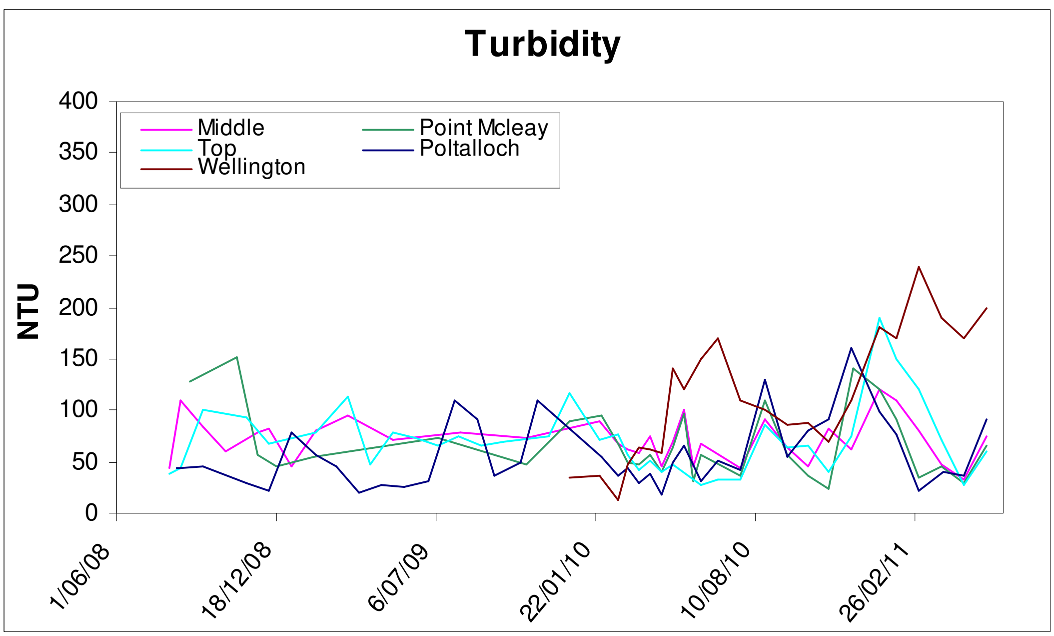

Figure 7 – Turbidity at the Lake Alexandrina ambient monitoring sites

Nutrients (total nitrogen and phosphorus)

- Total nitrogen and phosphorus levels within Lake Alexandrina remain stable with a slight increase at all sites during May (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).

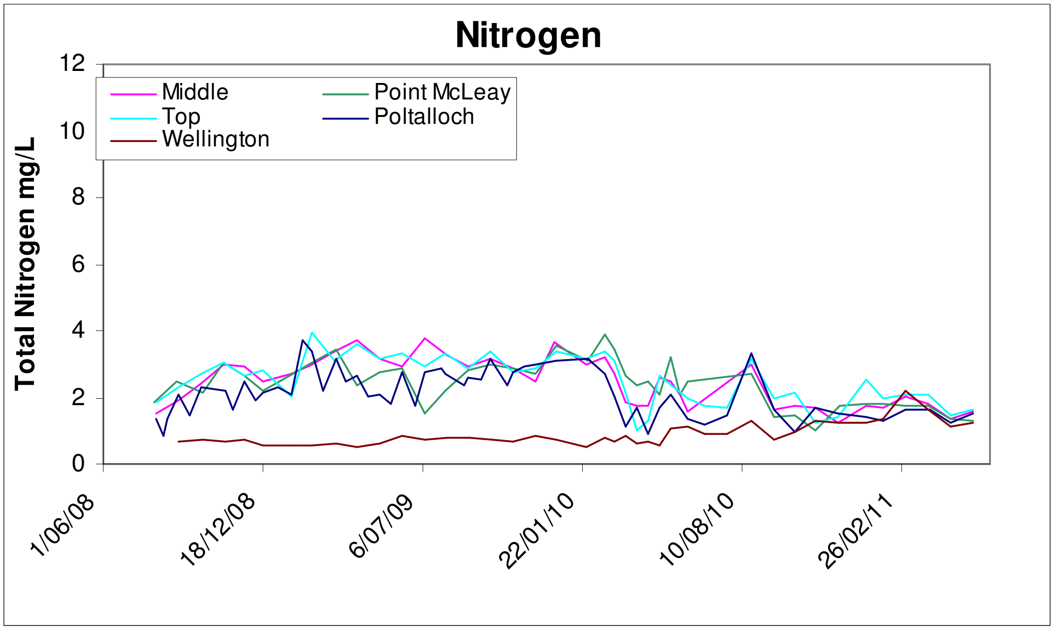

Figure 8 – Total nitrogen at the Lake Alexandrina ambient monitoring sites

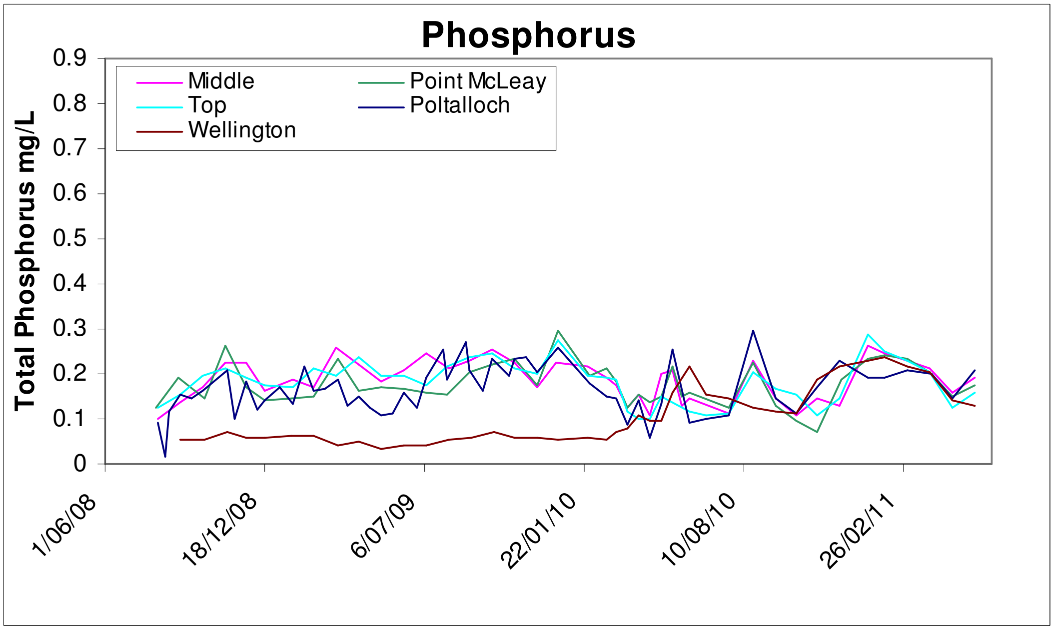

Figure 9 – Total phosphorus at the Lake Alexandrina ambient monitoring sites

Chlorophyll a (algae)

- Chlorophyll *a* in Lake Alexandrina was stable through May with the exception of Poltalloch which saw some increase in levels (Figure10). Cooler conditions and fewer hours of daylight will slow primary productivity and algal growth within Lake Alexandria. Despite this Chlorophyll *a levels* remain above ANZECC guidelines (15ug/L) and Lake Alexandria is considered hyper eutrophic.

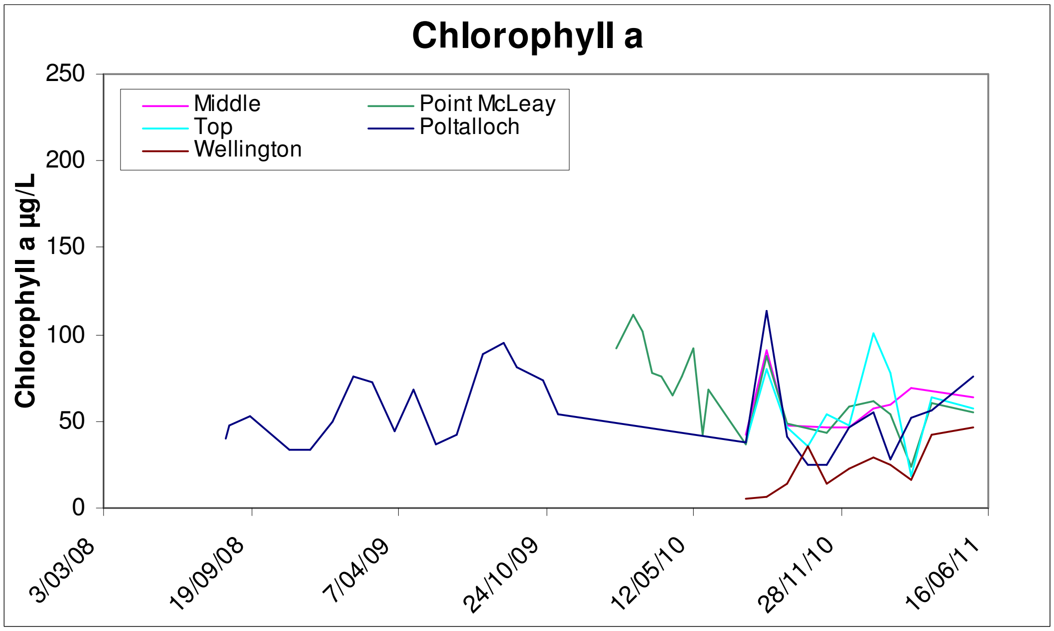

Figure 10 – Chlorophyll *a* at the Lake Alexandrina ambient monitoring sites

Metals

- Total aluminium and total iron levels within Lake Alexandrina remain stable 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.

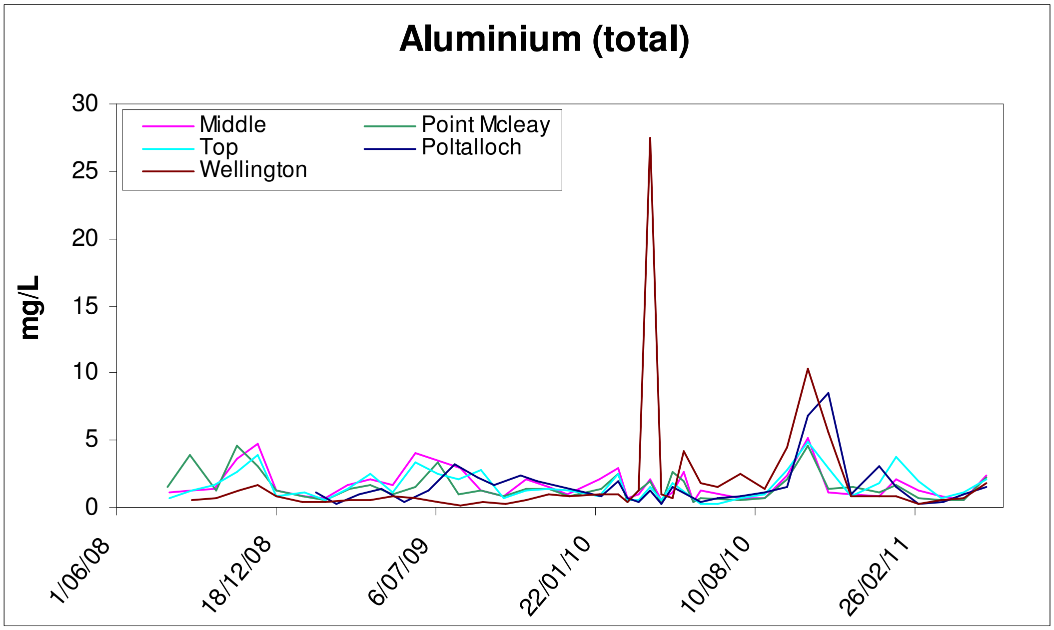

Figure 11 – Total aluminium at the Lake Alexandrina ambient monitoring sites

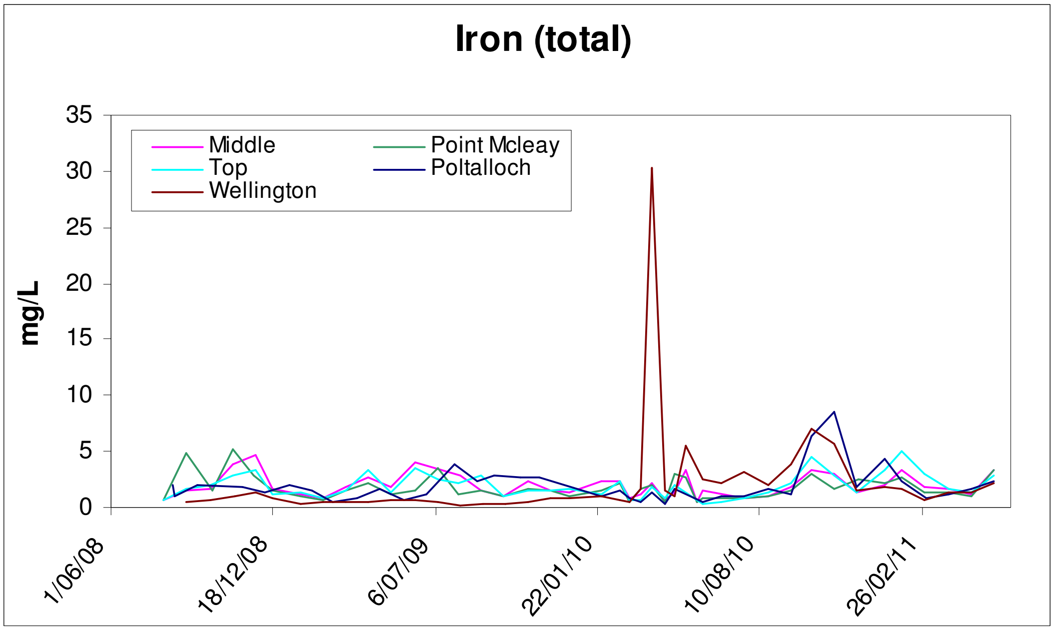

Figure 12 – Total iron at the Lake Alexandrina ambient monitoring sites

Dissolved Oxygen

- Dissolved oxygen levels in Lake Alexandrina increased for most sites in May and are at satisfactory levels at most sites (Figure 13). Lower dissolved oxygen levels continue to be observed at the Wellington site, likely as a result of a high organic load in the receding flood waters which decays and consumes oxygen. The rapid wind mixing on the lakes replenishes oxygen levels.

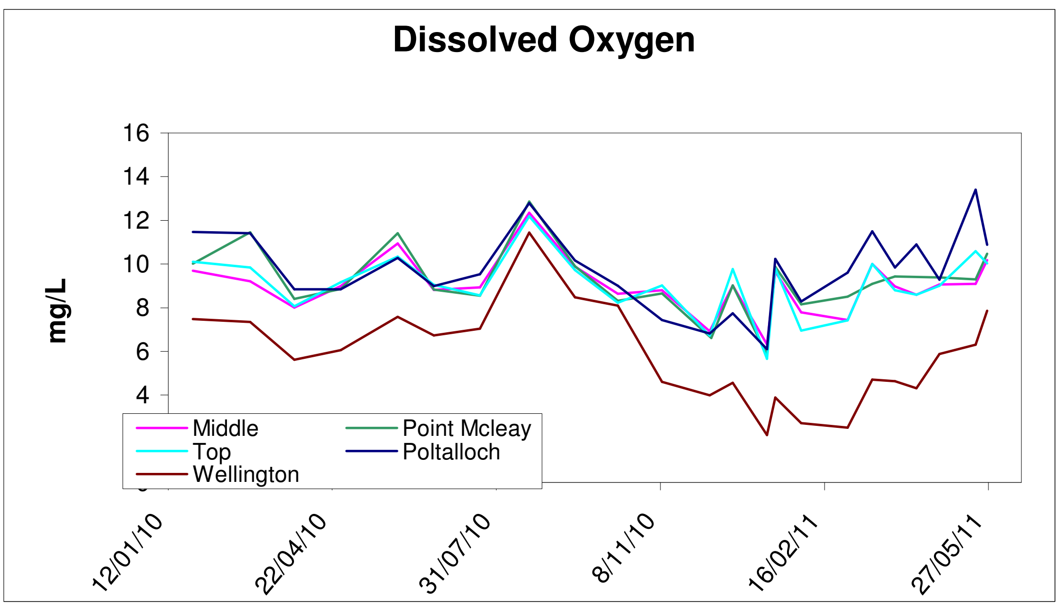

Figure 13 – Dissolved Oxygen at the Lake Alexandrina ambient monitoring sites

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 14 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.

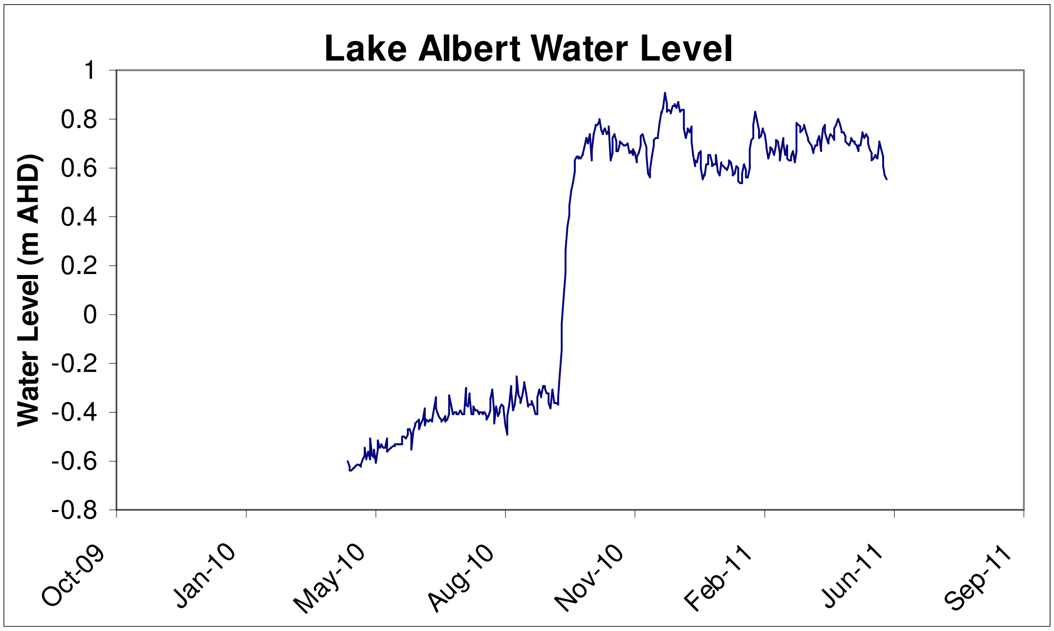

Figure 14 – Water Level within Lake Albert

pH

pH levels in Lake Albert decreased slightly for most sites (Figure 15) but remain within ANZECC guideline levels (pH 6.5-9.0).

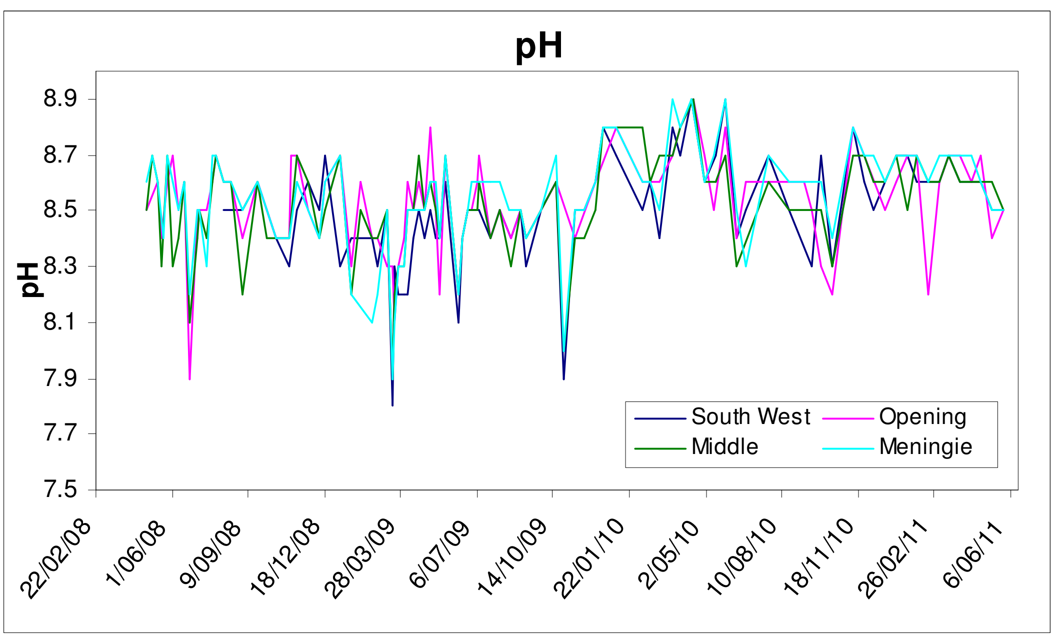

Figure 15 – pH at the Lake Albert ambient monitoring sites

Alkalinity

- Alkalinity within Lake Albert remained stable across most sites during May with the exception of the Opening site which continued to show significant variability in levels (Figure 16). The Opening site is the most influenced by inflow of lower alkalinity water from Lake Alexandrina and thus experiences more variability in concentrations.

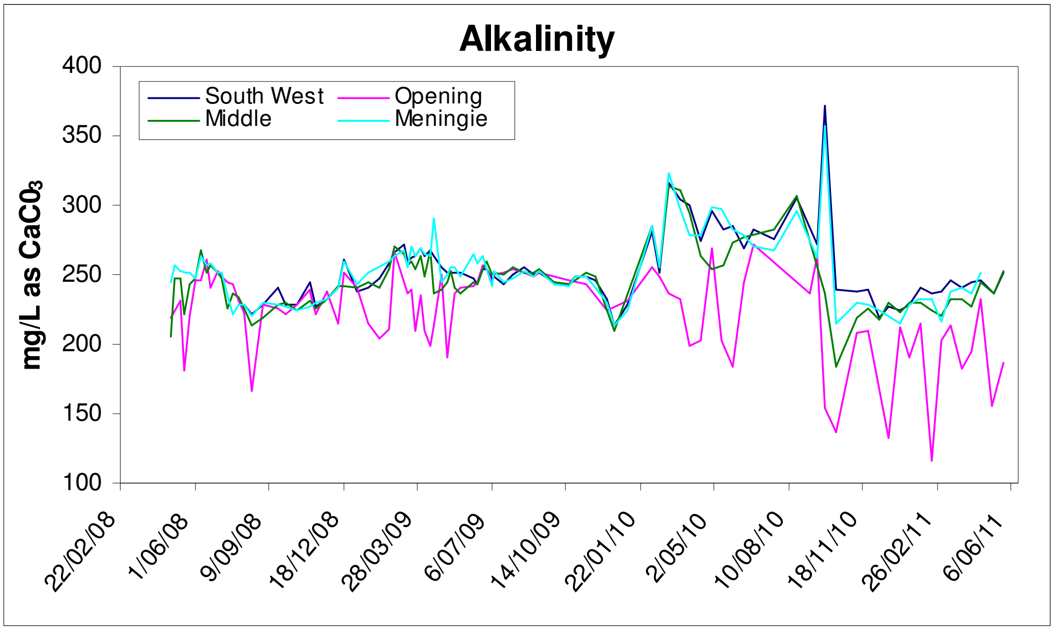

Figure 16 – Alkalinity at the Lake Albert ambient monitoring sites

Sulfate:chloride ratio

- The sulfate:chloride ratio has remained stable across all Lake Albert sites with only the Opening site showing any variation (Figure 17). This indicates that the lake system is not experiencing any additional sulfate inputs which would indicate the presence of acid sulfate soils and water movement through acidic soil profiles.

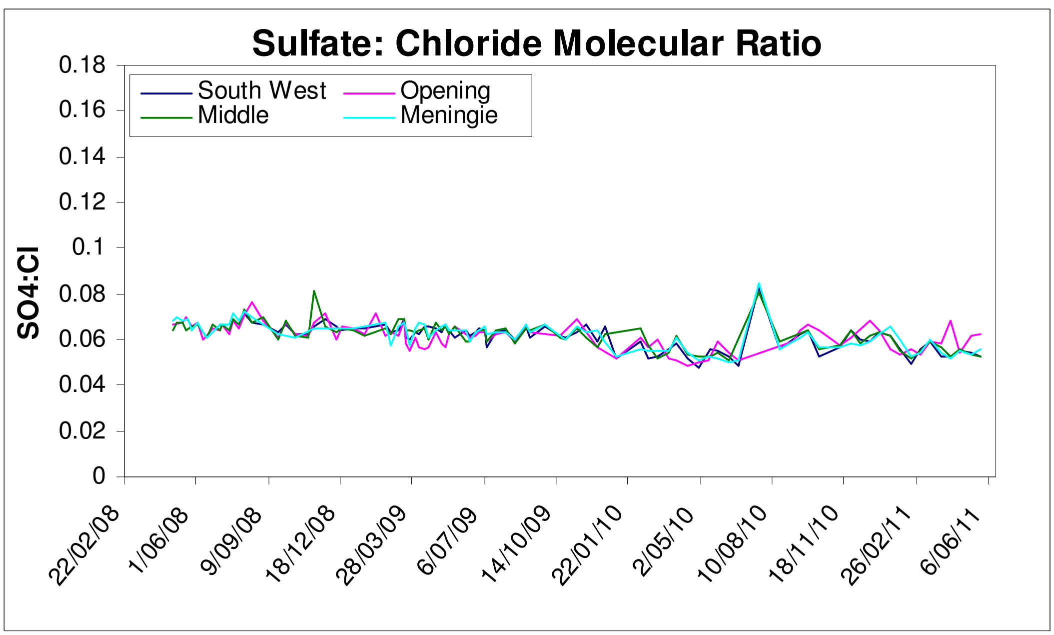

Figure 17 – Sulfate:chloride ratio at the Lake Albert ambient monitoring sites

Salinity (EC)

- Salinity levels continues to decrease across most sites in May but still remain high (between 2900 and 7000 µS/cm) compared to historical averages of <1600 µS/cm (Figure 18). 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.

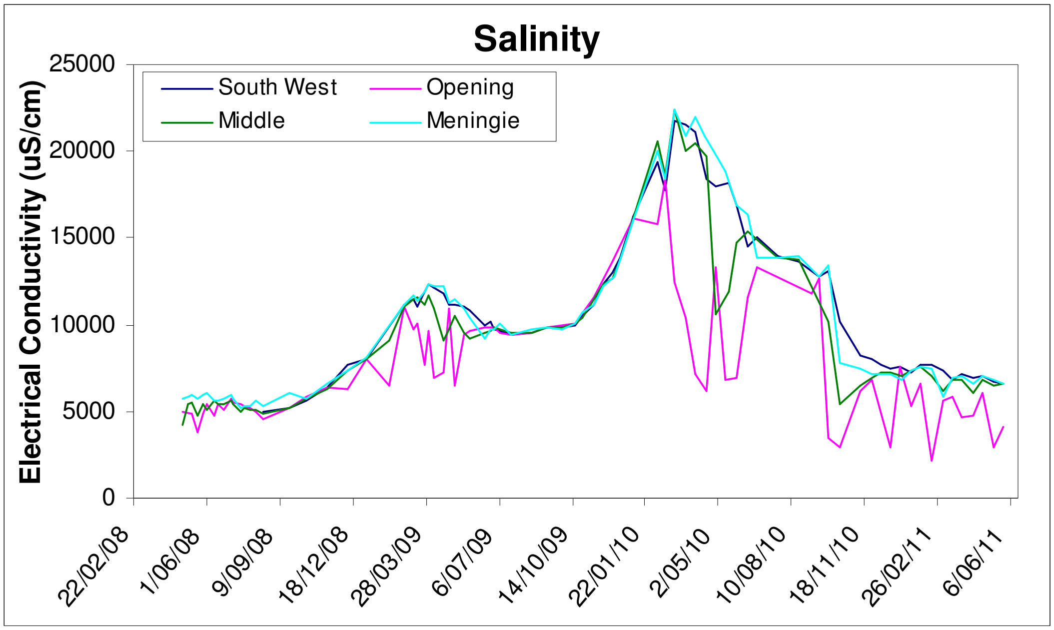

Figure 18 – Salinity at the Lake Albert ambient monitoring sites

Turbidity

- Turbidity in Lake Albert has increased across all sites in May (Figure 19). This could be due to an increase in highly turbid Lake Alexandrina inflows, or possibly an increase in wind events during autumn.

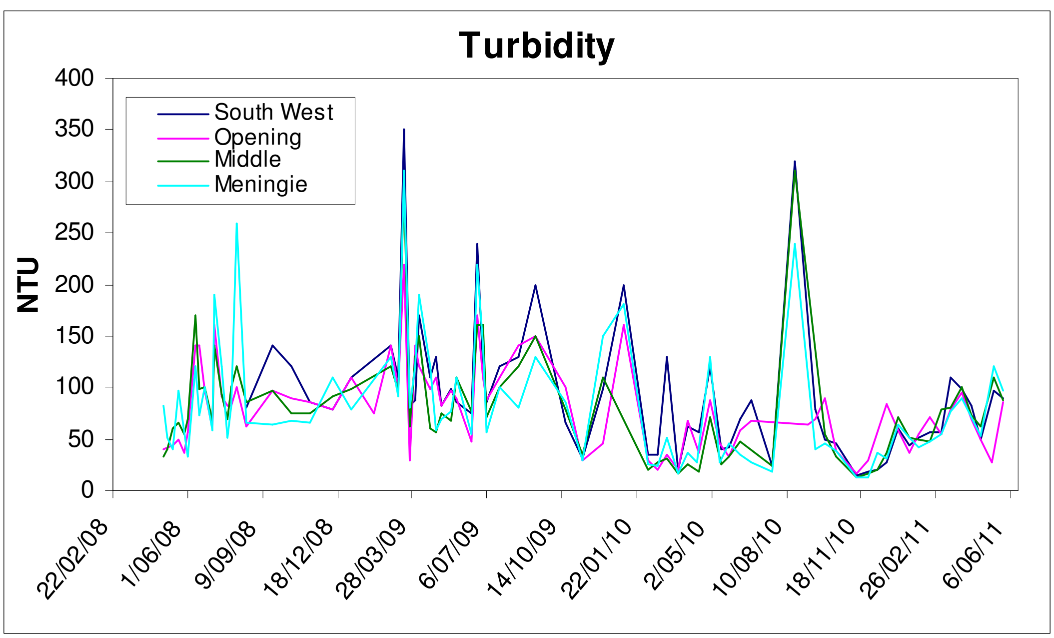

Figure 19 – Turbidity at the Lake Albert ambient monitoring sites

Nutrients (total nitrogen and phosphorus)

- Total nitrogen and phosphorus levels have remained stable across most Lake Albert sites during May (Figures 20 and 21). 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).

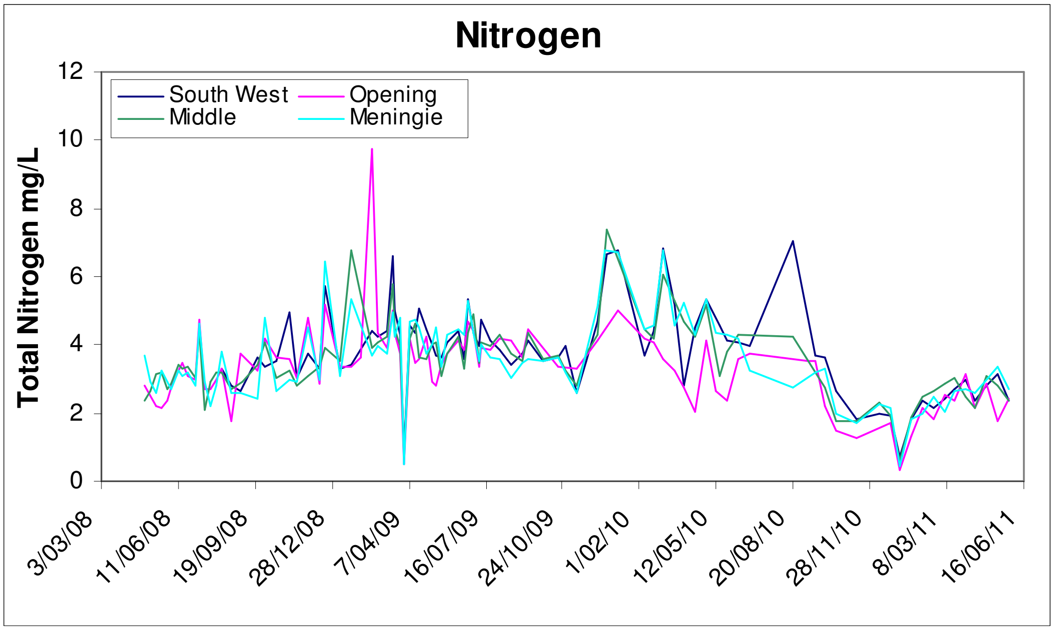

Figure 20 – Total Nitrogen at the Lake Albert ambient monitoring sites

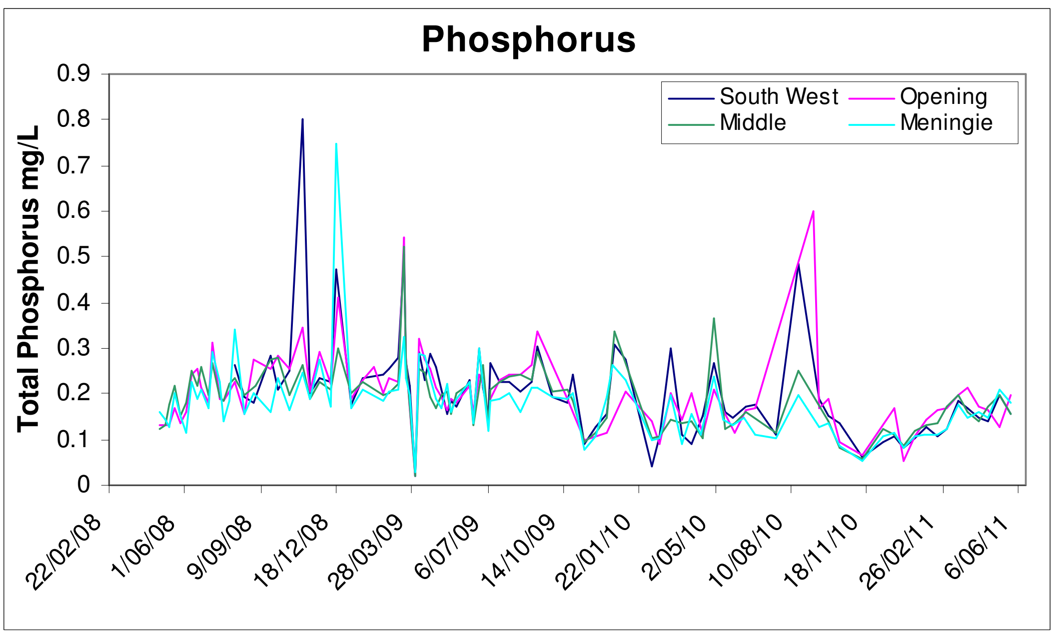

Figure 21 – Total phosphorus at the Lake Albert ambient monitoring sites

Chlorophyll a (algae)

- Chlorophyll *a* for Lake Albert has decreased overall at most sites yet levels remain well in excess of ANZECC guidelines (>15 µg/L considered hyper-eutrophic) and indicate a nutrient enriched system (Figure 22).

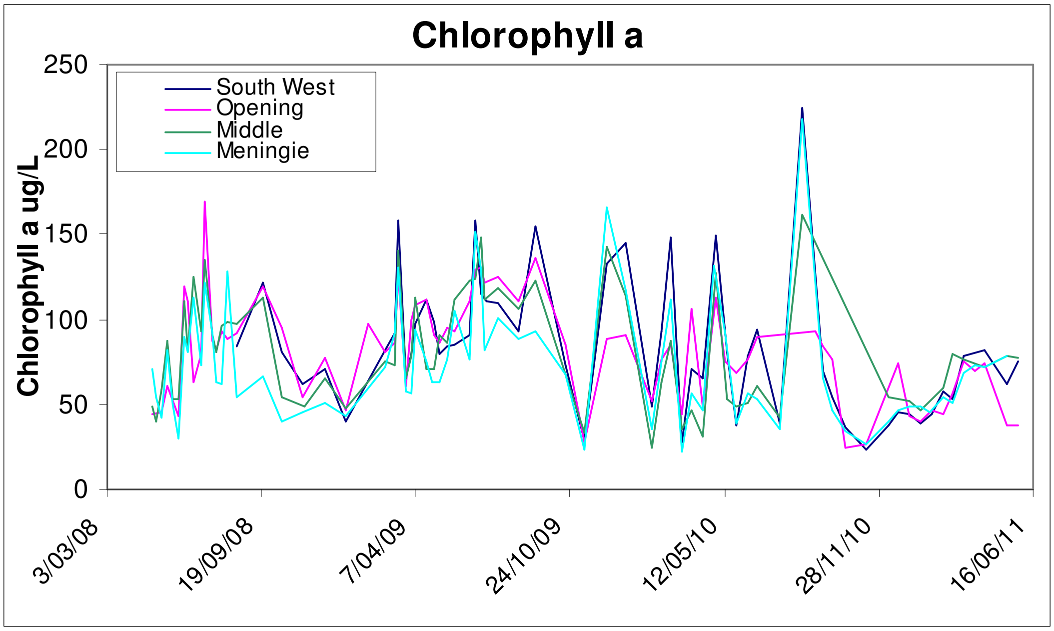

Figure 22 – Chlorophyll *a* at the Lake Albert ambient monitoring sites

Metals

Total aluminium and iron concentrations within Lake Albert remain at low levels but have increased at all sites during May (Figures 23 and 24).This is likely due to increased re-suspension of sediment (containing metals), consistent with the higher turbidities shown in Figure 19.

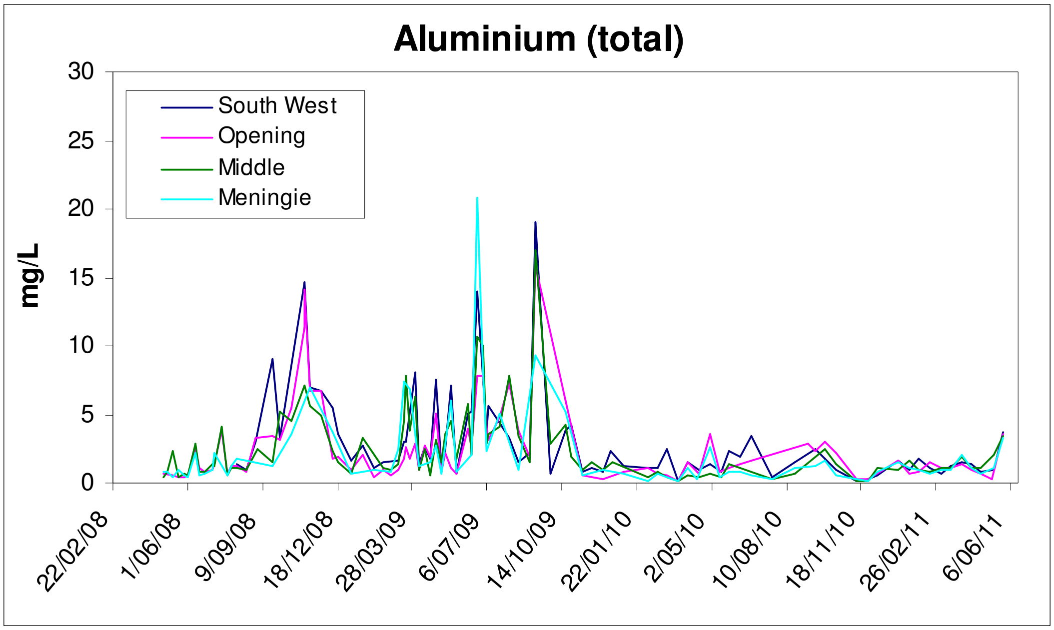

Figure 23 – Total aluminium at the Lake Albert ambient monitoring sites

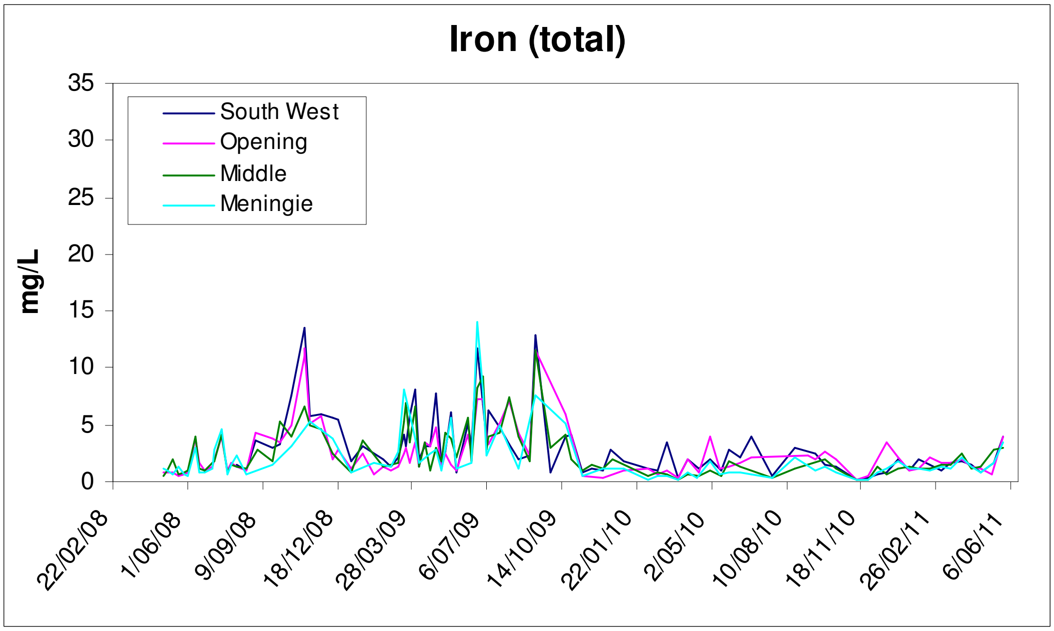

Figure 24 – Total iron at the Lake Albert ambient monitoring sites

Dissolved Oxygen

- Dissolved Oxygen levels in Lake Albert remained stable in May at all sites and remains within ANZECC guideline values (>6 mg/L) (Figure 25).

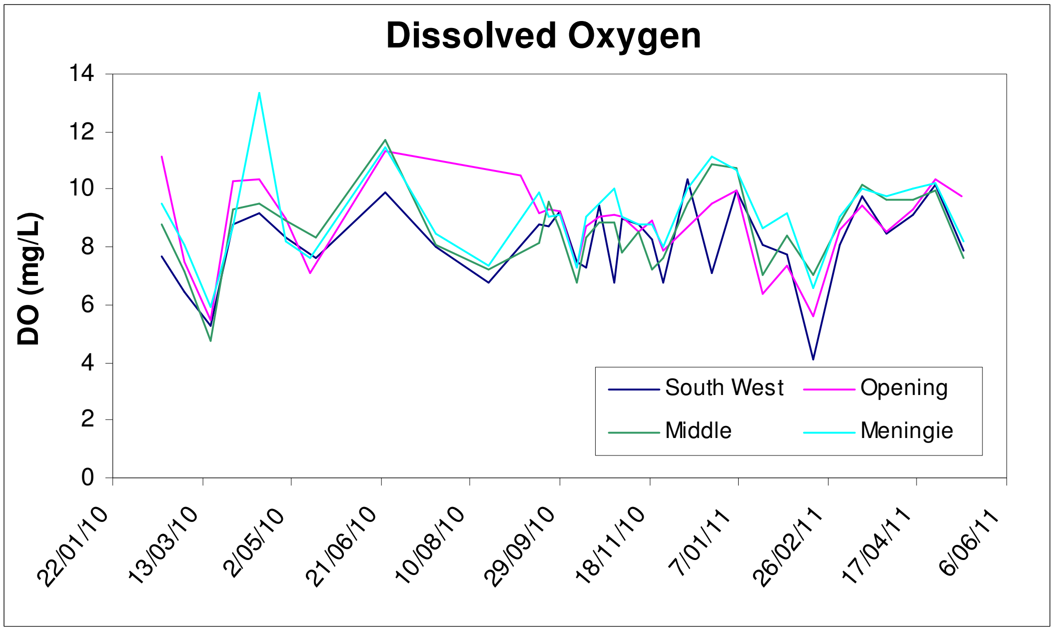

Figure 25 – Dissolved Oxygen at the Lake Albert ambient monitoring sites

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 26 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 so monitoring data after this will reflect changes due to inflows from Lake Alexandrina. The water level in this region is shown in Figure 27.

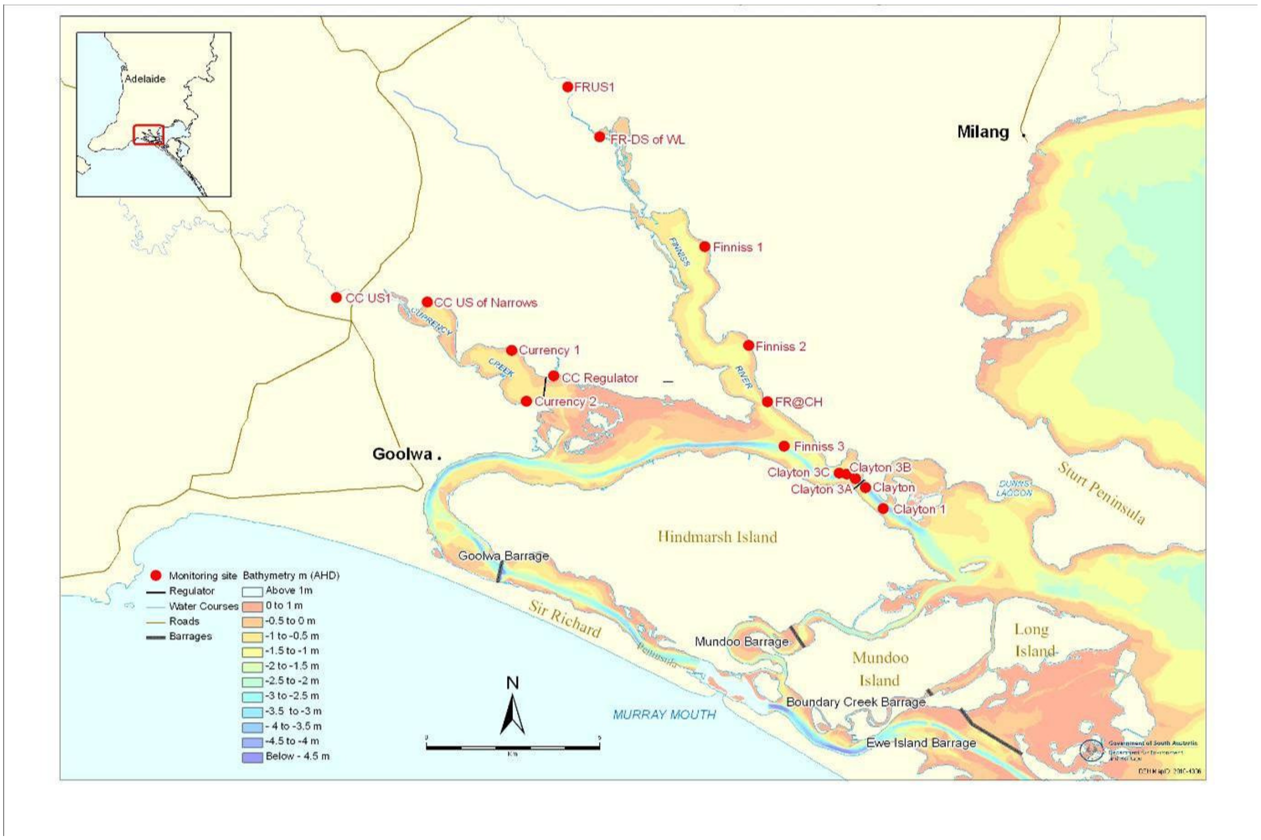

Figure 26 – Goolwa Channel and Tributaries ambient and event-based monitoring sites

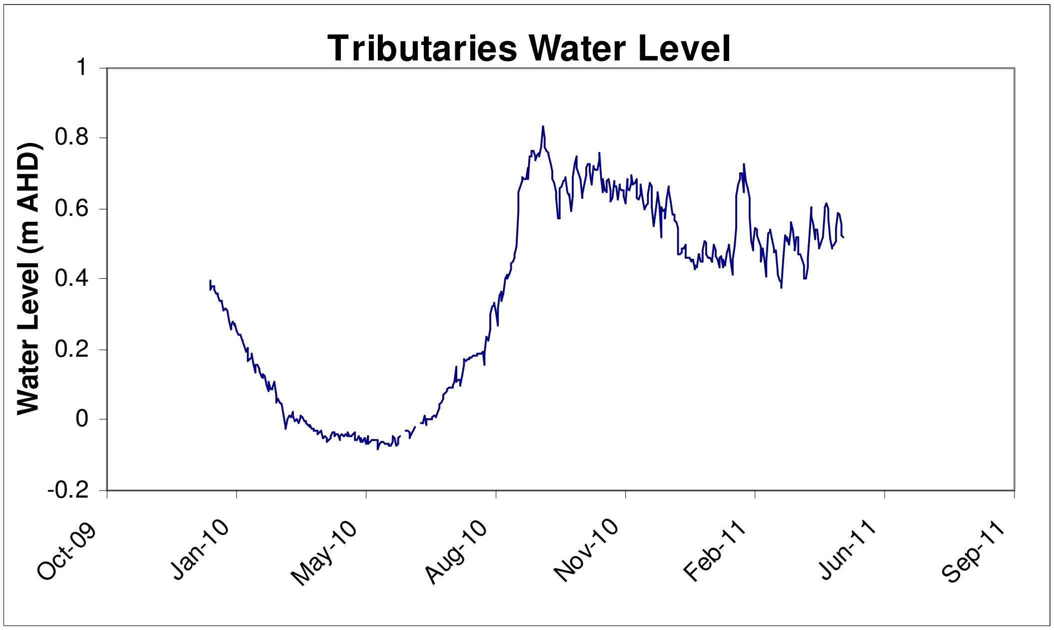

Figure 27 – Water level at the Goolwa Channel and Tributaries monitoring sites

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 mid February 2011 (Figure 28).

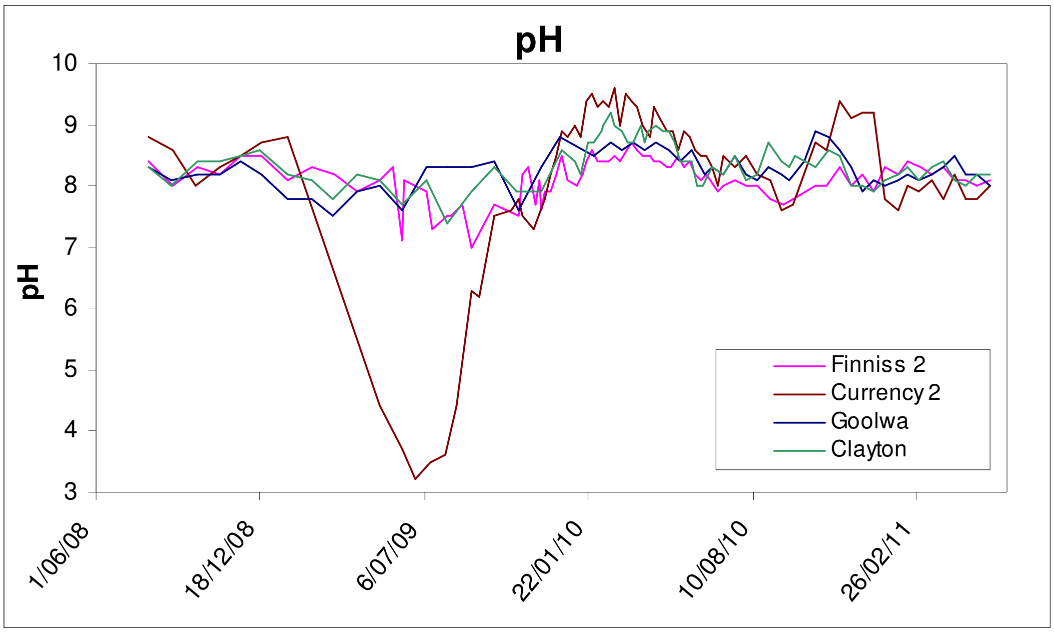

Figure 28 – pH at the Goolwa Channel and Tributaries monitoring sites

Alkalinity/Acidity

- Alkalinity levels at all of the Goolwa Channel and Tributaries sites remain stable with Currency 2 recording the highest levels (See Figure 29). Laboratory results (not displayed) have indicated there are low levels of acidity within Currency Creek. 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

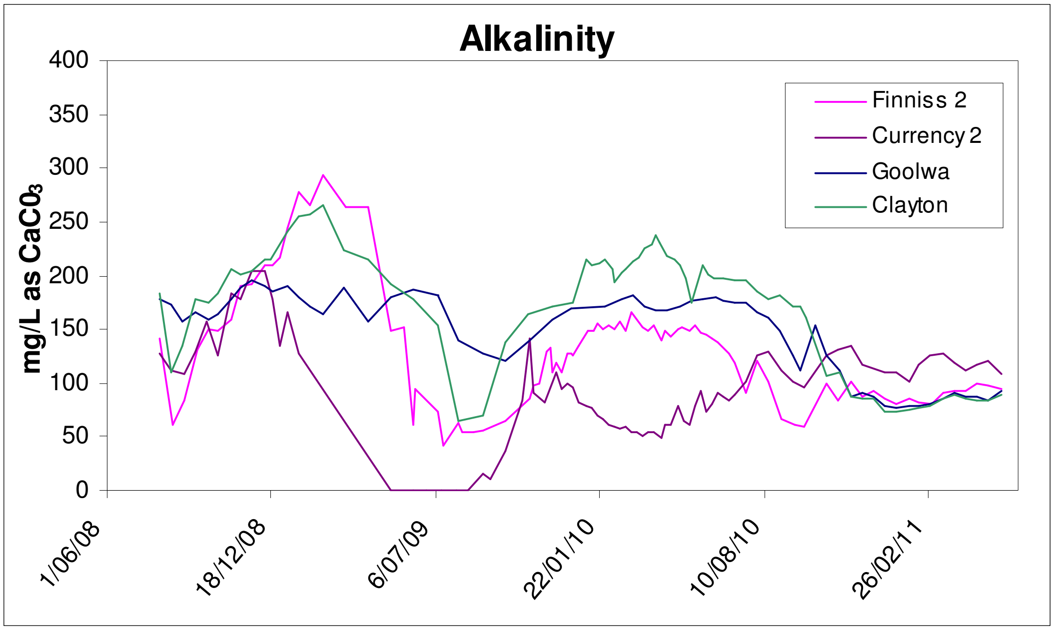

Figure 29 – Alkalinity at the Goolwa Channel and Tributaries monitoring sites

Sulfate:chloride ratio

- The sulfate: chloride ratio has decreased in May (Figure 30) 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.

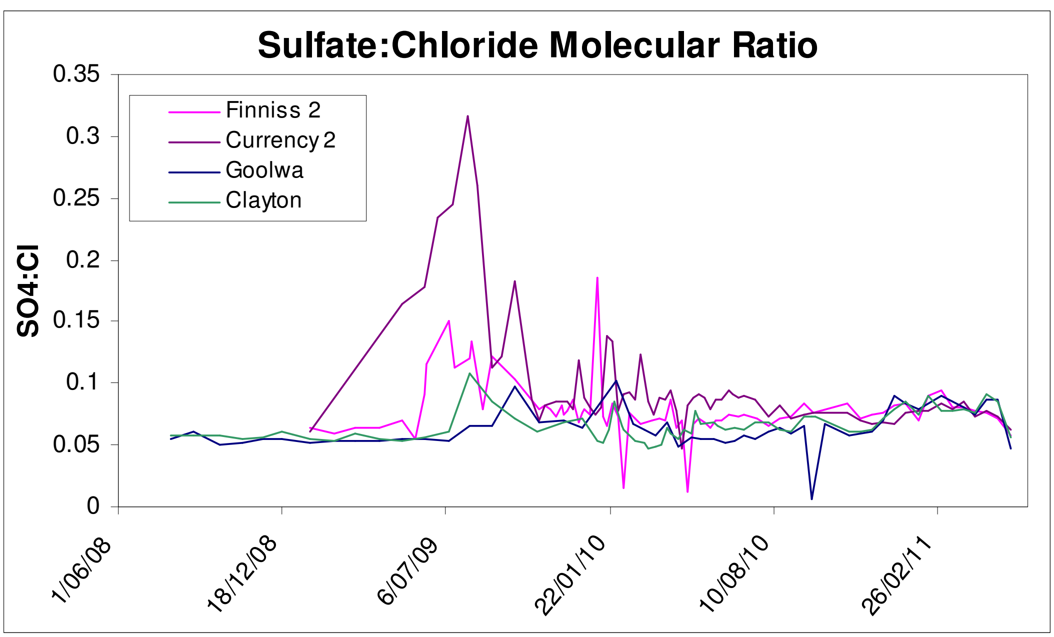

Figure 30 – Sulfate:chloride molecular ratio at the Goolwa Channel and Tributaries monitoring sites

Salinity (EC)

- Salinity levels spiked in May at all sites in the Goolwa Channel and Tributaries (Figure 31) with the biggest increase occurring in the Goolwa Channel. This is a result of a king tide event pushing salt water through the open barrages into the channel and tributaries.

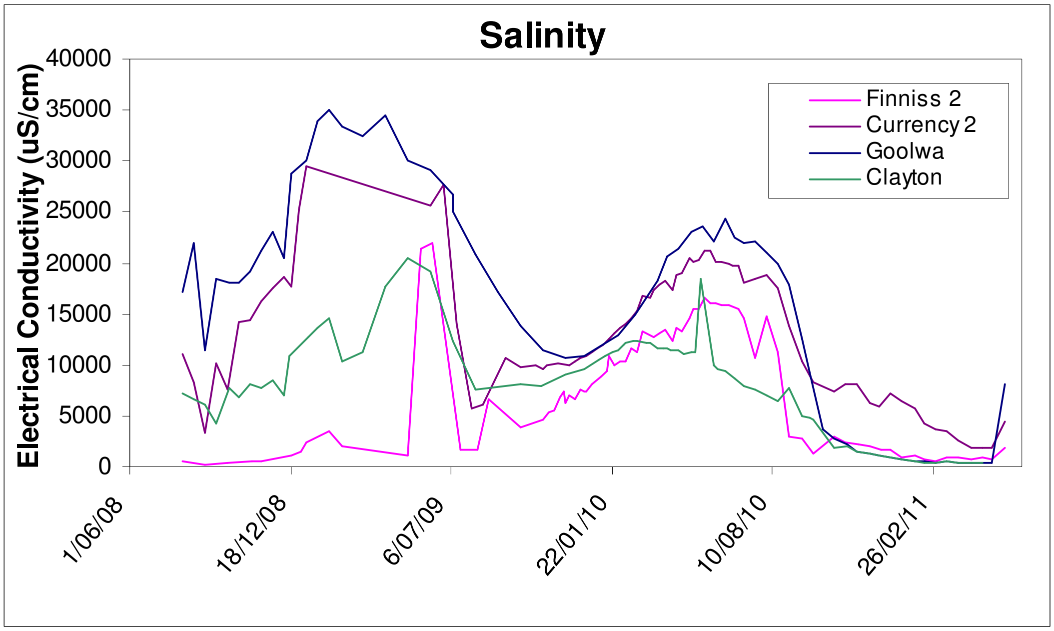

Figure 31 – Salinity at the Goolwa Channel and Tributaries monitoring sites

Turbidity

- Turbidity levels at the Goolwa Channel and Tributaries sites (Figure 32) have continued to decrease in May. Currency 2 still remains lower than other monitored sites which may be as result of increased settling of particles behind the (partly submerged) Currency regulator.

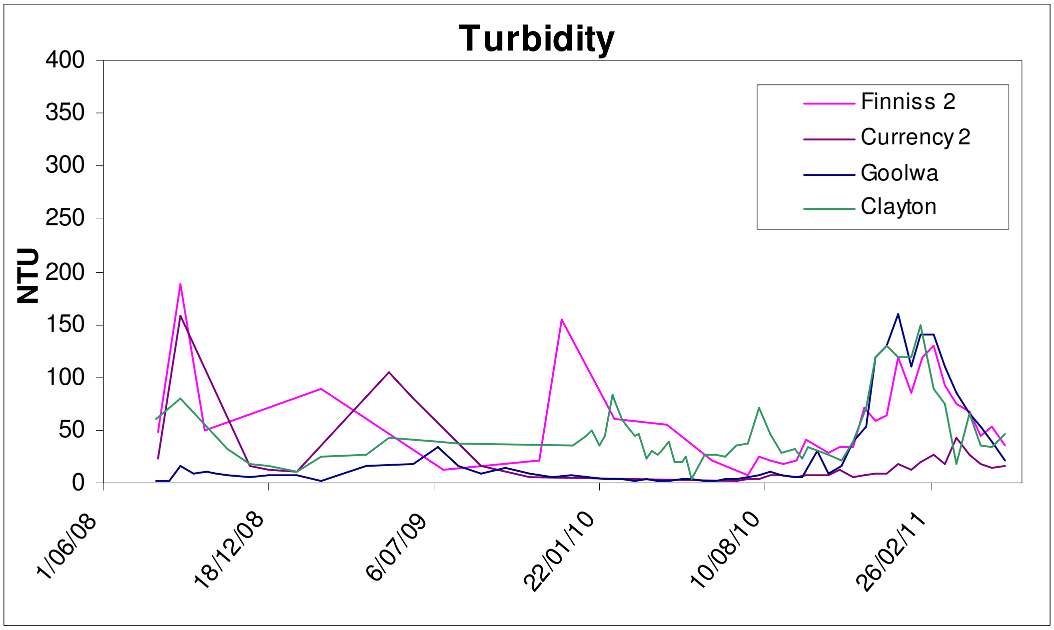

Figure 32 – Turbidity at the Goolwa Channel and Tributaries monitoring sites

Nutrients (total nitrogen and phosphorus)

- Total Nitrogen and Phosphorous levels continued to drop during May at all sites (Figures 33 and 34). Nutrient levels throughout the Goolwa channel and Tributaries appear to be becoming more uniform. The king tide event mentioned above may have resulted in Currency 2 and Goolwa Channel having more similar TP levels on the May sampling event. Nutrient levels continue to remain above ANZECC guidelines for freshwater ecosystems (<1mg/L TN, <0.025 mg/L TP).

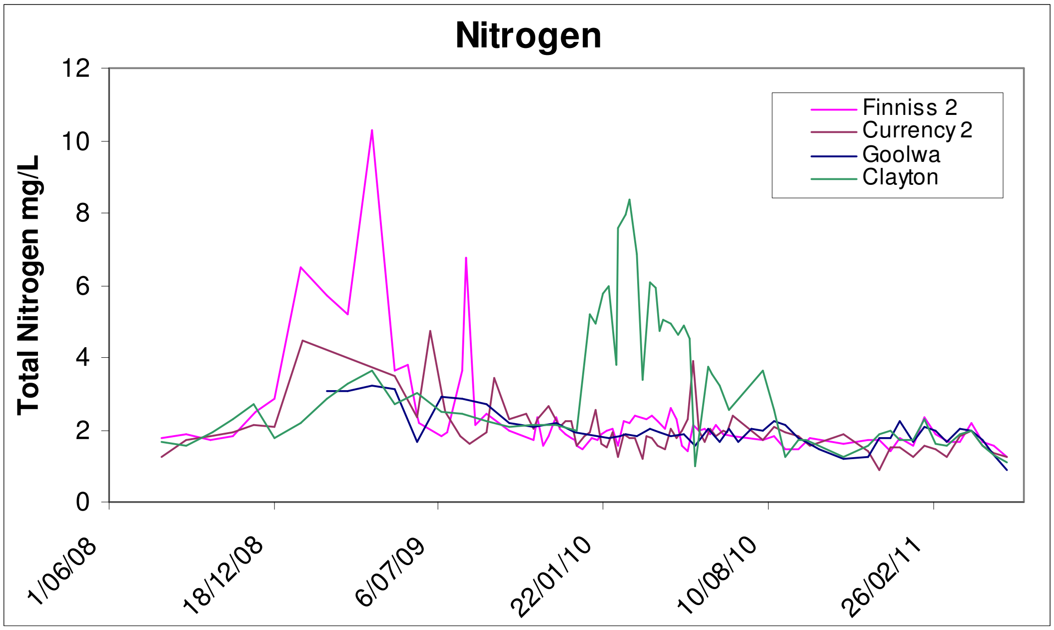

Figure 33 – Total Nitrogen at the Goolwa Channel and Tributaries monitoring sites

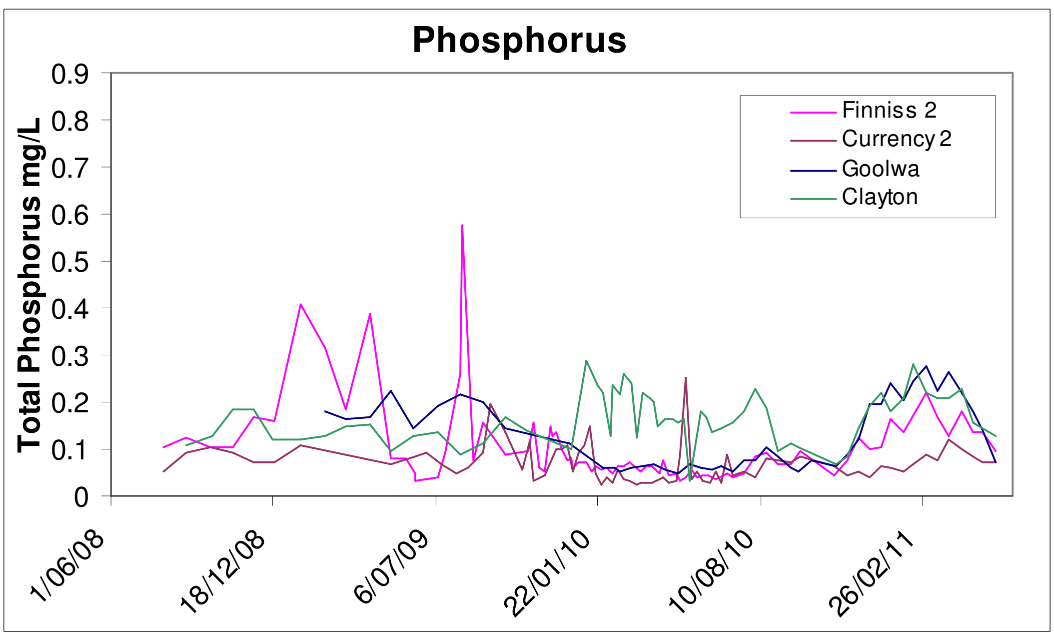

Figure 34 – Total phosphorus at the Goolwa Channel and Tributaries monitoring sites

Chlorophyll (algae)

- Chlorophyll *a* decreased within the Goolwa Channel and the Tributaries during May at most sites (See Figure 35). Cooler conditions and fewer hours of daylight are likely slowing primary productivity and algal growth within Lake Alexandria. Despite this Chlorophyll *a l*evels remain above ANZECC guidelines (15ug/L) which is considered hyper eutrophic

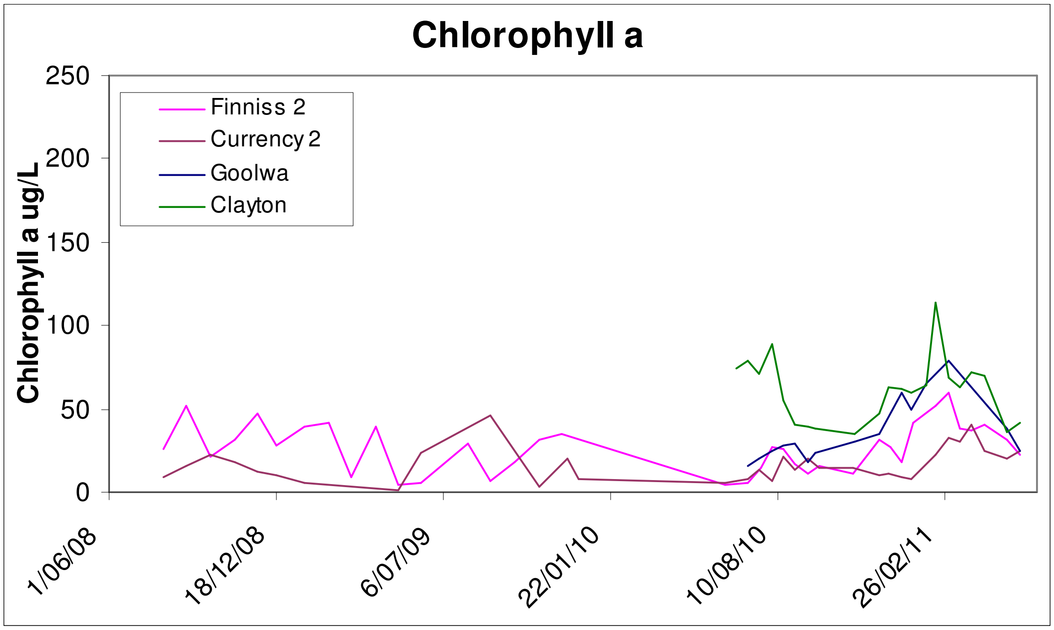

Figure 35 – Chlorophyll *a* at the Goolwa Channel and Tributaries monitoring sites

Metals

- Total aluminium and iron concentrations within the Goolwa Channel and Tributaries have remained stable during May (Figures 36 and 37). 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.

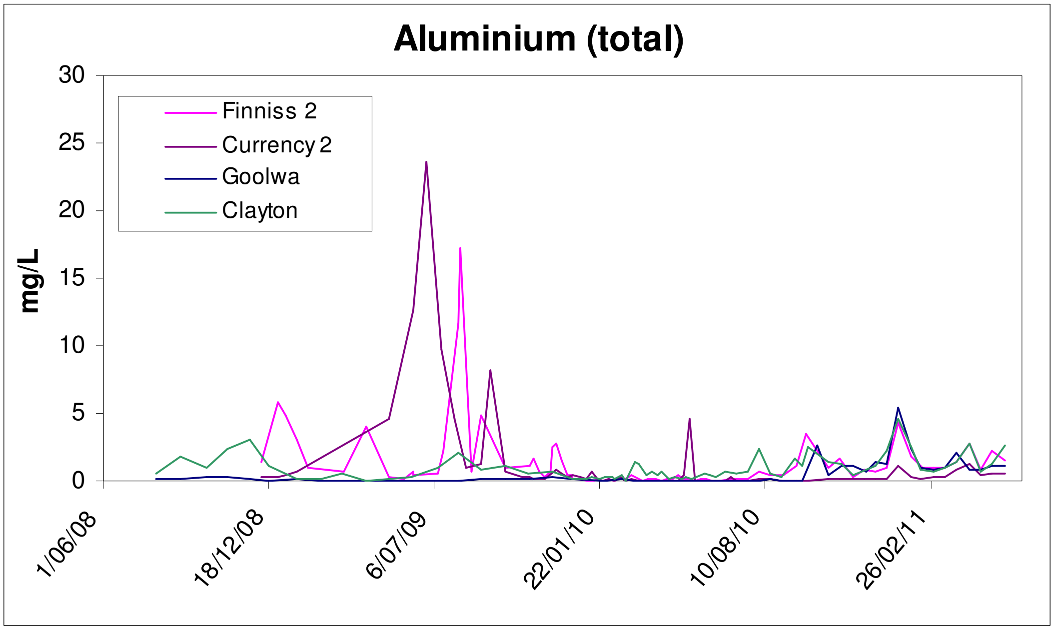

Figure 36 – Total aluminium at the Goolwa Channel and Tributaries monitoring sites

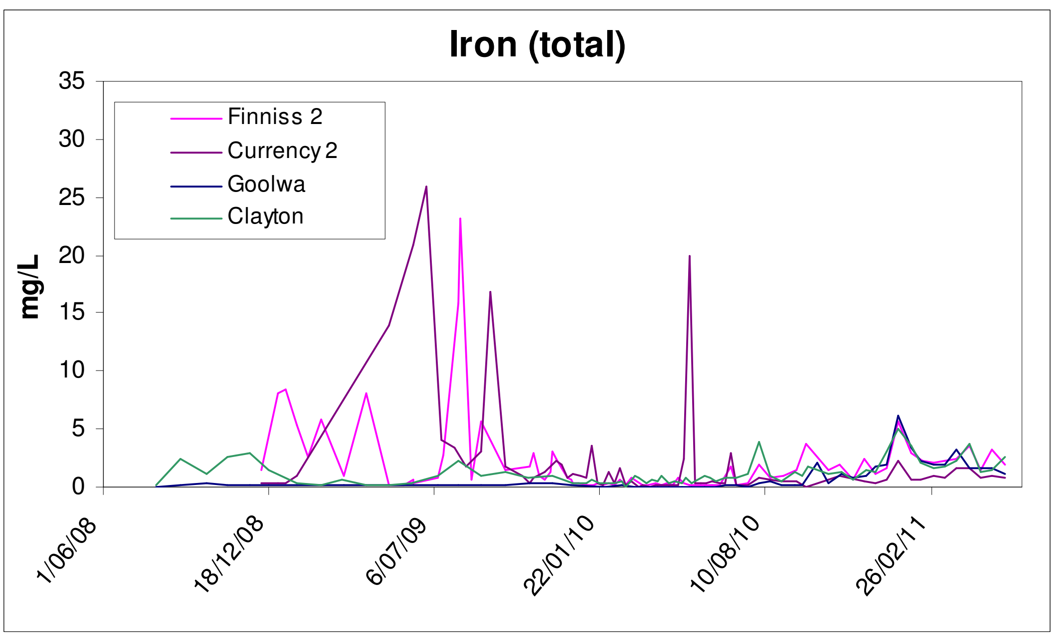

Figure 37 – Total iron at the Goolwa Channel and Tributaries monitoring sites

Dissolved Oxygen

- Dissolved oxygen levels in the tributaries have increased for most sites during May with only Goolwa showing a slight decrease (Figure 38). All sites remain above guideline values (>6 mg/L).

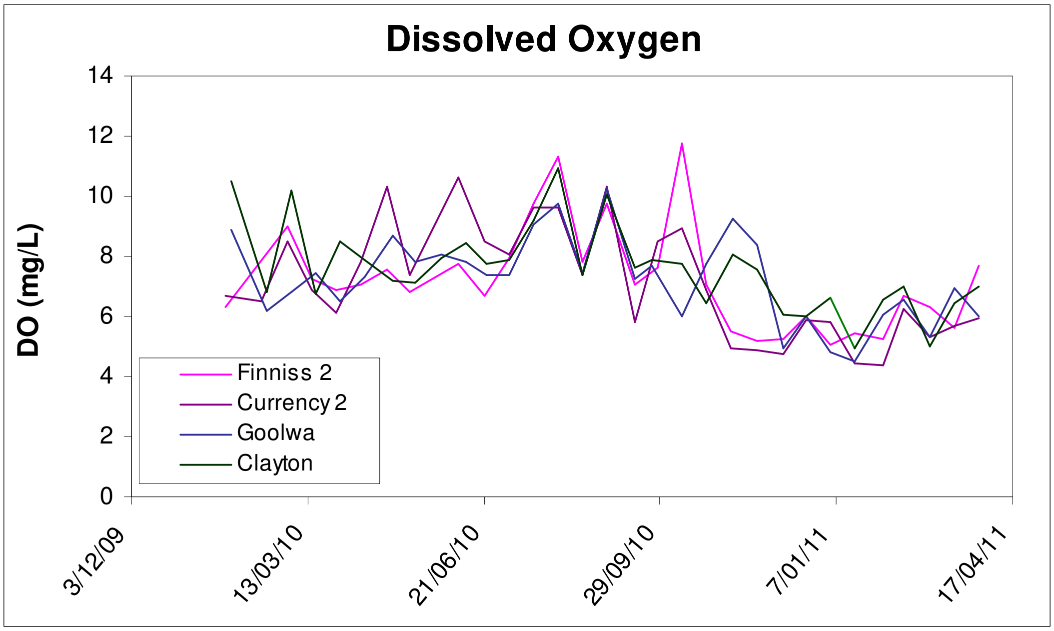

Figure 38 – Dissolved Oxygen at the Goolwa Channel and Tributaries monitoring sites

Event-based monitoring

Event-based water quality sampling is undertaken in regions that have experienced acidification or were at risk of acidification (Figure 39). 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 near the Tauwitchere and other barrages to better understand salt and other constituent export from the lakes during high flows (see Figure 39 for sites).

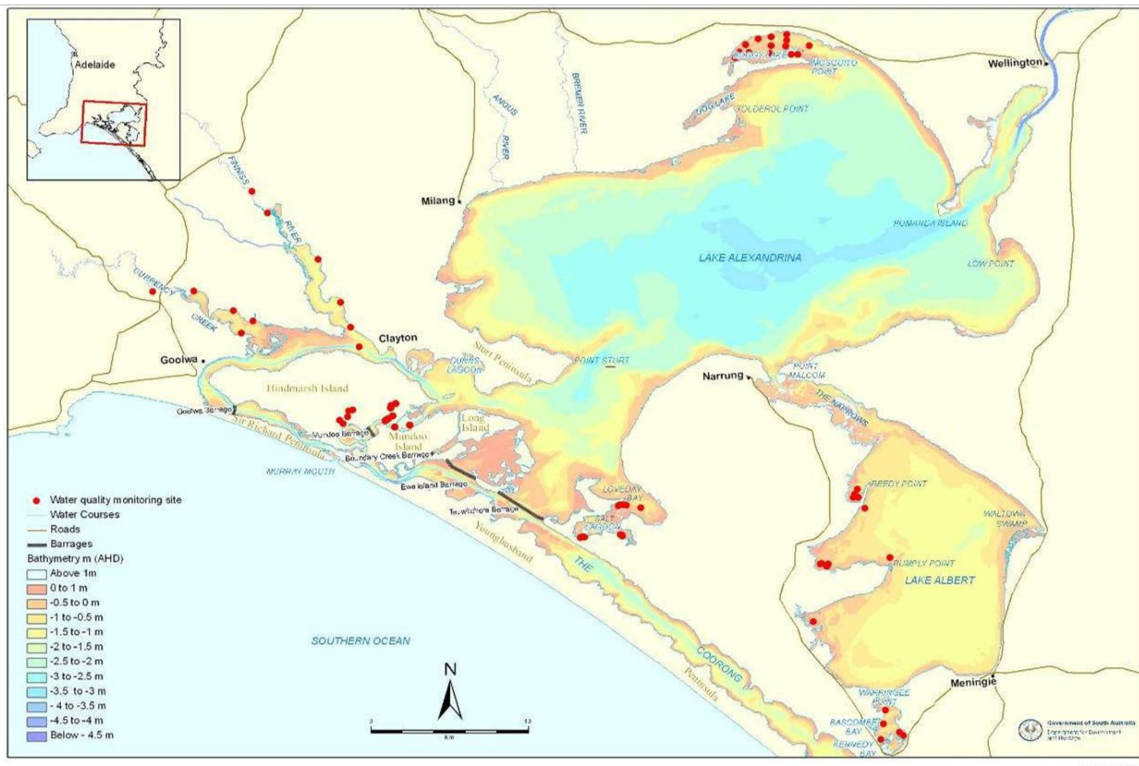

Figure 39 – Event-based water quality monitoring sites

Narrung Narrows

Figure 40 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 May (Figure 41). The variability of the 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 42 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 Narrows salinity was quite similar to that in Lake Alexandrina but increased rapidly when the main Lake Albert water body was encountered. This indicates that water was flowing into Lake Albert on this particular day. Opposite trends (export of salt from Lake Albert) have been seen on other days.

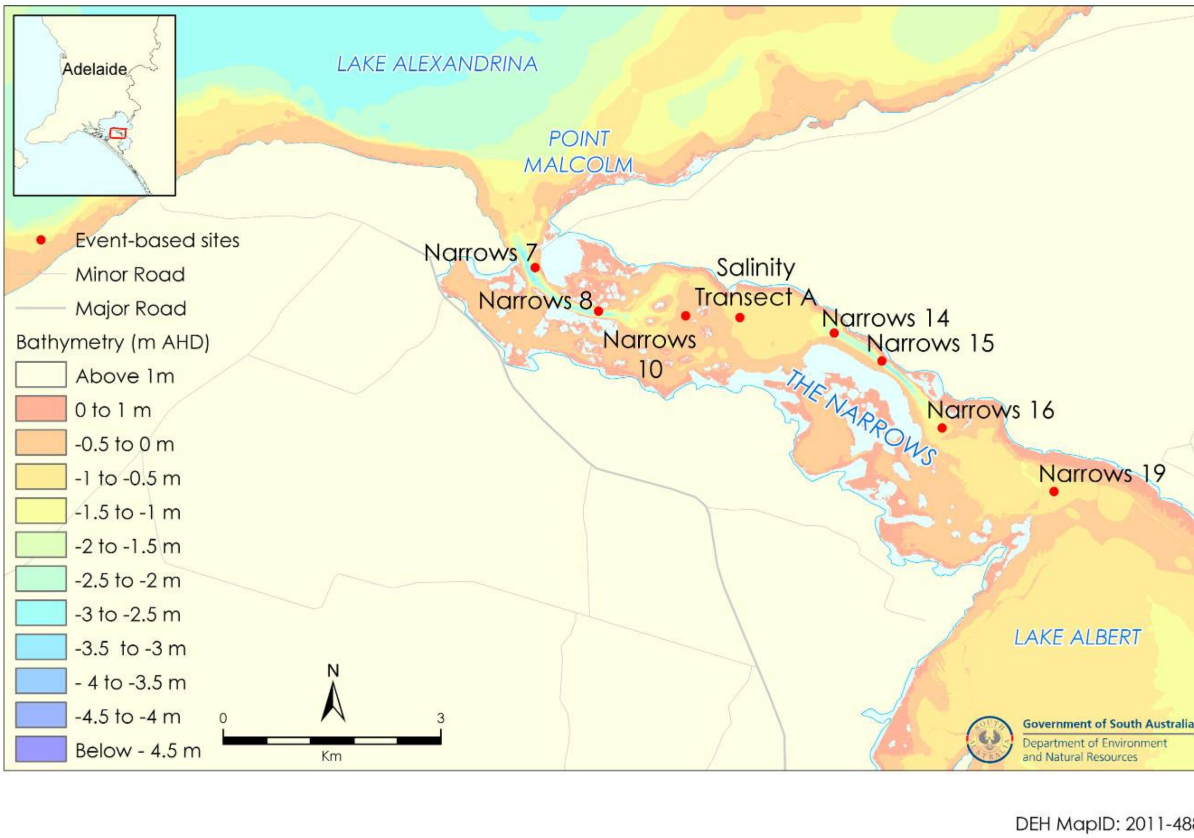

Figure 40 – Narrung Narrows monitoring sites

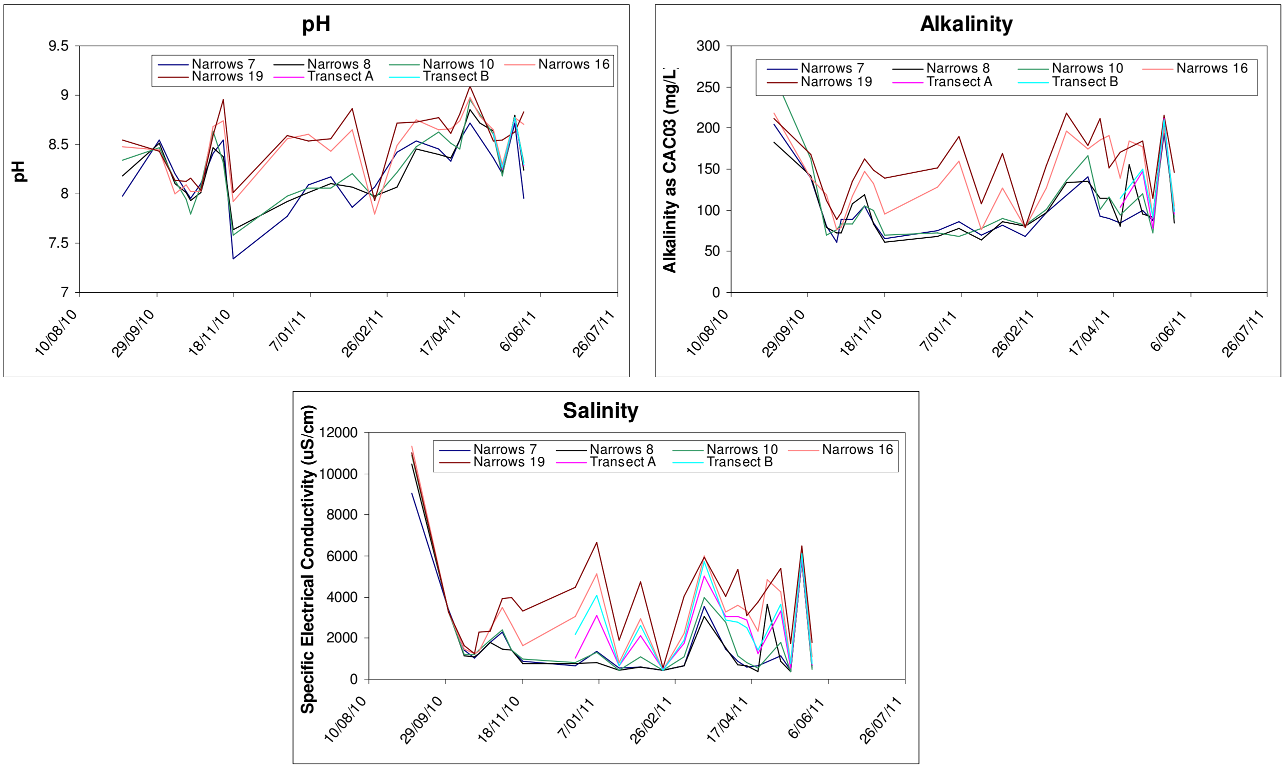

Figure 41 –Narrung Narrows water quality results

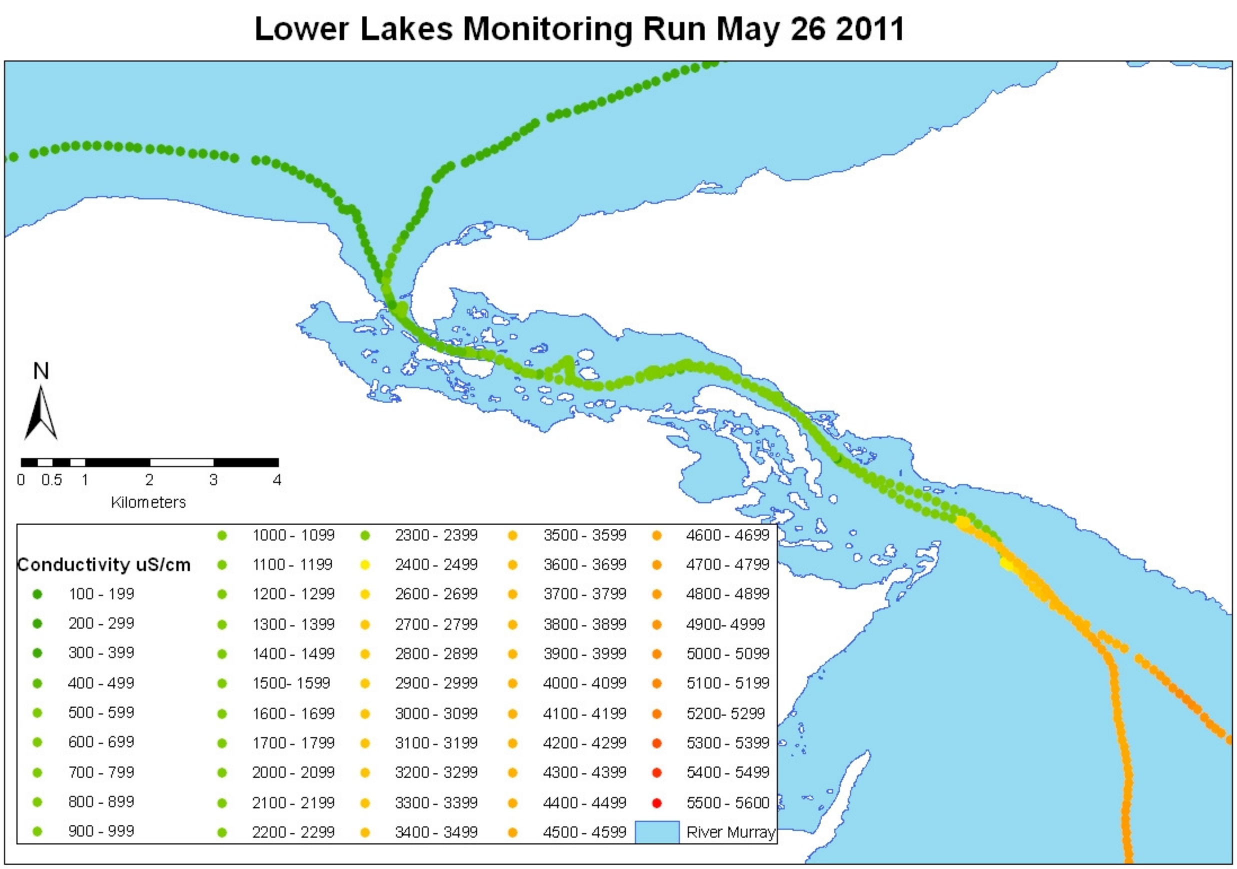

Figure 42 – Narrung Narrows salinity transect

Boggy Creek and Hunters Creek

Figure 43, 44 and 45 show the Boggy Creek and Hunters Creek sampling sites and water quality results respectively. During the month of May a king tide event occurred whilst the barrages were open causing a flux of marine water into the Mundoo channel as well as Boggy and Hunters creek. The sampling event coincided with this event as shown by the spike in salinity at sites closest to the Mundoo Channel (Figures 44 and 45). As the tide recedes and the marine water is flushed out into the Coorong the salinity will decrease. During May pH and alkalinity varied through out Boggy Creek but remained about ANZECC guidelines. Alkalinity within Hunters Creek decreased at all sites during May.

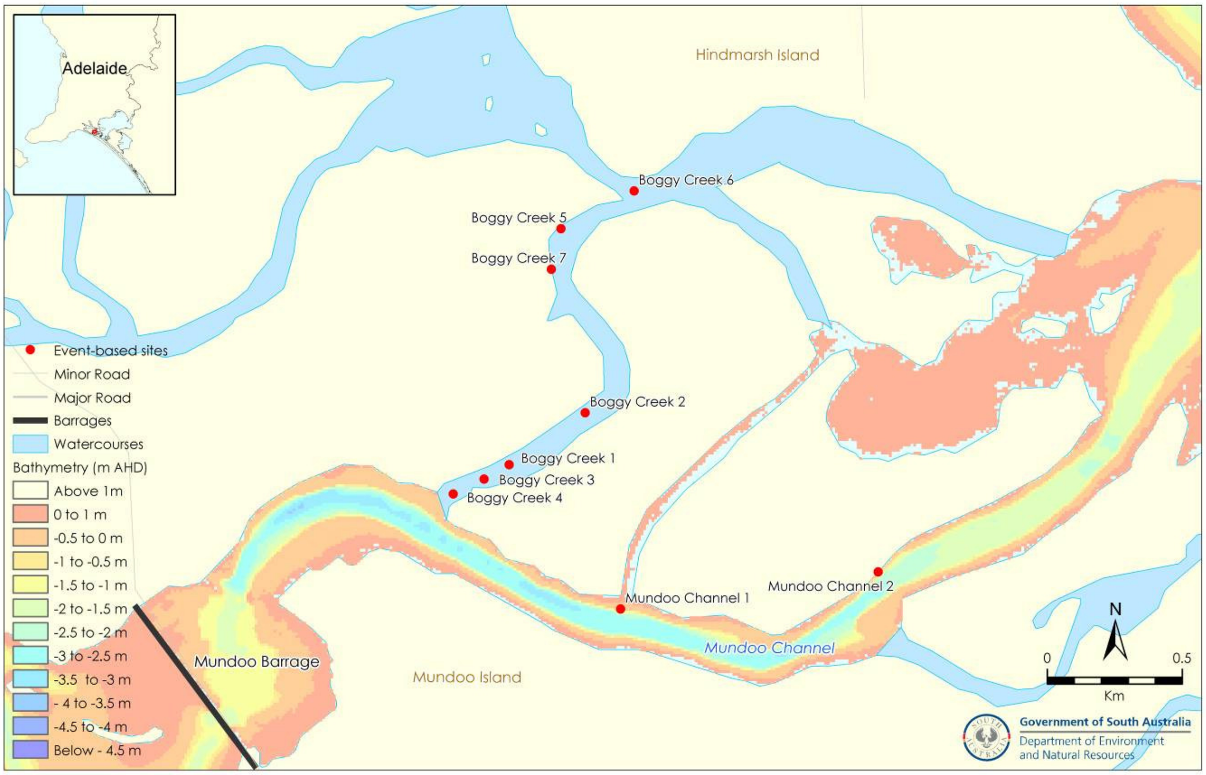

Figure 43 –Boggy and Hunters Creek Site Locations

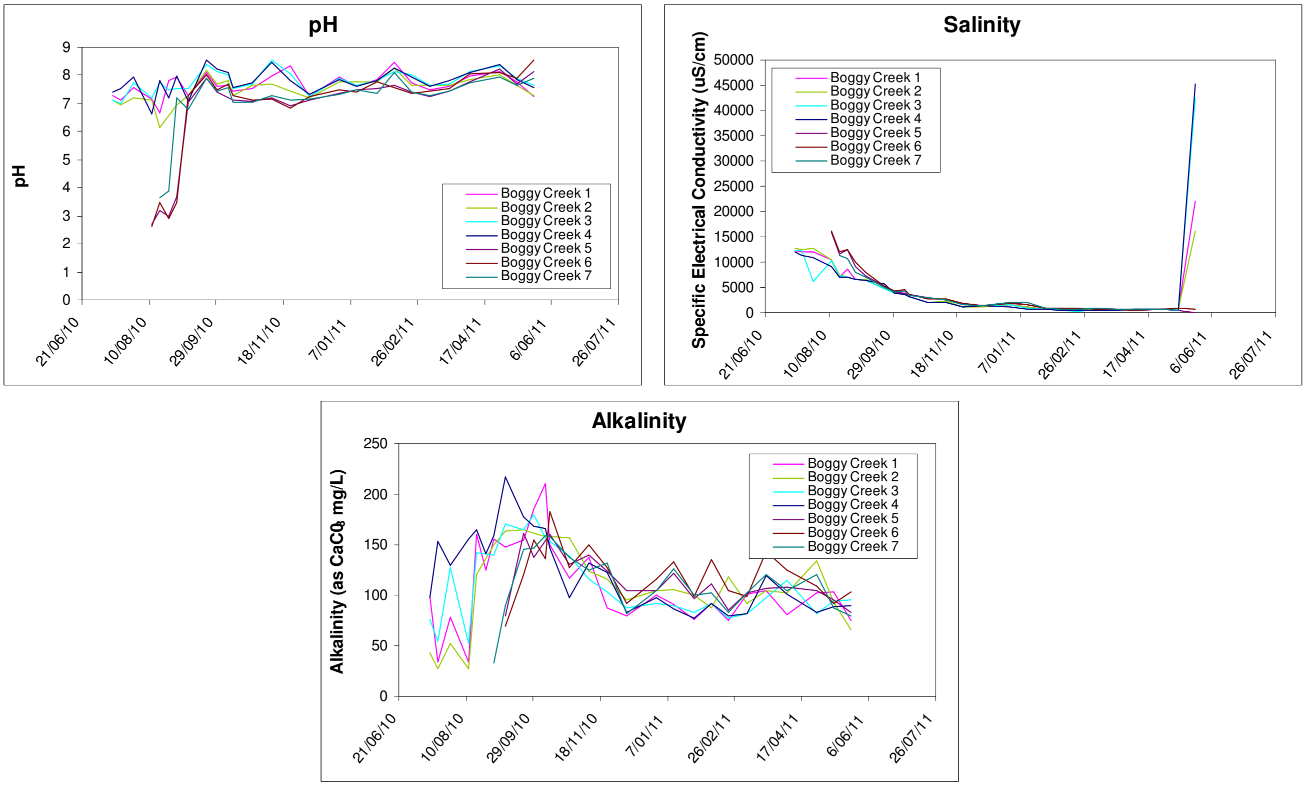

Figure 44 –Boggy Creek water quality results

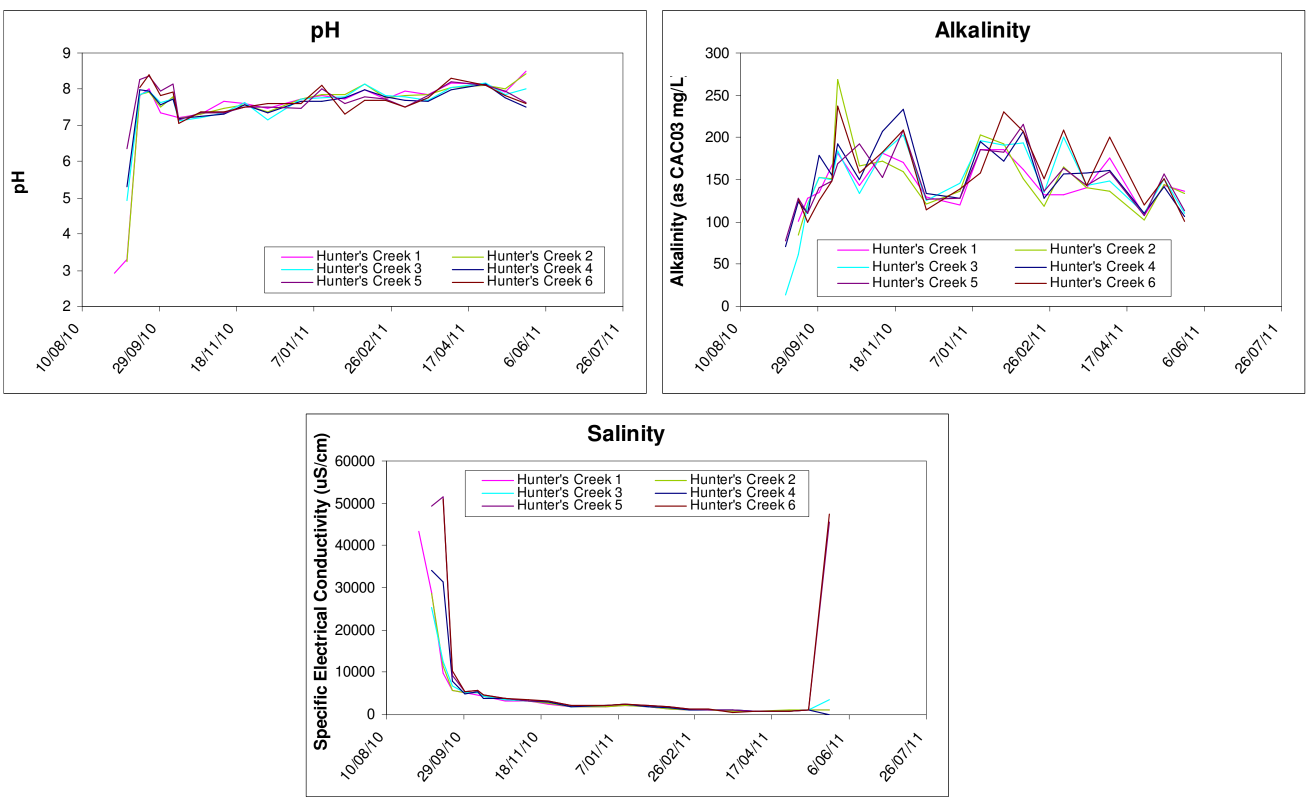

Figure 45 –Hunters creek water quality results

Tauwitchere

Figure 46 shows a map of the Tauwitchere area and the selected sampling sites. Salinity has remained relatively stable in May at low levels (Figure 47). The persistent low salinity is likely a result of the continued flushing of salt through the barrages. Alkalinity and pH slightly decreased at most sites but remain within ANZECC guidelines, and is consistent with the water quality flushing though the Lakes from the River Murray.

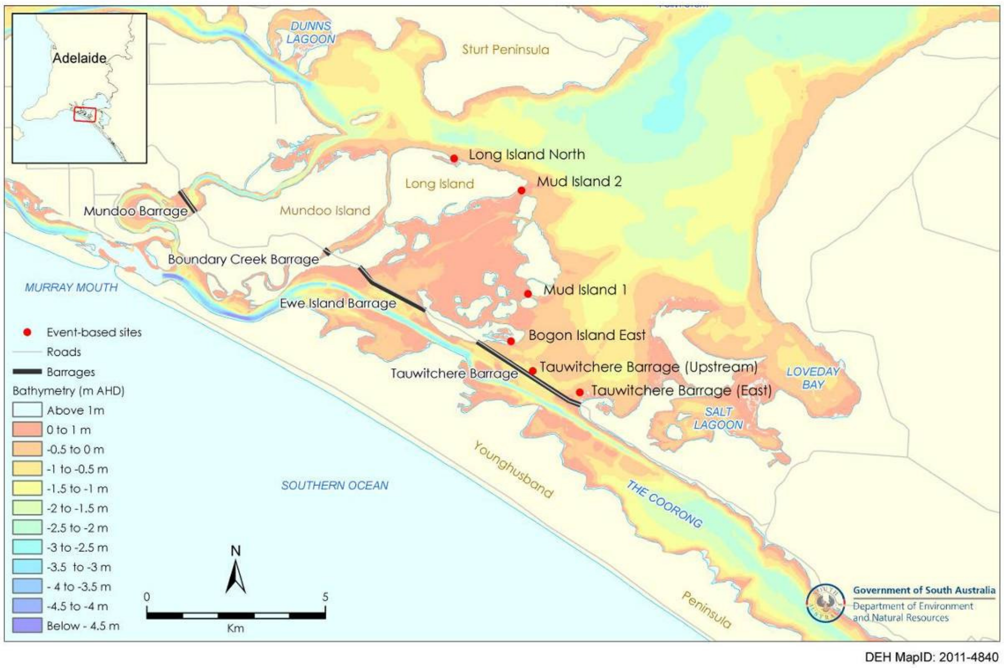

Figure 46 – Tauwitchere monitoring sites

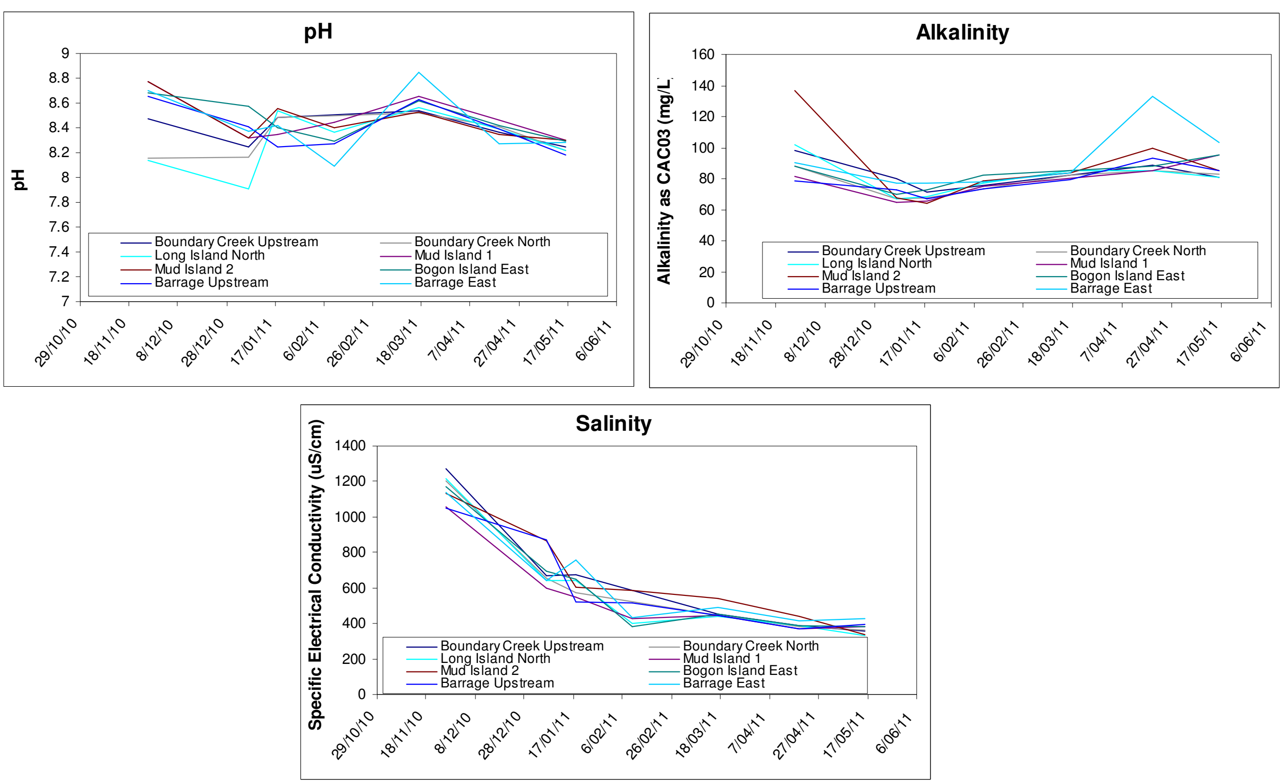

Figure 47 – Tauwitchere Water Quality

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 http://www.epa.sa.gov.au/environmental_info/water_quality/lower_lakes_water_quality_monitoring
- 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