Annual Report 2019

Salty Lagoon Post-Closure Monitoring Program (Years 6 – 10)

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Executive Summary

GeoLINK and Aquatic Science and Management have been engaged by Richmond Valley Council (RVC) to implement the Salty Lagoon Post Closure Monitoring Program. This report (Annual Report 2019) summarises the results of the monitoring undertaken between July 2018 and June 2019. Key findings are summarised below.

The reporting period was characterised by below average rainfall, with drought conditions occurring between November 2018 and March 2019. A saltwater ingress event from Salty Creek into Salty Lagoon in February 2019 was also a major influence of the water quality in Salty Lagoon system.

Water Quality (Monitored at Salty Lagoon and Salty Creek)

- Water level: Water levels in Salty Lagoon were variable in response to rainfall, periodic dry conditions and saltwater ingress.
- Conductivity: Conductivity measurements were generally high in Salty Lagoon during the reporting period as a result of periodic dry conditions and saltwater ingress from Salty Creek.
- Dissolved oxygen (DO): DO concentration measured at the Salty Lagoon permanent water quality monitoring station (PWQMS) dropped below 1 mg/L on a low number of occasions. A continued decrease in the occurrence of hypoxic conditions at the Salty Lagoon relative to the Monitoring Pre/Post Closure (MPPC) monitoring and generally higher dissolved oxygen concentrations than during the previous annual reporting period was recorded.
- pH: The pH measurements at the Salty Lagoon PWQMS were generally stable but relatively high throughout the reporting period.
- Temperature: Temperature fluctuated according to both daily and seasonal patterns. The relationship between the water level in Salty Lagoon and the magnitude of temperature variation was again observed over this reporting period.
- Turbidity: Turbidity measurements were relatively stable and low throughout the reporting period. Very few short periods of higher turbidity recorded were associated with heavy rainfall and very low water levels.
- Nitrogen: Total nitrogen (TN) concentrations were variable but within the range measured during the MPPC. The predicted dominance of dissolved organic nitrogen (DON) as the major form of nitrogen in samples was observed.
- Phosphorus: Median total phosphorus (TP) and orthophosphate concentrations complied with guiding values at all sites during this reporting period. Variations in phosphorus concentrations did not conform to a specific pattern. Site S2 is the site most influenced historically by discharged effluent from the Evans Head STP and is most often the site with the highest phosphorus concentration.
- Chlorophyll-a: Chlorophyll-a concentrations generally complied with guiding values for the majority of samples collected during this reporting period. The highest chlorophyll-a concentrations measured were recorded in the summer months while water levels were low and nutrient concentrations were high.
- Blue green algae: Blue green algae were not detected within Salty Lagoon during this monitoring period.

- Faecal indicator organisms: There was a high degree of variation among the faecal indicator organism results collected during this reporting period. The major contributors to the observed variation in the concentration of faecal indicator organisms are runoff from the catchment and the presence of waterfowl. The results do not suggest that discharge from the Evans Head Sewage Treatment Plant (STP) or leaks from the Evans Head sewerage system are strongly influencing the concentrations of faecal indicator organisms.

The majority of the median monitoring results complied with the project guiding values with the exception of pH, conductivity and DO. No results indicative of the current Evans Head Sewage Treatment Plant discharge adversely impacting the Salty Lagoon ecosystem were observed. The results indicate that saltwater ingress from Salty Creek has been a major influence on the water quality in Salty Lagoon. No fish kill events were recorded during the reporting period.

Erosion

The erosive headcut migrating towards Salty Lagoon from Salty Creek advanced significantly during this reporting period. This remains a considerable risk to the positive changes recorded in the Salty Lagoon environment since the closure of the artificial channel.

Aquatic Vegetation/ Weeds

- No significant introduced species of aquatic weeds have been recorded in the current monitoring period, though two native species sometimes considered nuisance plants have been recorded.
- The risk of weed invasion into Salty Lagoon remains.

Overall System Health

The overall health of the Salty Lagoon ecosystem has improved since closure of the artificial channel. No evidence of the current Evans Head Sewage Treatment Plant discharge adversely impacting the Salty Lagoon system were observed.

1. Introduction

1.1 Background

GeoLINK and Aquatic Science and Management (ASM) have been engaged by Richmond Valley Council (RVC) to implement *the Salty Lagoon Post Closure Monitoring Program* (GeoLINK 2017a). Prior to this current engagement, RVC implemented the *Salty Lagoon Ecosystem Response Monitoring Program* (ERMP – Worley Parsons) and the Salty Lagoon Monitoring Program: Pre/Post Channel Closure (MPPC – Hydrosphere 2010a).

In brief, the ERMP sought to monitor the ecological health of the system for a two-year period, and to collect data across a range of disciplines to allow for further planning to be undertaken in accordance with the broader aims of the rehabilitation strategy. The study site for the ERMP was more extensive than that being monitored under the MPPC or the current engagement and included sampling sites along the entire length of the drainage channel from the Evans Head Sewage Treatment Plant (STP) to Salty Lagoon, and areas of adjoining bushland to the north of this facility. This work was completed in March 2010 (Hydrosphere 2010b) and included the following components:

- Water quality and hydrology
- Diatoms
- Macroinvertebrates
- Fish
- Frogs and waterbirds
- Flora and vegetation mapping
- Weeds.

The MPPC sought to monitor the ecological health of the system before and after a trial closure of the artificial channel that once connected Salty Lagoon and Salty Creek. The study site for the MPPC was the same as the current engagement. The MPPC concluded at the end of June 2017 and included the following components:

- Water quality and hydrology
- Macroinvertebrates
- Fish
- Frogs and waterbirds
- Flora and vegetation mapping
- Aquatic Weeds.

The current post closure monitoring program continues from the MPPC monitoring with a reduced frequency of site visits and a reduced overall suite of monitoring components (GeoLINK 2017a).

1.2 Objectives

The objectives of the post closure monitoring program are summarised as follows:

1. Monitor the health of the Salty Lagoon ecosystem and confirm that the Evans Head STP discharge is not adversely impacting water quality and ecology at Salty Lagoon.

2. Monitor water quality and ecological attributes of the MPPC where predicted trends have not been confirmed and risks to the ecosystem remain.
3. Observe medium to long-term changes in the Salty Lagoon system in response to channel closure.

This report (*Annual Report 2019)* summarises the results of the monitoring undertaken between July 2018 and June 2019 as part of the post closure monitoring program.

2. Water Quality

2.1 Introduction

Adequate water quality has been identified as a key factor influencing the ecosystem processes in Salty Lagoon. Issues with water quality such as high nutrient concentrations and rapid changes in conductivity and dissolved oxygen have been identified in previous monitoring. Poor water quality in the past has led to fish kills, indicating ecosystem collapse (Hydrosphere 2009). The Salty Lagoon water quality monitoring program provides the key information for understanding the Salty Lagoon ecosystem.

Ongoing monitoring of water quality in Salty Lagoon has changed for the post closure monitoring period. However, there is still a multi-faceted approach to water quality sampling involving permanent water quality monitors, discrete sampling of surface waters and an additional response protocol. The range of parameters covered by each of these approaches to water quality monitoring is described in **Table 2.1**.

Table 2.1 Approaches to Water Quality Monitoring and Parameters Measured for the MPPC

Approach	*Sampling Type*	*Parameters*
Permanent water quality monitoring stations (PWQMS)	Physico-chemical	Temperature, conductivity, dissolved oxygen (DO), pH, turbidity, water level
Monthly discrete sampling and adaptive management response sampling	Physico-chemical	Temperature, conductivity, dissolved oxygen (DO), pH, turbidity, secchi depth, redox potential
	Chemical	Total nitrogen, ammonia, nitrate, nitrite, total kjeldahl nitrogen, total phosphorus, orthophosphate
	Biological	Chlorophyll-a, blue green algae, faecal coliforms, enterococci

2.2 Methods

2.2.1 Permanent Water Quality Monitoring Stations

There are two permanent water quality monitoring stations (PWQMS) in place measuring water level, temperature, pH, conductivity, turbidity and dissolved oxygen (DO) concentration. Each PWQMS is fitted with an YSI EXO3 sonde and a HOBO U50 water level data logger. Data is collected at 30-minute intervals, logged and accessed during bi-monthly site inspections. The water level data is corrected prior to reporting using the surveyed levels of the measuring boards at each of the permanent water quality monitoring stations and a barometric pressure logger deployed at Salty Lagoon (S1). The individual probes on each EXO3 sonde are removed from the PWQMS, calibrated and serviced after a four-month deployment.

2.2.2 Routine Discrete Sampling

Discrete water quality samples were taken from surface water (approx. 0.2 m depth) at four sites in Salty Lagoon (S1-S4) and a single site (S5) in Salty Creek on a bi-monthly basis. An additional quality assurance (QA) replicate sample was collected from a randomly chosen site each monitoring event. The specific locations of all sites sampled are presented in **Table 2.2** and displayed in **Illustration 2.1**. Sampling was undertaken bi-monthly (every second month) commencing at the end of July 2018 for the reporting period (six events in total).

Table 2.2 Locations of Water Quality Sample Sites in Salty Lagoon and Salty Creek (WGS84)

Site	*S1*	*S2*	*S3*	*S4*	*S5*
Easting	0542064	0541799	0542037	0541738	0542187
Northing	6782801	6782669	6783013	6783033	6783665
Site description	Salty Lagoon PWQMS	SE of drainage channel	NE area of lagoon	NW area of lagoon	Salty Creek PWQMS

Physico-chemical water quality parameters in discrete surface water samples were measured with an HORIBA U-52 hand held water quality meter. Depth profiling of physicochemical parameters was undertaken at one metre intervals at sites where the water depth was sufficient to allow it. Depth profiling is undertaken to improve the understanding of stratification of the water column at times when the water level is high. The results of depth profiling are reported in bi-monthly ecosystem health reports and will not be repeated here.

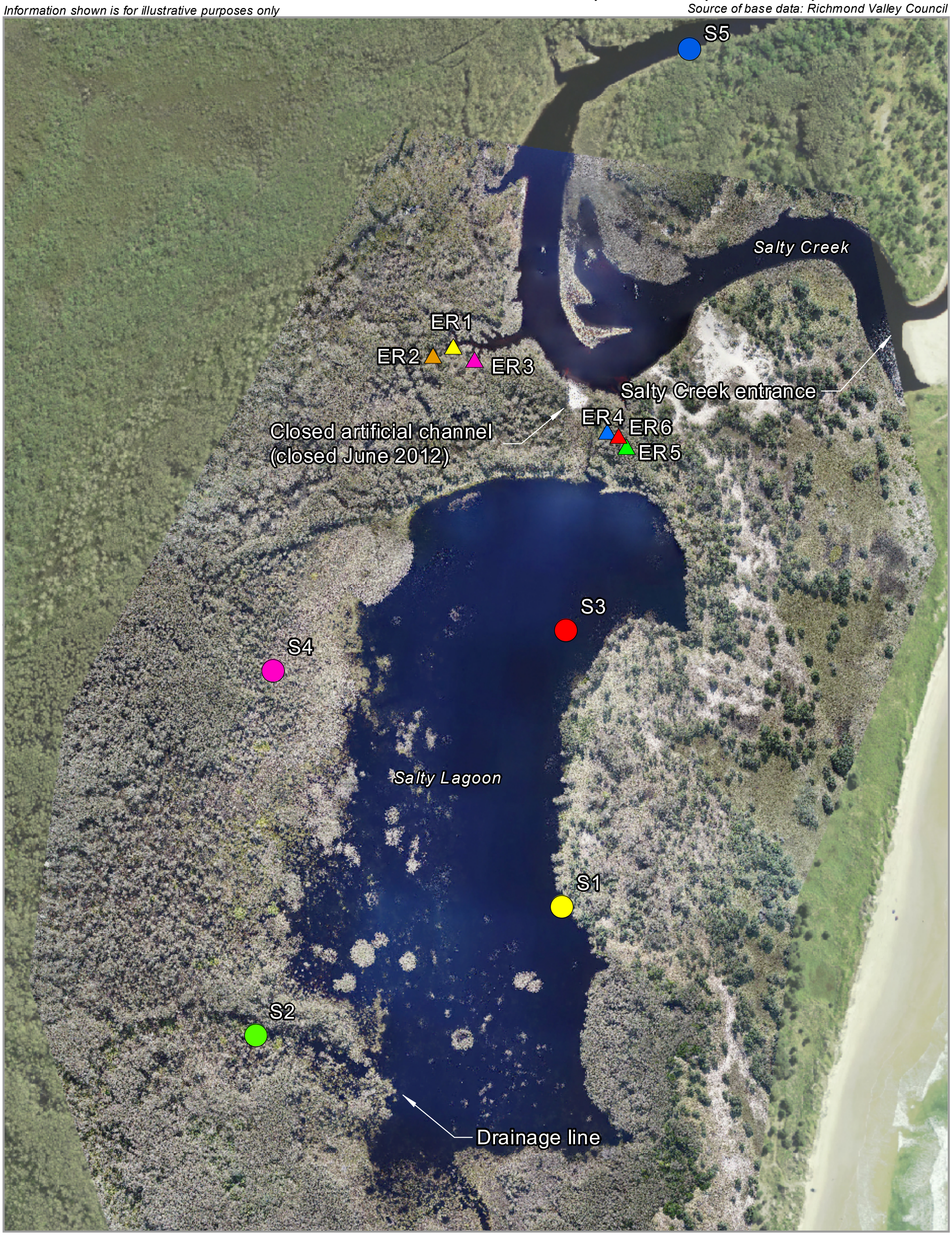
Discrete samples were collected in jars for analysis of chemical and biological parameters at the Coffs Harbour Laboratory (CHL). Sterile jars were used for bacteriological analysis and brown glass jars were used for analysis of chlorophyll-a and blue green algal (BGA) content. Samples were placed upon ice in an esky and delivered to CHL within 24 hours of collection.

2.2.3 Adaptive Management WQ Sampling

The MPPC Salty Lagoon Response Protocol was reviewed and updated in October 2017 to guide adaptive management as part of the post closure monitoring program (GeoLINK 2017b). The new protocol involves assessing the collected water quality data and environmental variables such as the status of the entrance to Salty Creek, the status of the headcut between Salty Creek and Salty Lagoon and seasonal rainfall fluctuations to prepare a risk level.

Adaptive management water quality sampling is only implemented when the Salty Lagoon system is in a 'high risk' status, a site inspection is undertaken, and an environmental incident is noted. During this reporting period Salty Lagoon retained a risk status of 'low' or 'unknown' and there were no adaptive management site inspections undertaken.

Drawn by: DSA Checked by: AB Reviewed by: AB Date: 04/10/2019
Source of base data: Richmond Valley Council
Information shown is for illustrative purposes only



LEGEND

Water Quality Site	Erosion Monitoring Site
S1	ER1
S2	ER2
S3	ER3
S4	ER4
S5	ER5
	ER6

0 120

Location of Water Quality and Erosion Monitoring Sites

2.2.4 Guiding Values

Guiding values for the MPPC monitoring program were revised in September 2012 using water quality data collected between April 2011 and September 2012 as part of the MPPC project. They were developed separately for Salty Lagoon and Salty Creek, from surface water data collected at all sites and incorporated all parameters measured as part of the MPPC.

The guiding values were set at the 80th percentile value of the collected data set for Salty Lagoon and Salty Creek with the following exceptions:

- The guiding values for dissolved oxygen were set at the 20th percentile value.
- A guiding value range was developed for pH, conductivity and temperature in Salty Creek due to the varying influences of sea water and freshwater runoff. The outlying points for the guiding value ranges were set at the 10th and 90th percentile values.

The guiding values were developed to assist with the contextualisation of results, rather than as a measure of the health of the waterway. However, guiding values also provide a yardstick, around which the adaptive management of Salty Lagoon can be discussed.

These guiding values are being used as part of the current post closure monitoring program for all water quality parameters being sampled; and are presented in **Table 2.3**.

Table 2.3 Guiding Values for all Water Quality Parameters

Measure		***Guiding Value***	
		Salty Lagoon	***Salty Creek***
Chemical	Total nitrogen (mg/L)	1.6	1.64
	Ammonia (mg/L)	0.05	0.11
	Nitrate (mg/L)	0.01	0.01
	Nitrite (mg/L)	0.01	0.01
	Total kjeldahl nitrogen (mg/L)	1.6	1.64
	Total phosphorus (mg/L)	0.14	0.04
	Orthophosphate (mg/L)	0.11	0.01
Biological	Chlorophyll-a (µg/L)	5	3
	Faecal coliforms (CFU/100mL)	135	150
	Enterococci (CFU/100mL)	170	40
	Blue green algae (cells/mL)	0	0
Physical	Dissolved oxygen (mg/L)	4.09	5.52
	Turbidity (NTU)	13.0	11.0
	pH	6.9	4.3 – 6.8
	Conductivity (mS/cm)	8.0	0.3 – 21.5
	Temperature (˚C)	25.9	13.1 – 28.8

2.3 Results and Discussion

2.3.1 Rainfall

Rainfall, or lack thereof, is a key factor influencing water quality in Salty Lagoon and Salty Creek. Monthly rainfall conditions for the reporting period are displayed in **Figure 2.1**. Daily rainfall for the reporting period is displayed in **Figure 2.2** and **Figure 2.3**. Overall, the monitoring period was characterised by below average rainfall. Total rainfall for this monitoring period was 1259.8 mm. The annual average rainfall for the Evans Head BOM station is 1453.6 mm. September and October 2018 were much wetter than average but the period between November 2018 and March 2019 could be described as drought conditions. Most of the rain fell as part of small to moderate rainfall events. There were four daily rainfall totals of greater than 50 mm during this reporting period and none greater than 60 mm.

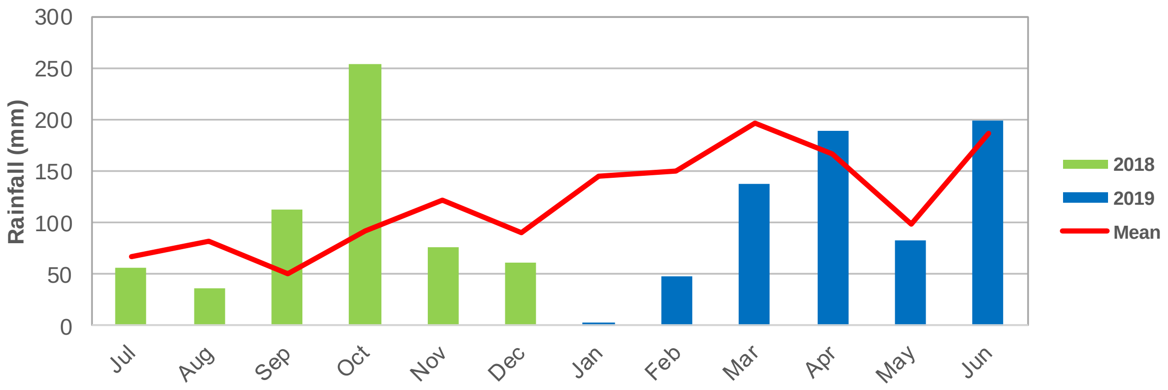


Figure 2.1 Monthly rainfall at the Evans Head BOM weather station for the reporting period displayed against average monthly rainfall (BOM 2019)

2.3.2 Permanent Water Quality Monitoring Stations

2.3.2.1 Data Quality and Consistency

Following the installation of the YSI EXO3 water quality monitoring systems in October 2017 the data quality and consistency improved significantly. However, for the period between July 2018 and June 2019 there are some gaps in the data from the PWQMS. These are either:

- Short-term (between 30 minutes and 2 hours) gaps in the data set associated with changing deployed probes for serviced and calibrated probes.
- A large gap in the Salty Creek turbidity, and the Salty Lagoon turbidity and water level measurements, between November 2018 and January 2019 where no data was collected due to an error during sonde and probe deployment.
- A large gap in most parameters measured in Salty Lagoon between 19 January and 28 March 2019 due to equipment failure, while the sonde was repaired under warranty and redeployed.

Over the monitoring period from 1 June 2018 to 30 June 2019, the missed data points from the Salty Lagoon PWQMS were as follows:

- <0.1 % temperature data points.
- 3189 (18.2 %) missed pH, conductivity and DO data points.
- 3263 (18.6 %) missed water level data points
- 6448 (36.8 %) missed turbidity data points

Over the monitoring period from 1 June 2018 to 30 June 2019, the missed data points from the Salty Creek PWQMS were as follows:

- <1 % missed temperature, pH, conductivity, dissolved oxygen and water level data points.
- 3267 (18.7 %) missed turbidity data points

As part of routine maintenance, the logged results are compared in the field with data collected from a handheld water quality probe every month. In general, the results correlate very well. The correlation has improved further since the deployment of the YSI EXO3 equipment.

2.3.2.2 Key Points Arising from the Salty Lagoon Data Set

The results from the Salty Lagoon PWQMS are presented in **Figure 2.2** and discussed below.

Water Level

The water level was high in Salty Lagoon at the beginning of the reporting period and increased slightly in response to moderate rainfall in September 2018 and heavy rainfall in October 2018. Dry weather conditions then resulted in falling water levels, a minimum of approximately 1.19 mAHD being experienced at the end of February 2019. Water levels in December 2018 and February 2019 were so low that there was no water to sample at site S4. Saltwater ingress from Salty Creek led to moderate water levels in late February 2019. Water levels remained at moderate levels from then until the end of the monitoring period when heavy rainfall led to high water levels. The water level chart in **Figure 2.2** indicates that the maximum water level reached in Salty Lagoon for the reporting period was 2.02 m AHD (Australian Height Datum), after heavy rainfall in the middle of October 2018.

Conductivity

Conductivity is a measure of the saltiness of the water. The key driving factors causing fluctuations in the conductivity of the water recorded in Salty Lagoon during this reporting period were rainfall, evaporation and saline water inflow from Salty Creek. Evaporation causes a gradual increase in conductivity measurements as salts become distilled. Rainfall has the opposite effect but typically operates over shorter timeframes.

The conductivity measurements show that the impact of rainfall on water quality in Salty Lagoon was limited, probably because the water levels were high at the times of the most significant rainfall events in September 2018, October 2018 and June 2019. The impact of evaporation upon water quality was most significant between late October 2018 and late February 2018.

Saline water inflow from Salty Creek occurred once during the reporting period. It led to higher than normal conductivity measurements for the last four months of the reporting period, with a maximum of 41.87 mS/cm (almost 80% of the conductivity of seawater). The average conductivity measured during this reporting period was 10.02 mS/cm.

Dissolved Oxygen

Historically, variation in the dissolved oxygen concentrations measured in Salty Lagoon relate to the following features (GeoLINK 2017b):

- Diffusion: The surface of the water is exposed to the air and dissolves oxygen constantly through diffusion. For this reason, DO concentrations tend to be higher in surface waters.
- Microalgal concentrations: Microalgae produce oxygen during the day through photosynthesis and consume it at night through respiration. Nutrient availability has an impact on DO concentrations indirectly through supporting microagal concentrations.
- Light availability: This influences the photosynthetic activity of microalgae throughout the water column and attached to the benthos. Turbidity, therefore, is a key regulator of DO concentrations.
- Wind and flow driven mixing: Mixing of the water column serves to bring well oxygenated water from the surface into lower parts of the water column. The stronger the wind or flow, the deeper the mixing. North and south winds have the greatest effect on Salty Lagoon due to the north-south orientation.
- Water level: The depth of the water determines the impact of wind driven mixing and the availability of light at the bottom of the water column.
- Salinity: There have been sharp reductions in DO concentration associated with saline water ingress in previous years, possibly due to the impact upon microalgal concentrations.

During this reporting period the major features of dissolved oxygen variation were:

- Diurnal fluctuations.
- More stable dissolved oxygen concentrations during freshwater conditions.
- More variable dissolved oxygen concentrations during times of higher salinity.
- Lower dissolved oxygen concentrations and greater daily fluctuations during the summer months, when water levels became lower.

During this reporting period the DO concentration measured at the Salty Lagoon PWQMS dropped below 1 mg/L on a low number of occasions. In the current reporting period, the DO concentration was 6 mg/L or less for approximately 48% of measurements and 1 mg/L or less for approximately 2% of measurements. This suggests a continued decrease in the occurrence of hypoxic conditions at the Salty Lagoon PWQMS relative to the MPPC monitoring and generally higher dissolved oxygen concentrations than during the previous annual reporting period. More reliable dissolved oxygen measurements from the new PWQMS equipment may have contributed to this result.

pH

The pH measurements at the Salty Lagoon PWQMS were relatively stable during this reporting period, particularly while freshwater conditions persisted. The data indicates that the pH in Salty Lagoon varied mostly in response to saltwater ingress from Salty Creek. There are also small daily fluctuations in pH associated with other diurnal changes in water quality such as dissolved oxygen concentration and small reductions in the pH are notable after heavy rainfall. Daily variations in response to dissolved oxygen concentrations were larger when saline conditions dominated. Overall the variation was low, with the measured pH mostly between 6.5 and 8.0.

Temperature

Over the reporting period temperature fluctuated according to both daily and seasonal patterns. There is also a relationship between water level in Salty Lagoon and the magnitude of daily temperature variation. When water levels are low, temperature variation tends to be greater. Other sources of variation evident from the data for this reporting period include greater temperature stability following times of high-water levels and rapid reductions in temperature following moderate to heavy rainfall.

Water temperature indirectly and directly impacts upon other parameters. For example, at higher temperatures water has a lower oxygen carrying capacity and higher temperatures encourage microalgal growth and activity and can therefore contribute to algal blooms.

Turbidity

Turbidity measurements fluctuate in response to various other factors such as wind driven sediment suspension and microalgal growth. During the current monitoring period turbidity measurements were relatively stable and mostly remained below 5 NTU. There were very few short periods of higher turbidity measurements, associated with a period of heavy rainfall and with a period of very low water levels.

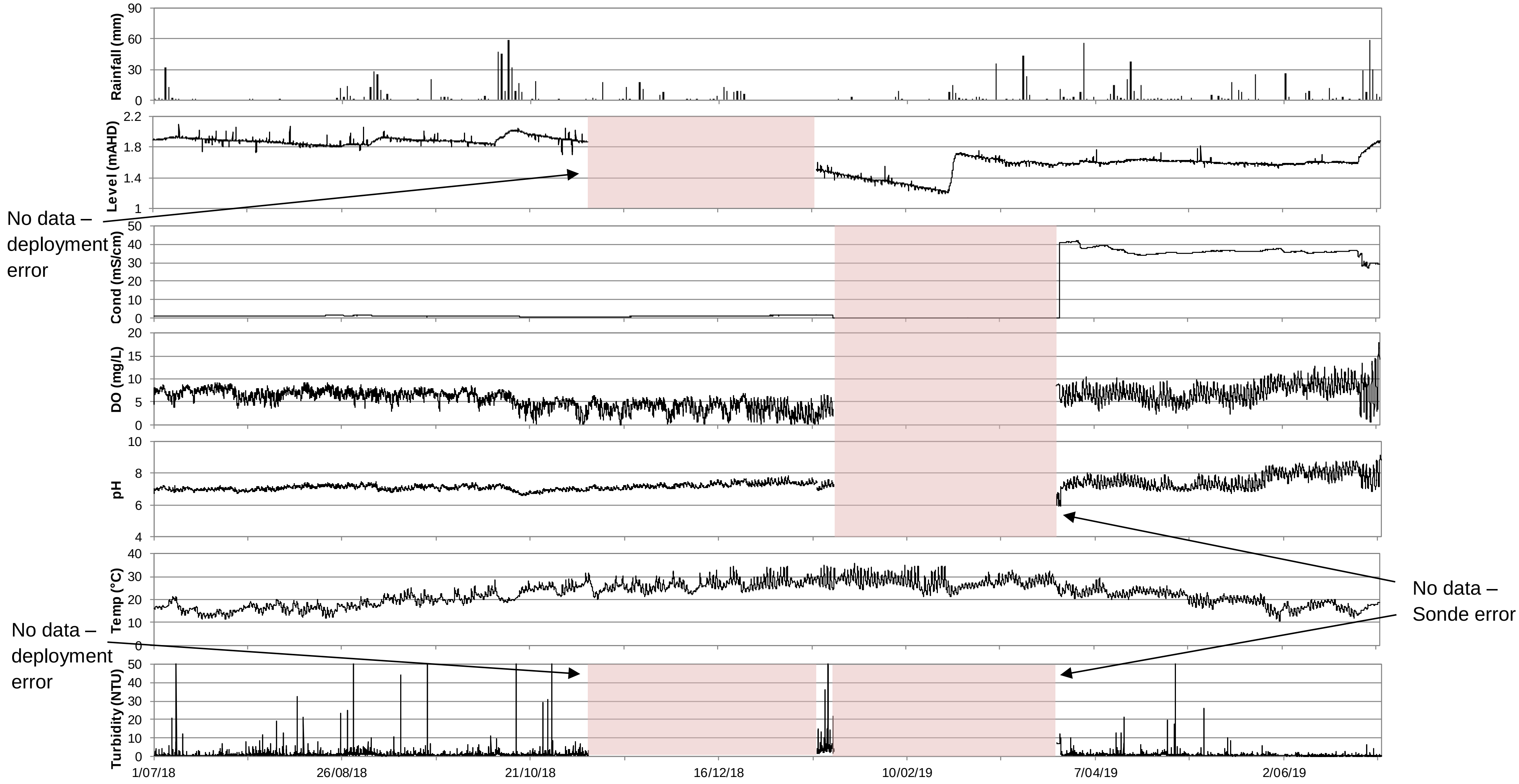


Figure 2.2 Data from the Salty Lagoon PWQMS for the 2018/19 reporting period

2.3.2.3 Key Points Arising from the Salty Creek Data Set

The Salty Creek PWQMS is important in the context of managing Salty Lagoon as it provides information about how water quality in Salty Creek can impact upon Salty Lagoon. The results from the Salty Creek PWQMS are presented in **Figure 2.3** and discussed below.

Water Level

The most important factor affecting the water level in Salty Creek is the status of its entrance. The collected data indicates that the entrance to Salty Creek opened at least five times in the current reporting period, compared with a minimum of two and a maximum of seventeen times in the annual reporting periods of the MPPC. The level of Salty Creek increased sharply on several occasions during this reporting period as a result of seawater ingress during large swell and storm surge conditions, and on a small number of times in response to heavy rainfall. The entrance to Salty Creek tends to close during the large swell events, which result in sand delivery to the beach and an increased height of the entrance berm. One such event in late February 2019 led to very high-water levels and a closed entrance. The entrance remained closed from that point until the end of the monitoring period.

Conductivity

The conductivity measurements from the Salty Creek PWQMS fluctuated widely in response to the dynamic state of the entrance, seawater ingress, medium and heavy rainfall events, and dry conditions. However, the water in Salty Creek remained very saline for most of the monitoring period and brackish for short periods following heavy rainfall. Conductivity measurements close to those of seawater persisted from late February until the end of the monitoring period.

Dissolved Oxygen

Dissolved Oxygen (DO) concentrations measured at the Salty Creek PWQMS fluctuated widely throughout the year. A variety of factors influence the DO concentrations in Salty Creek. The general patterns of variation were as follows:

- An extended period of very low DO concentrations occurred while brackish conditions persisted during September and October 2018.
- DO concentrations in Salty Creek fluctuated diurnally over the majority of the reporting period. During this reporting period diurnal fluctuations were most prominent when there were stable saline conditions.
- The water column in Salty Creek is often stratified with respect to DO concentration, although this is not apparent from the logged information.

The DO concentration measured at the Salty Creek PWQMS was 6 mg/L or less for approximately 96% of the reporting period and 1mg/L or less for approximately 41% of the reporting period. For the second consecutive reporting period these figures indicate that low DO concentrations were much more prevalent than during the years of the MPPC.

pH

The pH measurements from the Salty Creek PWQMS fluctuated regularly during this reporting period and were closely associated with conductivity and the state of the entrance. Runoff from the catchment is naturally acidic, resulting in lower pH measurements in Salty Creek following heavy rainfall. Such conditions only occurred after the heaviest rainfall event in October 2018. Seawater ingress has the opposite effect, leading to alkaline pH measurements. The pH in Salty Creek was greater than 7 for most of the current reporting period and averaged 6.99.

Temperature and Turbidity

Temperature measurements in Salty Creek fluctuated on a daily and seasonal basis. Daily fluctuations in temperature are strongest when water levels are low. Turbidity measurements from the Salty Creek PWQMS were generally low, with periods of greater turbidity occurring during low water levels, during seawater ingress events and after heavy rainfall.

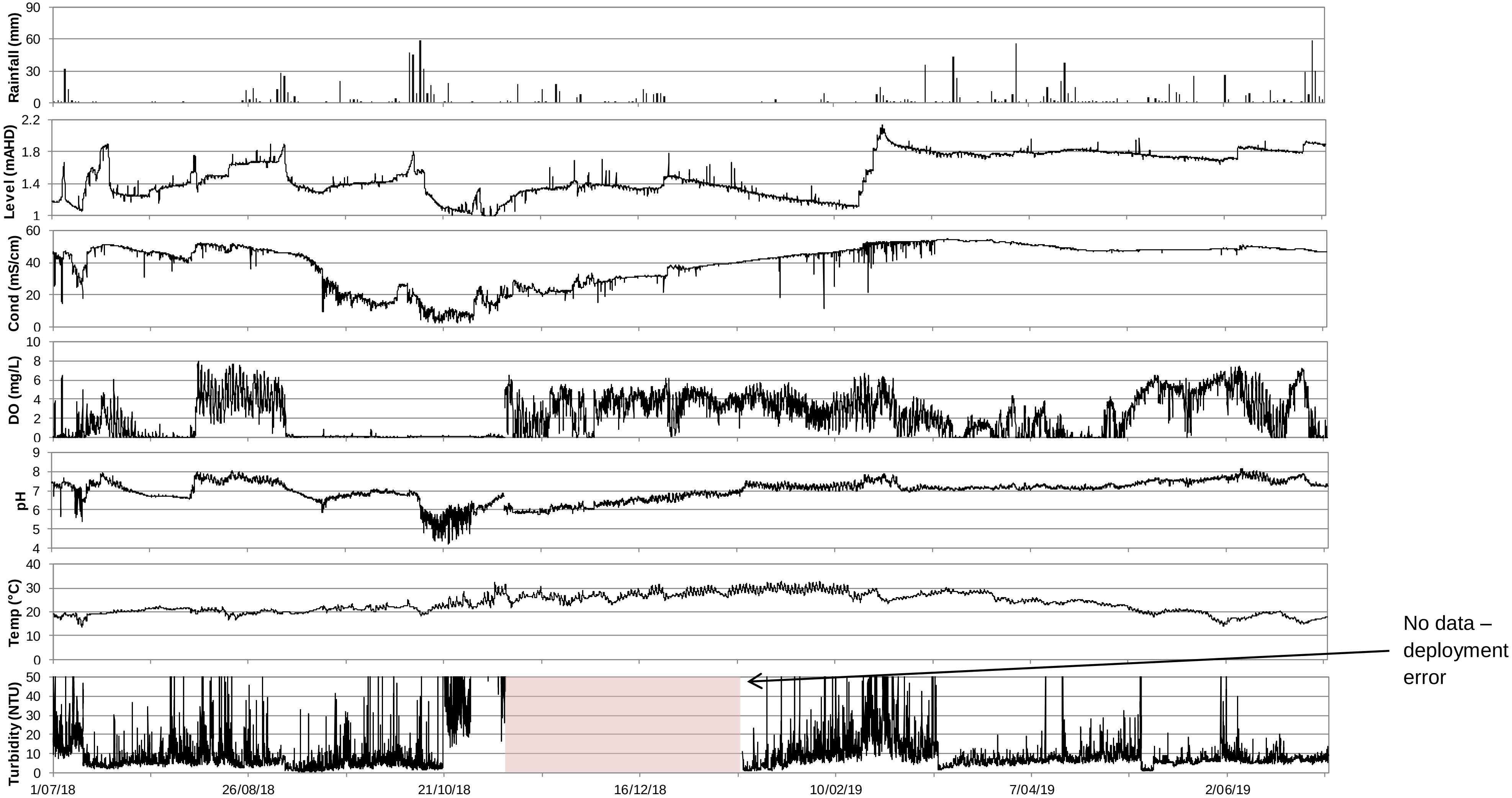


Figure 2.3 Data from the Salty Creek PWQMS for the 2018/19 reporting period

2.3.3 Discrete Water Quality Samples

This section describes the results of discrete water quality samples collected during normal bi-monthly water quality monitoring. A summary of median results for all samples from all sites is presented in **Table 2.4**. Most of the median results complied with guiding values.

Table 2.4 Median Results of Discrete Samples from Surface Waters at all Sites Between 1 July 2018 and 30 June 2019

Indicator	*Salty Lagoon*					*Salty Creek*	
	Guiding Value	*S1*	*S2*	*S3*	*S4*	*Guiding Value*	*S5*
Nitrite nitrogen (mg/L)	**1.6**	0.000	0.000	0.000	0.000	**1.64**	0.000
Nitrate nitrogen (mg/L)	**0.01**	0.000	0.000	0.000	0.000	**0.01**	0.000
Oxidized nitrogen (mg/L)	**-**	0.000	0.000	0.000	0.000	**-**	0.000
Ammonia nitrogen (mg/L)	**0.05**	0.027	0.000	0.014	0.000	**0.11**	0.000
Total kjeldahl nitrogen (mg/L)	**1.6**	1.38	1.50	1.43	**1.60**	**1.63**	0.61
Total nitrogen (mg/L)	**1.6**	1.39	1.50	1.44	**1.60**	**1.63**	0.61
Total phosphorus (mg/L)	**0.14**	0.10	0.12	0.11	0.04	**0.04**	0.00
Orthophosphate (mg/L)	**0.11**	0.045	0.079	0.041	0.000	**0.01**	0.000
Chlorophyll-a (µg/L)	**5**	3	**5**	**5**	2	**3**	0
Enterococcus (CFU/100mL)	**170**	23	154	10	53	**40**	28
Faecal coliforms (CFU/100mL)	**135**	33	**142**	33	18	**150**	9
Blue green algae (cells/L)	**0**	0	0	0	0	**0**	0
Temp (˚C)	**25.9**	21.90	20.83	22.26	16.09	**13.1-28.8**	23.60
pH	**6.9**	**7.10**	6.59	**7.25**	5.63	**4.3-6.8**	**6.91**
ORP (mV)	**-**	154	160	164	171	**-**	151
Cond (mS/cm)	**8.0**	**11.08**	7.27	**11.98**	6.84	**0.3-21.5**	**35.40**
Turbidity (NTU)	**13**	1.55	1.45	4.05	3.50	**11**	1.20
DO (mg/L)	**4.09**	4.20	**1.78**	5.61	**2.44**	**5.52**	**4.39**
DO (% sat)	**-**	55.50	21.10	71.45	27.40	**-**	64.40
TDS (ppt)	**-**	6.90	4.52	7.45	4.24	**-**	21.60
Salinity (ppt)	**-**	6.50	4.10	7.10	3.85	**-**	22.30

Note: ***red text:*** *not compliant with MPPC guiding values (GeoLINK 2012)*

In addition to summary results the discrete water quality data collected since the beginning of the post-channel-closure monitoring has been analysed for trends using the Mann-Kendall test. The Mann-Kendall test provides a Kendall score (S) and tau statistic (tau) that indicate the direction of trend, in addition to a variance value (VarS) and p-value (p) that indicate the statistical significance of the trend. The results of the Mann-Kendall test were analysed in a decision matrix to define the trends as either ‘Increasing’, ‘Decreasing’, ‘Possible Increasing’, ‘Possible Decreasing’, ‘No Trend’ or ‘Stable’ using a method derived from Newell *et al*., (2007).

The decision matrix is presented in **Table 2.5**. The results of the Mann Kendall test are presented in **Sections 2.3.3.1** to **2.3.3.5** along with discrete water quality monitoring results from individual sites.

Table 2.5 Mann-Kendall Test Decision Matrix

Mann Kendall Score (S) and Tau	*Statistical Significance (p)*	*Trend*
>0	<0.05	Increasing
>0	0.05 - 0.10	Possible Increasing
>0	>0.1	No Trend
≤0	>0.75	No Trend
≤0	0.1 - 0.75	Stable
<0	0.05 – 0.10	Possible Decreasing
<0	<0.05	Decreasing

2.3.3.1 Nitrogen

Nitrogen is an element that is essential to life. In waterways it plays an important role in supporting food webs. However, problems arise from excessive nitrogen concentrations in water. Nitrogen is frequently monitored as an indicator of water quality and its capacity to support a healthy aquatic ecosystem. Nitrogen is present in water in several forms. It can be dissolved or particulate and can be present in organic molecules that are unavailable for biological uptake or inorganic molecules that are bioavailable. For the MPPC and post closure monitoring, nitrogen is measured as total nitrogen (TN), and the dissolved inorganic nitrogen (DIN) forms; ammonia, nitrate and nitrite.

Some of the factors that have been found to influence nitrogen concentrations in Salty Lagoon and Salty Creek include seawater ingress, historical pollution, evaporative distillation and rainfall runoff (GeoLINK 2017b).

During the current reporting period the concentrations of TN were variable but within the ranges measured during the MPPC project (**Figure 2.4**). The majority of TN measurements complied with the guiding values. The highest TN concentrations during this reporting period were measured at sites S1, S2 and S4 in December 2018 while water levels were very low following almost 3 months of very dry conditions. At site S5 all TN concentrations recorded complied with the guiding values.

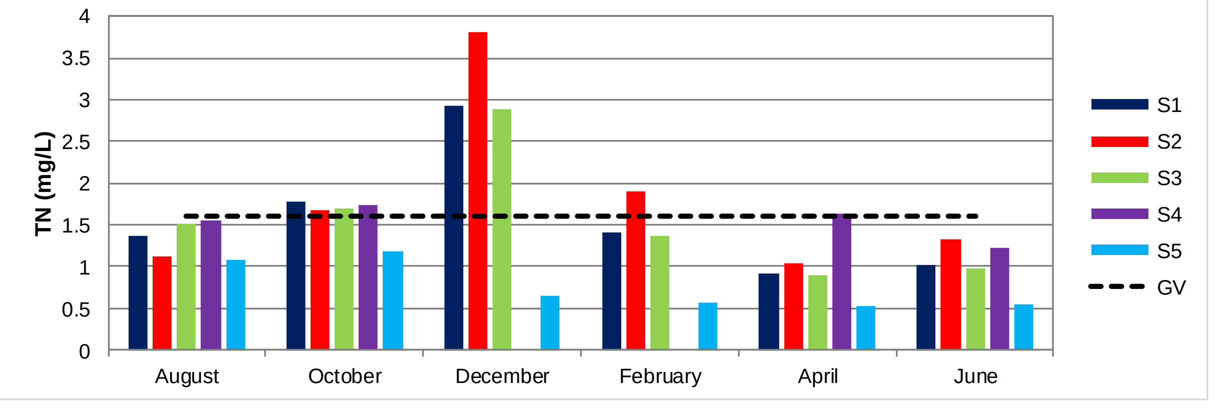


Figure 2.4 Time series of TN concentrations at all sites for the current reporting period

Aside from infrequent spikes in the concentration of nitrite, nitrate and ammonia, average DIN concentrations were low at all sites for this reporting period (**Figure 2.5)**. There was no obvious trend notable in the variation observed.

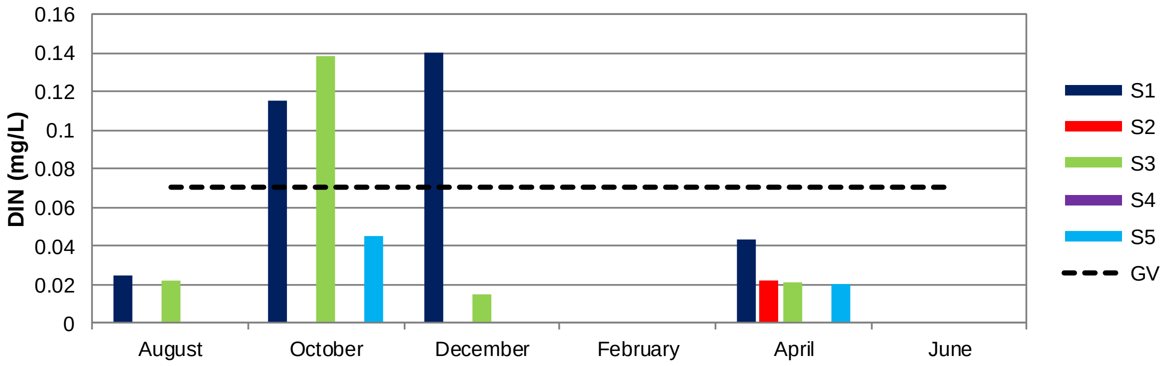


Figure 2.5 Time series of DIN concentrations at all sites for the current reporting period

Application of the Mann-Kendall test to the TN and DIN results since the beginning of the PCM did not find any upwards trends in concentration (**Table 2.6**). All of the results indicated either stable concentrations or no detectable trend, with the exception of the TN concentrations at S5, which indicated a downward trend.

Table 2.6 Mann-Kendall Test Results for TN and DIN Concentrations Since October 2017

Parameter	***Statistic***	***S1***	***S2***	***S3***	***S4***	***S5***
DIN	S	-4.00	1.00	-15.00	-16.00	3.00
	Variance (S)	164.00	73.00	160.33	98.67	99.67
	Tau	-0.07	0.03	-0.28	-0.42	0.08
	P	0.81	1.00	0.27	0.13	0.84
	Trend	**No Trend**	**No Trend**	**Stable**	**Stable**	**No Trend**
TN	S	-7.00	-4.00	-3.00	-16.00	-33.00
	Variance (S)	165.00	164.00	165.00	164.00	165.00
	Tau	-0.13	-0.07	-0.05	-0.29	-0.60
	p	0.64	0.81	0.88	0.24	0.01
	Trend	**Stable**	**No Trend**	**No Trend**	**Stable**	**Decreasing**

2.3.3.2 Phosphorus

Phosphorus is also essential to life and, like nitrogen, plays a role in supporting aquatic food webs and can be detrimental to aquatic ecosystems at excessive concentrations. Phosphorus exists in a variety of forms in water, either as bioavailable phosphorus (orthophosphate) or organic molecules containing phosphorus unavailable for biological uptake.

Median TP and orthophosphate concentrations complied with guiding values at all sites during this reporting period. There was no evident pattern to the variation in phosphorus concentrations (refer to **Figure 2.6** and **Figure 2.7**. However, the data does allow for some general observations:

- Site S2 is the site most influenced by historical and current discharged effluent from the Evans Head STP and is most often the site with the highest total phosphorus and orthophosphate concentrations.
- No phosphorus was detected in Salty Creek in any sample during this reporting period.
- The highest concentrations of phosphorus were measured after drought conditions between October and February 2019, indicating that evaporative distillation impacts nutrient concentrations.
- After saltwater ingress in February 2019 bioavailable phosphorus concentrations were only at detectable levels in one sample.

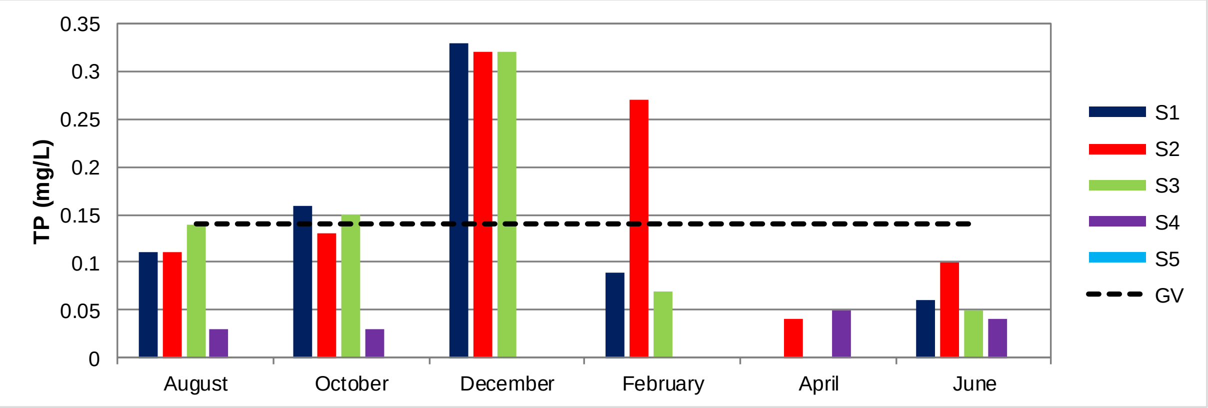


Figure 2.6 Time series of TP concentrations at all sites for the current reporting period

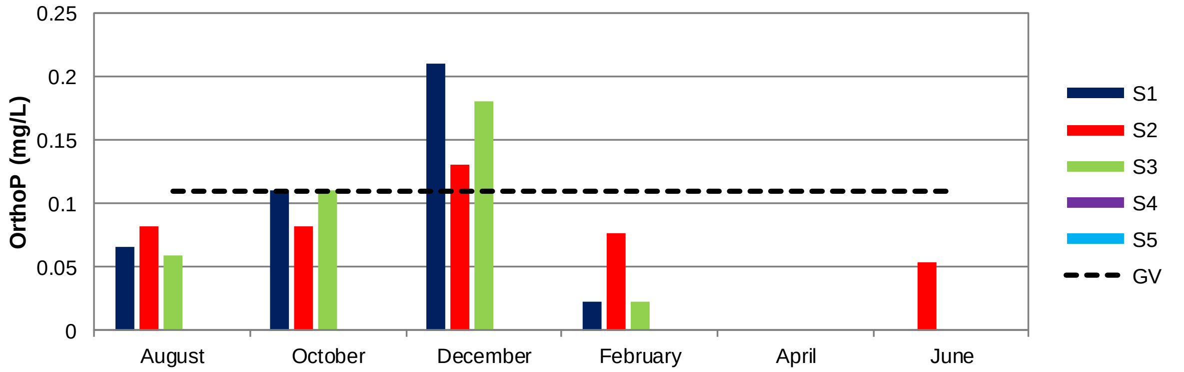


Figure 2.7 Time series of orthophosphate concentrations at all sites for the current reporting period

Application of the Mann-Kendall test to the TP and orthophosphate results since the beginning of the PCM did not find any upwards trends in concentration (**Table 2.7**). All of the results indicated either stable concentrations or no detectable trend.

Table 2.7 Mann-Kendall Test Results for TP and Orthophosphate Concentrations Since October 2017

Parameter	Statistic	S1	S2	S3	S4	S5
TP	S	6.00	7.00	3.00	-3.00	0.00
	Variance (S)	164.00	160.33	164.00	135.67	0.00
	Tau	0.11	0.13	0.06	-0.06	-
	p	0.70	0.64	0.88	0.86	-
	Trend	**No Trend**	**No Trend**	**No Trend**	**No Trend**	**Stable**
Ortho-P	S	6.00	12.00	2.00	-10.00	0.00
	Variance (S)	161.33	164.00	161.33	72.00	0.00
	Tau	0.11	0.22	0.04	-0.32	-
	p	0.69	0.39	0.94	0.29	-
	Trend	**No Trend**	**No Trend**	**No Trend**	**Stable**	**Stable**

2.3.3.3 Chlorophyll-a

The concentration of chlorophyll-a is a measurement of microalgae in the water column. Microalgal abundance fluctuates naturally in response to temperature, nutrient concentrations and light availability, but algal blooms are usually considered to be an indication of poor ecosystem health. Chlorophyll-a concentrations in Salty Lagoon complied with guiding values for the majority of samples collected during this reporting period (refer to **Figure 2.8**).

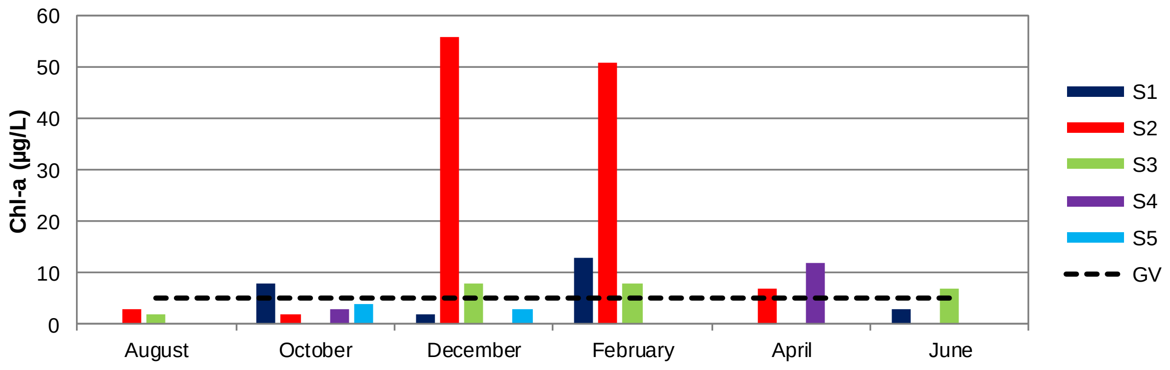


Figure 2.8 Time series of chlorophyll-a concentrations at all sites for the current reporting period

The highest chlorophyll-a concentrations measured were collected during the summer months while water levels were low and nutrient concentrations were high (**Figure 2.8**). During that time levels at site S2 indicated a significant algal bloom. The median chlorophyll-a measurements from sites S2 and S3 did not comply with guiding values. The chlorophyll-a measurements from Salty Creek during this reporting period all complied with guiding values.

Application of the Mann-Kendall test to the chlorophyll-a concentrations measured since the beginning of the PCM did not find any upwards trends in concentration (**Table 2.8**). All of the results indicated either stable concentrations or no detectable trend.

Table 2.8 **Mann-Kendall Test Results for Chlorophyll-a Concentrations Since October 2017**

Parameter	*Statistic*	*S1*	*S2*	*S3*	*S4*	*S5*
Chlorophyll-a	S	12.00	0.00	3.00	-8.00	5.00
	Variance (S)	136.67	161.33	154.33	155.33	73.00
	Tau	0.26	0.00	0.06	-0.16	0.15
	p	0.35	1.00	0.87	0.57	0.64
	Trend	**No Trend**	**No Trend**	**No Trend**	**Stable**	**No Trend**

2.3.3.4 Blue Green Algae

Blue green algae are naturally occurring photosynthetic bacteria. Under bloom conditions they can be toxic to humans and aquatic fauna and can cause other problems related to deoxygenation of the water column and reduced light penetration. Blue green algae were only detected in one sample, from site S5 during this reporting period. The source was likely to have been marine.

2.3.3.5 Faecal Indicator Organisms

Enterococcus and faecal coliforms are bacteria that can be measured as an indication of faecal pollution of waterways. Both enterococcus and faecal coliforms can be sourced from humans or animals and sometimes from rotting vegetation. Faecal indicator organisms are most commonly measured to assess the risks associated with recreational activity in and on waterways.

There was a high degree of variation among the faecal indicator organism results collected during this reporting period (refer to **Figure 2.9** and **Figure 2.10**). The highest concentrations were most often measured at site S2. The median faecal coliform concentration at S2 did not comply with the guiding values for the project.

The major contributors to the observed variation in the concentration of faecal indicator organisms are runoff from the catchment and the presence of waterfowl. The sources of faecal pollution in Salty Lagoon are most likely to be terrestrial fauna and avifauna utilising the lagoon and its immediate catchment. The results do not suggest that discharge from the Evans Head STP or leaks from the Evans Head sewerage system are influencing the concentrations of faecal indicator organisms. Faecal coliform concentrations in discharge from the Evans Head STP are routinely lower than those measured in Salty Lagoon (GeoLINK 2017b).

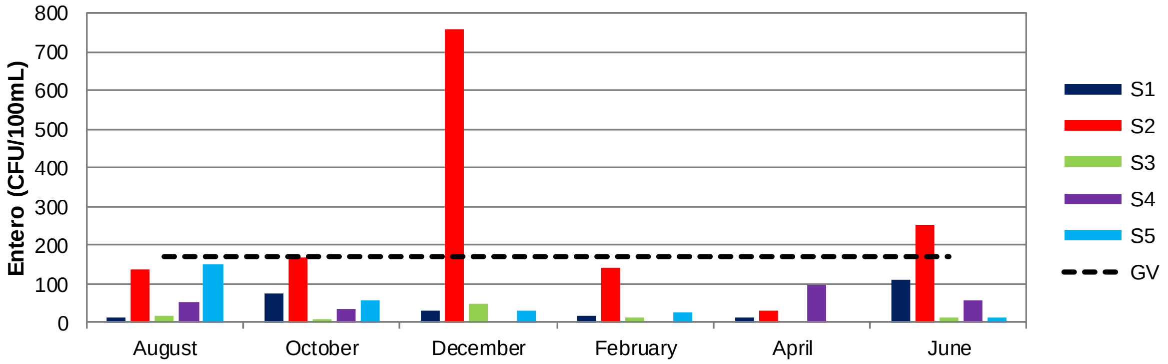


Figure 2.9 Time series of enterococcus concentrations at all sites for the current reporting period

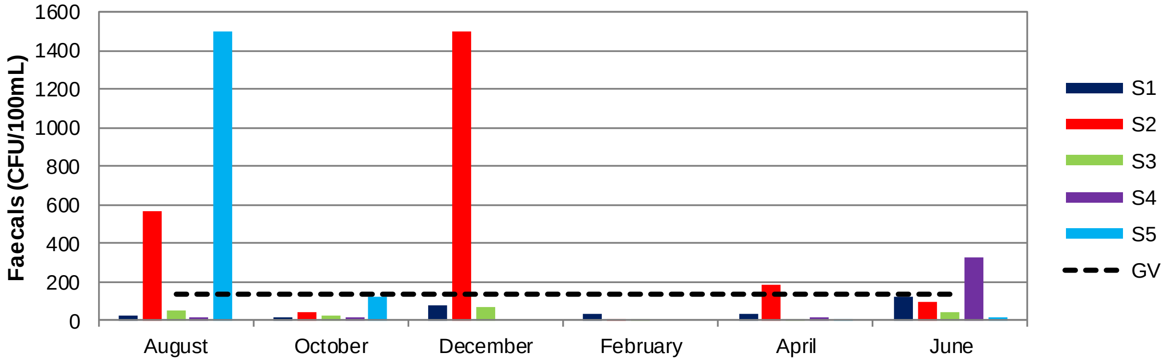


Figure 2.10 Time series of faecal coliform concentrations at all sites for the current reporting period

Application of the Mann-Kendall test to the chlorophyll-a concentrations measured since the beginning of the PCM did not find any upwards trends in concentration (**Table 2.9**). All of the results indicated either stable concentrations or no detectable trend.

Table 2.9 Mann-Kendall Test Results for Enterococcus and Faecal Coliform Concentrations Since October 2017

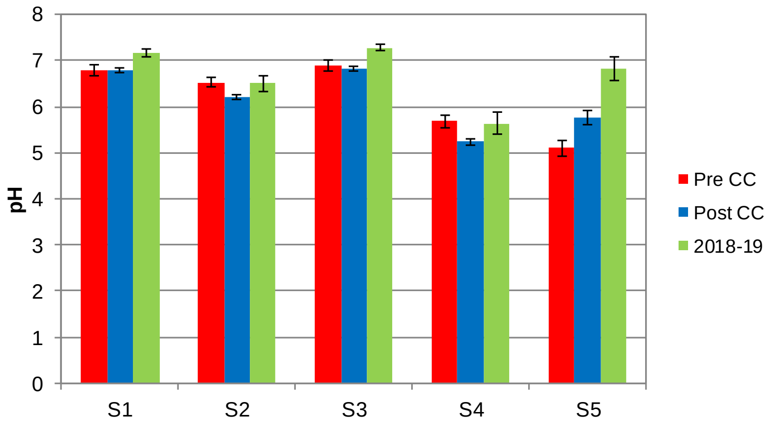
Parameter	*Statistic*	*S1*	*S2*	*S3*	*S4*	*S5*
Enterococcus	S	5.00	12.00	5.00	-3.00	-15.00
	Variance (S)	160.33	164.00	160.33	163.00	165.00
	Tau	0.09	0.22	0.09	-0.06	-0.27
	p	0.75	0.39	0.75	0.88	0.28
	Trend	**No Trend**	**No Trend**	**No Trend**	**No Trend**	**Stable**
Faecal Coliforms	S	14.00	-1.00	3.00	-14.00	-22.00
	Variance (S)	164.00	165.00	165.00	162.00	164.00
	Tau	0.26	-0.02	0.05	-0.26	-0.40
	p	0.31	1.00	0.88	0.31	0.10
	Trend	**No Trend**	**No Trend**	**No Trend**	**Stable**	**Stable**

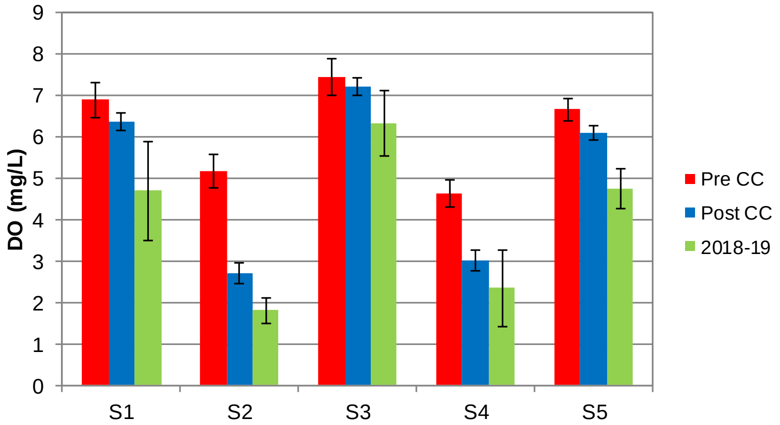
2.3.4 Comparison Against Rehabilitation Targets

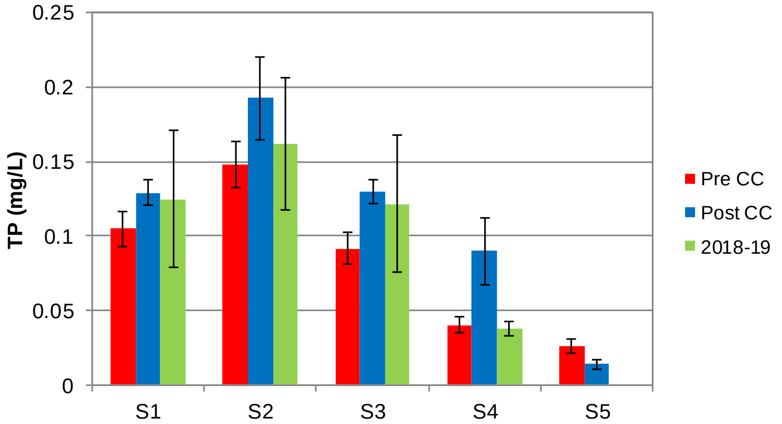
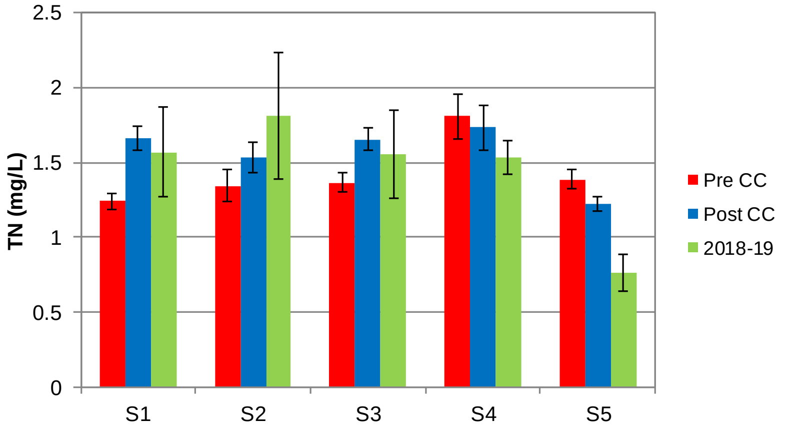
The primary purpose of the PCM program is to confirm predictions that closure of the artificial channel will result in an overall improvement to the ecological and cultural values of Salty Lagoon. A key objective of the post closure monitoring program is to monitor water quality and the ecological attributes of the system where predicted trends have not been confirmed and risks to the ecosystem health remain. A summary of the predicted major changes to the Salty Lagoon system and the post closuring findings are provided in **Table 2.10**. Collectively the outcomes measured during this reporting period were neutral. Generally, where negative and neutral outcomes have been determined for this reporting period, these conclusions are clearly related to the combination of drought conditions and seawater ingress.

Table 2.10 Predicted Major Changes to the Salty Lagoon System and Outcomes for the 2018-2019 Reporting Period

Predicted Major Changes to System	*Summary of Annual Reporting Period Findings*
More natural hydrology and salinity regime including higher water levels – 1.9 m AHD for approximately 63% of the time.	Neutral outcome for this reporting period: Water levels remained high for a large proportion of this reporting period with water levels of 1.9 m AHD or greater for 16% of captured data and water levels of 1.8 m AHD or greater for 44% of the captured data. High water levels occurred for a lower proportion of this reporting period than for the previous reporting period. High salinity was a feature of this reporting period. Both low water levels and high salinity were a response to 'natural' events, primarily drought conditions and seawater ingress during large swell and storm surge events.
A reduced magnitude and rate of water level variation.	Positive outcome for this reporting period. There were significant changes in water level recorded during this monitoring period but they occurred over long periods of time with the exception of one incident where water flowed in from Salty Creek during a large swell and storm surge event.
Less frequent saline water ingress.	Neutral outcome for this reporting period. Although saline conditions persisted for much of this reporting period saline water ingress only occurred on one occasion.
Improved productivity of the benthic microalgal assemblage resulting in nutrient assimilation reduced algal blooms and reduced potential for deoxygenation.	Unclear outcome for this reporting period: It is uncertain if the productivity of the benthic macroalgal assemblage has changed since the closure of the artificial channel. Incidental observations indicate good light penetration to benthic surfaces which could encourage increased benthic productivity. Saline water ingress is likely to have interfered with benthic productivity, at least for a short period. Algal blooms and deoxygenation events were both recorded at lower frequencies during this reporting period, indicating good benthic productivity.
Reduced water column algal biomass.	Positive outcome for this reporting period: Average chlorophyll-a concentrations were low for this reporting period.

Predicted Major Changes to System	*Summary of Annual Reporting Period Findings*
Improved water quality generally with a risk of poor water quality episodes in the period immediately following the channel closure.	Variable outcome for this reporting period: With respect to nutrient and microalgal concentrations the average concentrations are slightly higher than those from the previous annual reporting period. However, trend analysis using the Mann-Kendall test did not find any trends towards poor water quality. Almost all parameters at all sites either show no detectable trends or are stable since the beginning of the PCM. With respect to turbidity, pH and DO the outcomes have been variable during this reporting period. Again, Mann-Kendall analyses failed to detect trends or indicated stability for these parameters since the beginning of the PCM. Although drought conditions prevailed for much of the current reporting period there were no poor water quality episodes (relative to the conditions observed during the MPPC project). The risk of an environmental incident was either low or uncertain at the time of each of the six bi-monthly reports. The uncertain risk classifications were arrived at in response to variable combinations of drought conditions, increased salinity and potential for worsening headcut erosion. There were no fish kills or other ecological incidents.
Less temperature variability.	Negative outcome for this reporting period: Due to low water levels experienced during the summer period daily water temperature variation up to and exceeding 10 °C was common between December 2018 and February 2019. Maximum daily temperatures of over 35 °C were also common during that period.
Reduced average and maximum pH values.	Negative outcome for this reporting period: Prior to channel closure the average logged pH at S1 was 6.88 with a 90th percentile value of 7.42 and a 10th percentile value of 6.34. During this reporting period the average logged pH was 7.26, the 90th percentile value was 7.80 and the 10th percentile value was 6.92. Average pH measurements at the western sites, which were found to have reduced significantly in the post channel closure environment, were functionally equivalent during this reporting period (see figure below). The high average pH measurements captured during this reporting period are a result of the dry conditions and the seawater ingress. 

Predicted Major Changes to System	*Summary of Annual Reporting Period Findings*
Generally higher DO concentrations with a reduction in dramatic DO crashes and more predictable diurnal variation of DO.	Variable outcome for this reporting period: The average DO concentrations in surface waters were significantly lower during this reporting period than the pre channel state at S1, S2 and S5.  However, the logged DO concentrations generally varied according to a relatively predictable diurnal pattern, and the proportions of logged measurements below 1 mg/L and below 6 mg/L have both continued to decrease since the end of the MPPC. Also, the DO crashes that were associated with fish kill events prior to channel closure have not eventuated during this reporting period.
Potential for low DO occurring as a result of high BOD of the marsh sediments and/or increased photo-oxidation of tannins in the warmer months.	Neutral outcome for this reporting period: This prediction has been realised.
Reduced probability of wind driven turbidity increases and no draining related turbidity spikes.	Positive outcome for this reporting period: This prediction has been realised.

Predicted Major Changes to System	*Summary of Annual Reporting Period Findings*
Reduced TP concentrations over time resulting from greater benthic microbial uptake and higher burial rates.	Variable outcome for this reporting period: Lower TP concentrations have been measured during this reporting period at site S4 but not at the other sites. Phosphorus concentrations have been highly variable and there are no upward or downward trends apparent since the inception of the PCM program. The mechanisms resulting in reduced phosphorus concentrations are not certain. 
Poor water quality episodes around high-risk periods such as low water levels and high temperatures.	Positive outcome: This predicted risk has not been realised during this reporting period. Although there were temperature spikes during the period of low water levels there were no significant algal blooms DO crashes or nutrient spikes.
Reduced TN concentrations and continued dominance of DON.	Variable outcome for this reporting period: Average TN concentrations were lower during this reporting period at some sites but variability was high and there are no statistically significant upward or downward trends at any of the sites in Salty Lagoon. The predicted continued dominance of DON as the major form of nitrogen in samples has continued. 
Reduced severity of Salty Creek drawdown during draining events.	Neutral outcome for this reporting period: Drawdown rates for Salty Creek were variable during draining events. The maximum drawdown over a period of 1 hour was 14.6 cm. This compares with a maximum of 13.7 cm experienced during the pre-channel closure period and 15.4 cm during the first five years of the post-channel closure period.

Predicted Major Changes to System	***Summary of Annual Reporting Period Findings***
Less protracted entrance opening of Salty Creek.	Positive outcome for this reporting period: Opening events at the Salty Creek entrance were relatively short during this reporting period.
Potential for aquatic weed growth in early stages with change to freshwater.	Positive outcome for this reporting period: The risk of aquatic weed invasion has not been realised.
Reduced risk of fish kills.	Positive outcome for this reporting period: There have been no fish kill events during this reporting period and the conditions that were related to fish kills in the past have not eventuated.

2.3.5 Emerging Trends and Issues

The erosive headcut to the east of the old artificial channel continues to present a threat to the project. Ongoing monitoring has observed continued advancement of the headcut, albeit at a reduced rate in relation to the previous reporting period. The position and continued advance of the headcut could potentially lead to a new channel between Salty Lagoon and Salty Creek supporting flow in both directions and return Salty Lagoon to the pre-closure state. Erosion monitoring is explained in more detail in **Section 3**.

3. Erosion Monitoring

3.1 Introduction

An eroding headcut to the east of the infilled artificial channel has been identified as a risk to the freshwater ecosystem values that are emerging in the Salty Lagoon system. The headcut was first identified as a potential risk after heavy rainfall in 2014 (GeoLINK 2014). In the final years of the MPPC it advanced approximately 20 m towards Salty Lagoon, effectively eroding a channel that could reconnect Salty Lagoon and Salty Creek at much lower water levels than they are currently.

Eventually, the eroding channel has the potential to reverse the work done to restore the freshwater values identified in the Salty Lagoon environment. A monitoring program was implemented in July 2017 to measure the progress of the headcut over the course of the post closure monitoring program.

3.2 Methods

A series of six monitoring stations, three at the impact site and three at a control site were set up to assess the progression of erosion between Salty Lagoon and Salty Creek. The specific locations of all sites sampled are presented in **Table 3.1** and **Illustration 2.1**.

The stations were set up in July 2017 at the headcut (Stations ER4, ER5 and ER6), with control sites at points where lateral tributaries from Salty Creek lead towards Salty Lagoon (Stations ER1, ER2 and ER3). At each site the bi-monthly monitoring involves a fixed-point photo and a measurement from a fixed peg to the nearest point of the headcut.

Table 3.1 Type and Locations (WGS84) of Erosion Monitoring Sites

Site	*Control/ Impact*	*Peg Location*	
		Easting	*Northing*
ER1	Control	541961	6783356
ER2	Control	541934	6783355
ER3	Control	541978	6783342
ER4	Impact	542112	6783277
ER5	Impact	542129	6783262
ER6	Impact	542121	6783272

3.3 Results

The headcut at the impact site advanced significantly during this reporting period. The progression of the erosion towards the monitoring pegs at all six monitoring sites is displayed in **Figure 3.1**.

At site ER5, the most easterly of the erosion sites, the headcut progressed a further 3.75 m towards Salty Lagoon during this monitoring period. The progression of the headcut towards the other monitoring pegs was slower, 0.9 m and 0.4 m towards stations ER4 and ER6 respectively. The majority of the progression at each of the impact sites happened after August 2018, coinciding with the heavy rainfall experienced in October 2018 and the period of higher water levels in Salty Lagoon that followed (see **Figure 2.2**). There was no significant measured progression of erosion at any of the control sites.

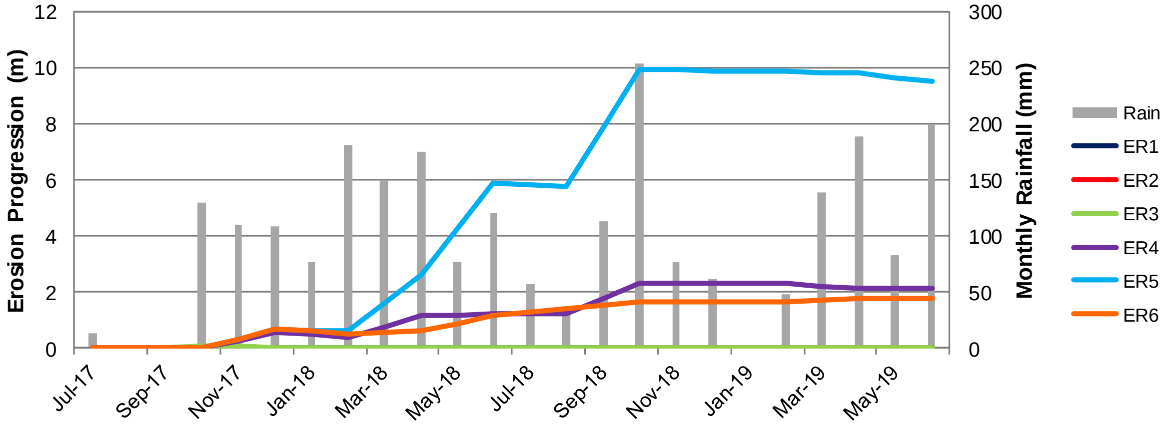


Figure 3.1 Measured erosion progression at all six sites plotted against monthly rainfall (BoM 2018)

3.4 Discussion

The erosion monitoring detected a significant advance in the erosive headcut between Salty Creek and Salty Lagoon. Station ER5 best monitors the advance of the erosion directly towards Salty Lagoon. The erosive headcut between Salty Creek and Salty Lagoon could result in a new channel forming with the potential to undo the measurable positive benefits of the recent channel closure. This is a very high priority for the ongoing management of Salty Lagoon.

RVC and National Parks and Wildlife Services (NPWS) have been liaising in relation to the headcut remediation. Remediation designs have been developed by RVC, while a Review of Environmental Factors (Part 5 of the *Environmental Planning and Assessment Act 1979* {EP&A Act} assessment) has been prepared by NPWS. Project approval and funding investigations for the rehabilitation works have continued over the reporting period.

4. Aquatic Vegetation/ Weeds

4.1 Introduction

Aquatic weed invasion is considered a significant risk during the period following the closure of the artificial channel as Salty Lagoon makes the transition to a freshwater system. In order to assess the response of aquatic vegetation to the changes and to provide a mechanism for adaptive management of aquatic weeds, regular surveys were undertaken as part of the MPPC program and have continued as part of the post closure monitoring program. Incidental observations of aquatic weeds noted during the bi-monthly site inspections are also recorded.

4.2 Methods

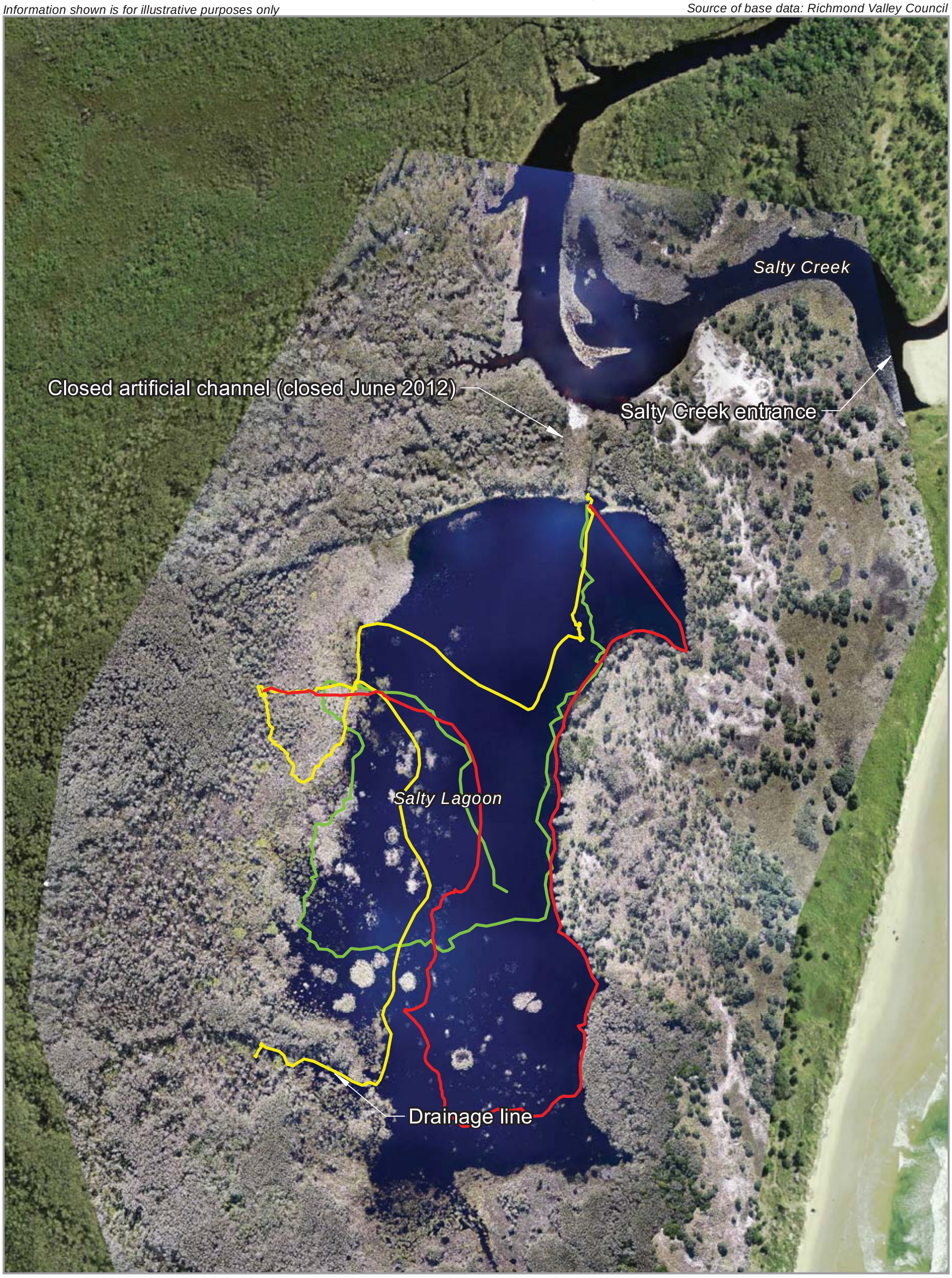
Aquatic weeds were monitored on a seasonal basis across all seasons except winter. The dates of the aquatic weed surveys undertaken during this reporting period are 7 November 2018 (spring), 14 January 2019 (summer) and 11 March 2019 (autumn).

The aquatic weed surveys involved following a meandering transect selected to cover most of the open water areas of Salty Lagoon. Each species of aquatic plant, weedy or otherwise, encountered during the survey was recorded. The position of any aquatic weed encountered was recorded with a handheld GPS unit and the aerial extent of the weed population estimated and recorded. Plants that could not be identified in the field were sampled for later identification.

The pathway of the meandering transect was recorded using the tracking feature of a handheld GPS set to track points at intervals of 20 seconds. The approximate transect pathways used during weed surveys are displayed in **Illustration 4.1**.

Drawn by: DSA Checked by: AB Reviewed by: AB Date: 02/10/2019
Source of base data: Richmond Valley Council

Information shown is for illustrative purposes only



LEGEND

- Spring 2018 weed transect
- Summer 2018 weed transect
- Autumn 2018 weed transect

0 120

Aquatic Weed Monitoring Transects

4.3 Results

There have been no notable aquatic weeds observed during the current reporting period. A total of 18 plant taxa were observed during this reporting period. Of these, all except *Eleocharis acuta* were observed among the 38 plant taxa identified during the MPPC project. Two types of native aquatic plant sometimes regarded as nuisance plants have been encountered. These were Pacific Azolla (*Azolla flilculoides*) and Duckweed (*Lemna sp*.). One non-native plant, *Nymphaea capensis*, was identified during surveys.

Blue green algae were not detected during the aquatic weed surveys or in any of the water quality samples collected from Salty Lagoon during this reporting period. They were identified in one sample collected from Salty Creek but that record is thought to be associated with seawater ingress. Pacific Azolla and Duckweed were encountered at varying densities to the west of Salty Lagoon, particularly around site S2. The abundance of these two plants tends to fluctuate in response to temperature and freshwater flow. They are less likely to be observed growing at high densities during the winter months.

During the aquatic weed surveys, a list of all aquatic plant species encountered was collected and a basic estimate of their abundance made. The list of aquatic plant species encountered is shown in **Table 4.1**.

Table 4.1 List of Aquatic Plant Species Detected During Aquatic Weed Surveys and an Assessment of Abundance

Species Name	*Common Name*	*Survey*		
		Spring 2018	*Summer 2019*	*Autumn 2019*
Hydrocotyle verticillata	Shield Pennywort	C	C	-
Enydra fluctuans	Buffalo Spinach	C	UC	UC
Machaerina articulata	Jointed Twigrush	UC	C	UC
Machaerina sp.	A Rush	VC	VC	VC
Cyperus difformis	Dirty Dora	C	VC	C
Eleocharis acuta	Common Spike Rush	-	UC	-
Gahnia sieberiana	Red-fruit Saw-sedge	VC	VC	C
Shoenoplectus validus	River Club-rush	VC	VC	VC
Juncus krausii	Sea Rush	UC	UC	UC
Lemna sp.	Duckweed	C	C	-
Utricularia spp.	Bladderwort	VC	C	-
*Nymphaea capensis^*	Cape Waterlily	UC	UC	-
Bacopa monnieri	Water Hyssop	C	VC	VC
Paspalum vaginatum	Saltwater Couch	VC	VC	VC
Phragmites australis	Common Reed	VC	VC	VC
Azolla filiculoides	Pacific Azolla	VC	UC	-
Typha orientalis	Cumbungi	VC	C	C
Enteromorpha sp.	Enteromorpha	C	VC	VC

Note UC = Uncommon, C = Common, VC = Very Common
^ Introduced Species

4.4 Discussion

The aquatic weed surveys undertaken during this reporting period did not detect any significant aquatic weeds. Despite this, the risk of weed invasion into Salty Lagoon remains, particularly as the system continues the transition to a freshwater ecosystem.

A change to the overall aquatic plant community in Salty Lagoon was noted during the MPPC (GeoLINK 2017b). The aquatic weed surveys undertaken during this reporting period indicate that continued stabilisation of the freshwater aquatic plant community was disrupted by saltwater ingress in late February 2019. All taxa identified during this reporting period were encountered during the MPPC weed monitoring except for *Eleocharis acuta*. *E. acuta* is a relatively common emergent native freshwater plant that is known from other parts of Broadwater National Park.

5. Conclusion

5.1 Conclusion

The overall health of the Salty Lagoon ecosystem has improved since closure of the artificial channel. Water quality remained adequate during this reporting period. Below average rainfall (including drought conditions between November 2018 and March 2019) and seawater ingress were major factors influencing the system and most instances of poor water quality were related to these factors.

The majority of the median monitoring results complied with the project guiding values with the exception of pH, conductivity and DO. No results indicative of the current Evans Head Sewage Treatment Plant discharge adversely impacting the Salty Lagoon ecosystem were observed.

No fish kill events were recorded during the reporting period. Conditions that were related to fish kills in the past did not occur.

The erosive headcut between Salty Creek and Salty Lagoon that developed during the later years of the MPPC, continued to advance towards Salty Lagoon. It remains a threat to the positive changes recorded in the Salty Lagoon environment during the MPPC. The channel forming, if it reaches Salty Lagoon, could potentially lead to a new channel between Salty Lagoon and Salty Creek supporting flow in both directions and return Salty Lagoon to the pre-closure state. Remediation designs have been developed whilst approvals and funding investigations for the works are continuing.

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