Salty Lagoon
Post Closure Monitoring

Project Management and Ecosystem Health Report
December 2018

GeoLINK
environmental management and design

AQUATIC SCIENCE AND MANAGEMENT

PO Box 119
Lennox Head NSW 2478
T 02 6687 7666

PO Box 1446
Coffs Harbour NSW 2450
T 02 6651 7666

info@geolink.net.au

Prepared for: Richmond Valley Council

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1. Introduction

1.1 Introduction

This document comprises the third bi-monthly monitoring report for year 7 of Salty Lagoon Post-Closure monitoring year's 6-10 program (GeoLINK 2017). The monitoring program is as described in *Final Evaluation Report - Salty Lagoon Monitoring: Pre-Post Closure of Artificial Channel – Project Finalisation Report*, which forms an extension of the monitoring undertaken as part of the *Salty Lagoon Ecosystem Recovery Monitoring Program; Pre-Post Closure of Artificial Channel* (MPPC) (Hydrosphere Consulting 2010).

This report is for the monitoring period 1 November 2018 until 31 December 2018.

1.2 Guiding Values

Guiding values were developed for Salty Lagoon and Salty Creek as part of the MPPC program (GeoLINK 2012) to assist with the contextualisation of monthly water monitoring results, rather than as a measure of the health of the waterway. These values are used as part of the current post-closure monitoring and provide a yardstick around which the adaptive management of Salty Lagoon can be discussed.

2. Methodology

2.1 Discrete Sampling

This was the third bi-monthly site visit for year 7 post-closure monitoring at Salty Lagoon. It included routine maintenance of permanent water quality monitoring stations and discrete water quality sampling. The site visit was undertaken on 14 January 2019. Water quality samples were collected between the hours of 7:00 am and 11:30 am on that day. A low tide of 0.73 metres was forecast for 8:36 am.

Discrete water quality samples were taken from surface water (approximately 0.2 metre depth) at three sites in Salty Lagoon and a single site (S5) in Salty Creek. An additional quality assurance (QA) replicate sample was collected at S3. There was no water at site S4. The specific locations of all sites sampled are presented in **Table 2.1** and **Illustration 2.1**. They are the same sites previously used for the MPPC (GeoLINK 2017).

Table 2.1 Locations of Water Quality Sample Sites in Salty Lagoon and Salty Creek (WGS84)

Site	*S 1*	*S 2*	*S 3*	*S 4*	*S 5*
Eastings	0542064	0541799	0542037	0541738	0542187
Northings	6782801	6782669	6783013	6783033	6783665
Site Description	Lagoon monitoring station	SE of Drainage Channel	NE area of lagoon	NW area of lagoon	Creek monitoring station

Physico-chemical water quality parameters were measured with a calibrated HORIBA U-52 hand held water quality meter. Samples were collected from the surface, and at depth intervals of one metre where water levels allowed.

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

2.2 Fixed Point Photo Monitoring

In addition to water quality samples, photos were taken showing the environment to the north, east, south and west of each water quality sample site. An additional photo monitoring site is located on the in-filled artificial channel.

2.3 Aquatic Weed Monitoring

Aquatic weed monitoring occurs three times each year; once in each of the summer, autumn and spring seasons. Maps of the monitoring meander and detailed data are provided in the annual reports. Aquatic weed monitoring for the summer 2019 season was undertaken during the site inspection for this reporting period on 14 January 2019.

2.4 Erosion Monitoring

A series of stations have been set up around the active head cut to the east of the infilled channel and some nearby control sites to assess the progression of erosion between Salty Lagoon and Salty Creek. The specific locations of all sites sampled are presented in **Table 2.2** and **Illustration 2.1**.

The stations were set up in July 2017 at the head cut (Stations 4, 5 and 6), with control sites at points where lateral tributaries from Salty Creek lead towards Salty Lagoon (Stations 1, 2 and 3). At each site the monitoring involves a fixed-point photo and a measurement from a fixed peg to the nearest point of the head cut.

Table 2.2 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

2.5 Permanent Water Quality Monitoring Stations

There are two permanent water quality monitoring stations (PWQMS) in place with YSI EXO3 series water quality sondes measuring temperature, pH, conductivity, turbidity and dissolved oxygen (DO) concentrations at 30-minute intervals. One PWQMS is located in Salty Lagoon at S1 and one in Salty Creek at S5. The data from these sites is downloaded at bi-monthly intervals for reporting purposes.

HOBO U20 water level loggers were installed in the water at each PWQMS and a third HOBO was installed above the water at S1 to collect barometric pressure data for offsetting atmospheric variability.

The temperature, pH, conductivity, turbidity and DO sensors on the EXO3 sonde installed at the Salty Lagoon PWQMS were removed on 14 January 2019 and replaced by a serviced and calibrated set.

The status of the two YSI EXO3 sondes on 14 January 2019 is displayed in **Table 2.3**.

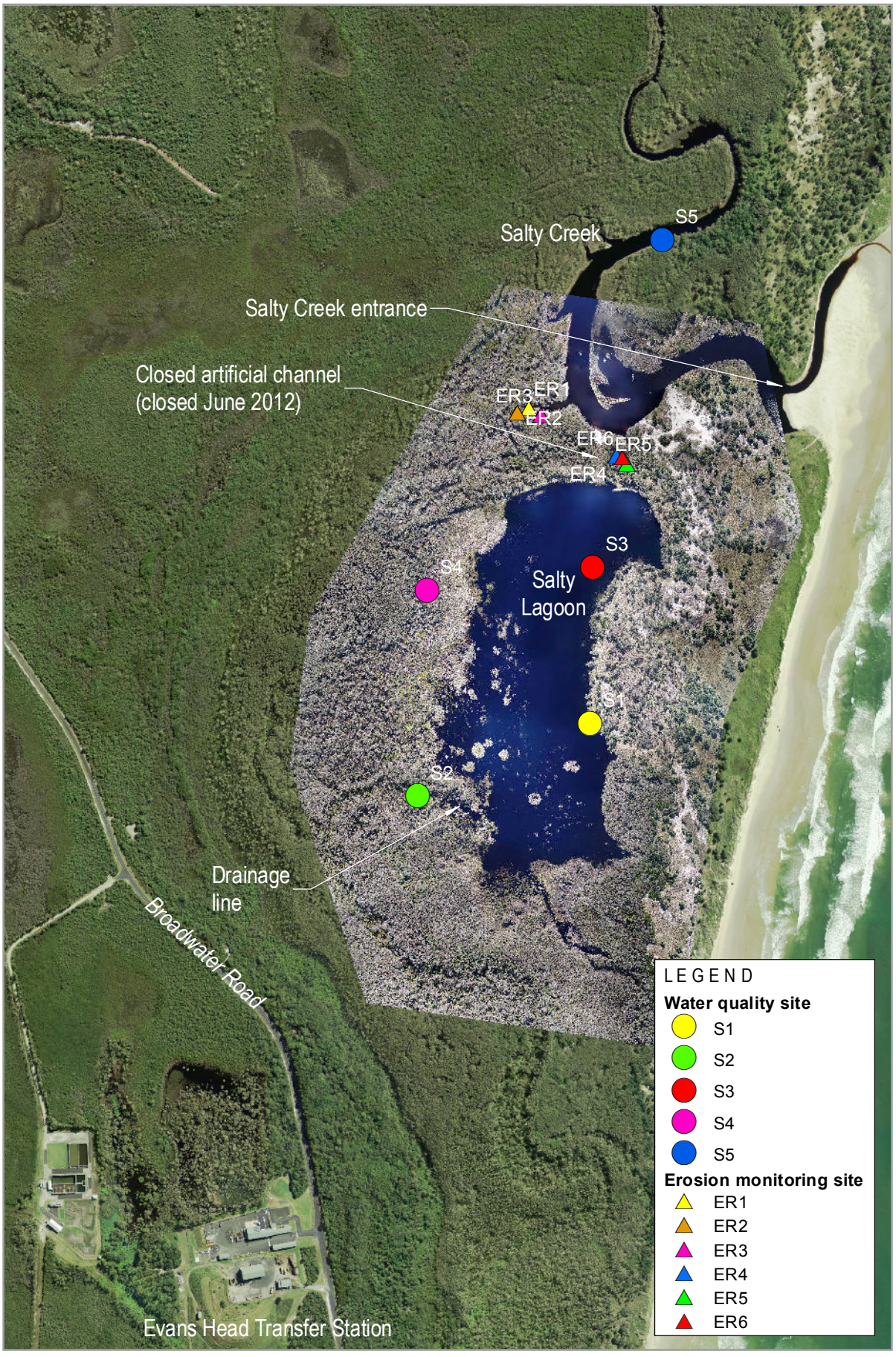
Table 2.3 YSI sonde Status on 14 January 2019

Sonde	*SN17F104100*	*SN 17H104488*	*Spare Probes*
pH (cap life expectancy 18 months)	EXO pH 17H105047 Manufactured 08/2017	EXO pH 17H105049 Manufactured 08/2017	EXO pH 17H105048 Manufactured 08/2017
Temp/ cond (life expectancy 7-10 years)	EXO Wiped CT 17F102047 Manufactured 06/2017	EXO Wiped CT 17F102685 Manufactured 06/2017	EXO Wiped CT 17F103252 Manufactured 06/2017
DO (cap life expectancy 18 months)	EXO Optical DO 17H103493 Manufactured 08/2017	EXO Optical DO 17H103494 Manufactured 08/2017	EXO Optical DO 17H103495 Manufactured 08/2017
Turbidity (life expectancy 7-10 years)	YSI EXO Turbidity 17H101465 Manufactured 08/2017	YSI EXO Turbidity 17H103513 Manufactured 08/2017	YSI EXO Turbidity 17H101468 Manufactured 08/2017
Wiper	YSI Exo Wiper 17G101952	YSI Exo Wiper 17G101954	No Spare Wiper
Status	Serviced probes installed in Salty Lagoon 14/01/2019	Serviced probes installed in Salty Creek 07/11/2018	Probes being calibrated and serviced for redeployment
Notes	- 217 days estimated battery life - Memory cleared – 50045.3 days logging available	- 217 days estimated battery life - Memory cleared – 50045.3 days logging available	- Probes Removed 07/11/2018

Climate information was sourced from the Evans Head bombing range weather station on the Bureau of Meteorology website (BoM 2019). Evans Head Sewage Treatment Plant (STP) facility routine sampling information was provided by Richmond Valley Council (RVC).

Information shown is for illustrative purposes only

Drawn by: GJM Checked by: RE Reviewed by: DSA Date: 9/01/2018
Source of base data: Richmond Valley Council



0 200

North

Water Quality and Erosion Monitoring Site Locations

3. Results

3.1 Water Quality Samples

Results of the water quality monitoring undertaken on 14 January 2019 are reported in **Table 3.1**.

3.2 Permanent Water Quality Monitoring Stations

The data collected at the PWQMS, and rainfall data correlating to the reporting period are presented in **Illustration 3.1** and **Illustration 3.2**.

Table 3.1 Results of Discrete Samples Collected 14 January 2019

Parameter	Salty Lagoon								Salty Creek	
	Guiding Value	S1	S1 (1m)	S2	S3	S3 (1m)	S3* (QA)	S4	Guiding Value	S5
Blue Green Algae ID (cells/mL)	**0**	Nil	ns	Nil	Nil	ns	Nil	-	**0**	Nil
Nitrite Nitrogen (mg/L)	**0.01**	<0.010	ns	<0.010	<0.010	ns	<0.010	-	**0.01**	<0.010
Nitrate Nitrogen (mg/L)	**0.01**	<0.010	ns	<0.010	<0.010	ns	<0.010	-	**0.01**	<0.010
Oxidized Nitrogen (mg/L)	**-**	<0.010	ns	<0.010	<0.010	ns	<0.010	-	**-**	<0.010
Ammonia Nitrogen (mg/L)	**0.05**	**0.14**	ns	<0.010	0.015	ns	<0.010	-	**0.11**	<0.010
Total Kjeldahl Nitrogen (mg/L)	**1.6**	**2.93**	ns	**3.8**	**2.89**	ns	**2.87**	-	**1.63**	0.66
Total Nitrogen (mg/L)	**1.6**	**2.93**	ns	**3.8**	**2.89**	ns	**2.87**	-	**1.63**	0.66
Total Phosphorus(mg/L)	**0.14**	**0.33**	ns	**0.32**	**0.32**	ns	**0.31**	-	**0.04**	<0.03
Orthophosphate (mg/L)	**0.11**	**0.21**	ns	**0.13**	**0.18**	ns	**0.19**	-	**0.01**	<0.010
Chlorophyll-a (µg/L)	**5**	2	ns	**56**	**8**	ns	**21**	-	**3**	**3**
Enterococcus (CFU/100mL)	**170**	30	ns	**760**	46	ns	82	-	**40**	30
Faecal Coliforms (CFU/100mL)	**135**	78	ns	**TNTC***	72	ns	66	-	**150**	0
Temp (˚C)	**25.9**	**26.87**	**27.02**	25.52	**29.13**	**27.82**	ns	-	**13.1 - 28.8**	**29.73**
pH	**6.9**	**6.99**	**7.03**	**7.11**	**7.44**	**7.35**	ns	-	**4.3 - 6.8**	**7.67**
ORP (mV)	**-**	99	100	158	151	155	ns	-	**-**	132
Cond (mS/cm)	**8.0**	1.55	1.54	1.83	1.55	1.54	ns	-	**0.3 - 21.5**	**39.8**
Turbidity (NTU)	**13**	5.3	8.5	**14.7**	**13.7**	10.1	ns	-	**11**	0
DO (mg/L)	**4.09**	**0.25**	**2.62**	**3.09**	5.51	4.55	ns	-	**5.52**	**4.28**
DO (% sat)	**-**	3.2	33.5	38.6	72.5	58.7	ns	-	**-**	65.7
TDS (mg/L)	**-**	0.993	0.987	1.17	0.99	0.988	ns	-	**-**	24.3
Sal (ppt)	**-**	0.8	0.8	0.9	0.8	0.8	ns	-	**-**	25.4
Depth (m)	**-**	Surface	1m	Surface	Surface	1m	Surface	-	**-**	Surface

Note: * = randomly selected quality assurance sample.
red text = not compliant with MPPC guiding values (see GeoLINK 2012).
levels below detection limits will be incorporated into databases as 0 for the purpose of statistical analyses
TNTC = too numerous to count

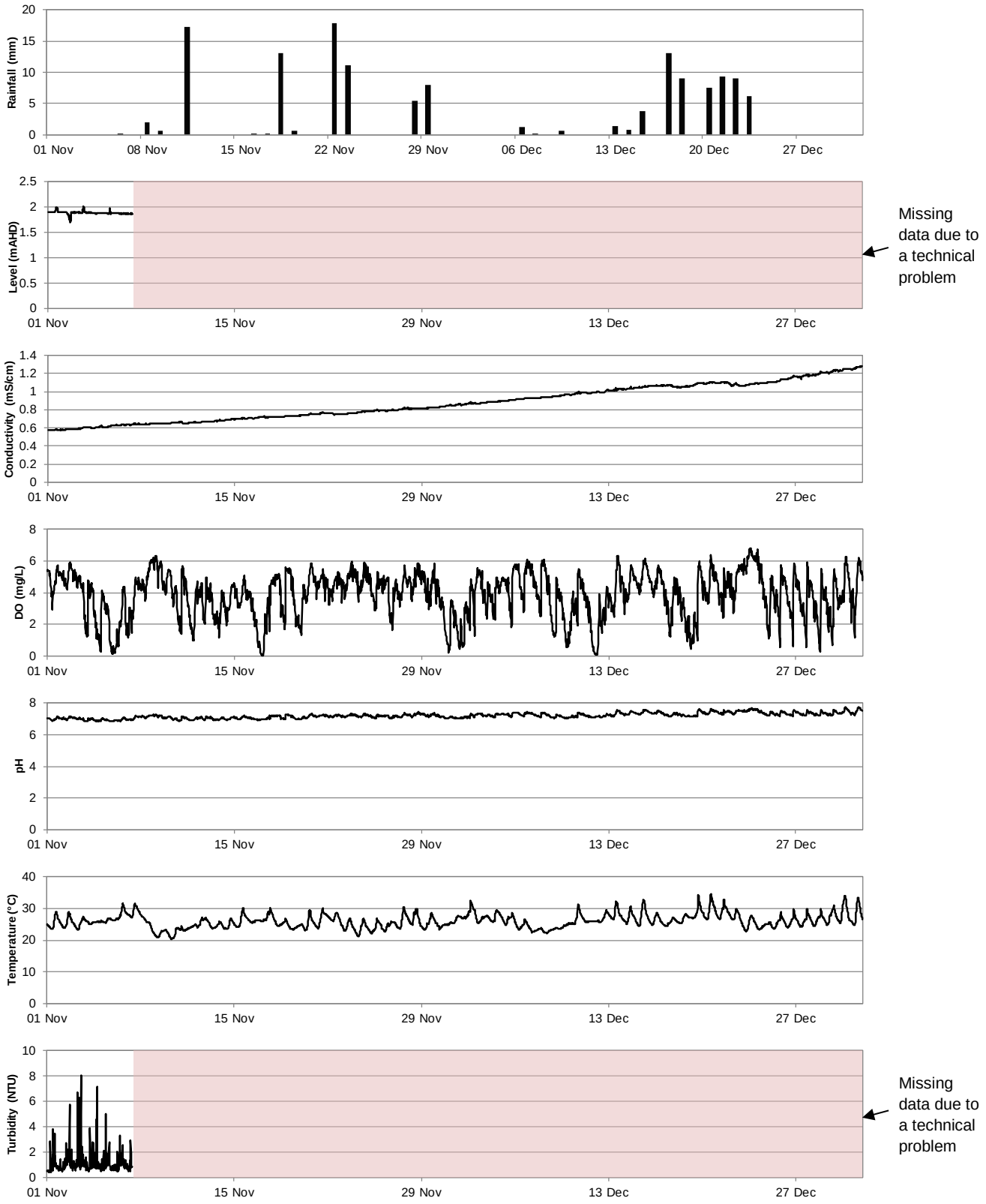


Illustration 3.1 Salty Lagoon Rainfall and Water Quality Monitoring Station Data 1 November 2018 to 31 December 2018

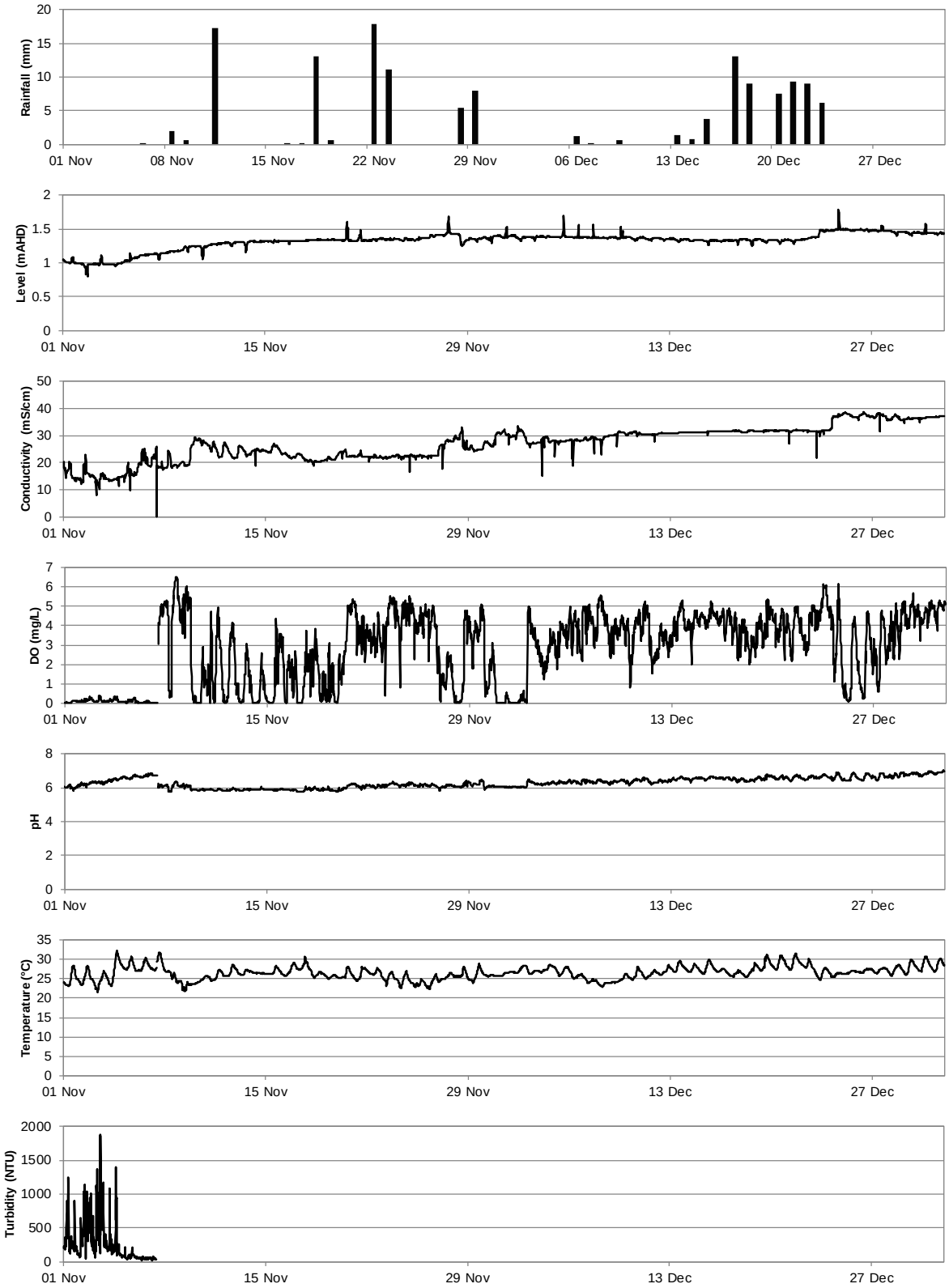


Illustration 3.2 Salty Creek Rainfall and Water Quality Monitoring Station Data 1 November 2018 to 31 December 2018

3.3 Aquatic Weed Monitoring

No aquatic weeds of significance were identified during the summer 2019 aquatic weed monitoring on 14 January 2019. However, one non-native plant, *Nymphaea caerula,* and two native plants sometimes considered problematic, *Azolla filiculoides* and *Lemna sp.* were observed.

3.4 Erosion Monitoring Stations

The data collected at the erosion monitoring stations is presented in **Table 3.2**. There was no advance of the head cut at the three impact stations in relation to the previous measurements on November 7 2018. The head cut has advanced at least 9.9 m towards Salty Lagoon since the monitoring began in July 2017.

Table 3.2 Erosion monitoring results from 14 January 2019

Station	*Control/Impact*	*Distance 25 July 2017 (m)*	*Distance 14 January 2019 (m)*	*Cut Movement (m)*
ER1	Control	7.55	7.55	0.00
ER2	Control	10.20	10.15	0.05
ER3	Control	9.95	9.90	0.05
ER4	Impact	8.35	6.05	2.30
ER5	Impact	12.35	2.45	9.90
ER6	Impact	10.40	8.75	1.65

4. Discussion

4.1 Water Quality

There were several light to moderate days of rainfall during this reporting period. However, rainfall for both November and December 2018 was below average. The conductivity and level data from the Salty Creek PWQMS indicate that the entrance to Salty Creek remained closed for the entire monitoring period. At the time of the site inspection on 14 January 2019 the entrance to Salty Creek was closed. The water level in Salty Lagoon was not logged for most of this reporting period due to a technical error. However, the water level in Salty Lagoon was relatively low at the time of the inspection on 14 January 2019 and, in combination with the conductivity data from Salty Lagoon and Salty Creek, this indicates that evaporation was a major factor influencing water quality during this reporting period. Due to the low water levels in Salty Lagoon there was no water at S4, to the west of Salty Lagoon, and no results to report from that site.

Erosion monitoring indicated that the head cut did not advanced during this reporting period. There has been little or no measured advance of the head cuts at the three control sites. This indicates that there was little flow between Salty Lagoon and Salty Creek during this monitoring period.

Conductivity measurements from the PWQMS show the impact of evaporation on water quality in Salty Lagoon and Salty Creek and also indicate that there was low level seawater ingress into Salty Creek during this monitoring period. The conductivity measurements from the Salty Lagoon PWQMS remained low but more than doubled in magnitude during this monitoring period. At the time of the site inspection the conductivity measurements in Salty Lagoon showed that the water column was well mixed at all sites. The conductivity measurements from the Salty Creek PWQMS almost doubled in magnitude during this monitoring period.

The DO concentrations in discrete samples collected on 14 January 2019 were relatively low at all sites and, for the second consecutive month, did not comply with guiding values except at site S3. Low DO concentrations in the open water of Salty Lagoon (sites S1 and S3) are common after periods of low rainfall. Low DO concentrations are common at the sites to the west of Salty Lagoon (sites S2 and S4) and in Salty Creek during brackish and saline conditions. The measurements from the Salty Lagoon PWQMS indicate that the diurnal fluctuations in light availability were the major source of variation during this reporting period. The magnitude of these fluctuations increased as water levels reduced and a greater proportion of the available dissolved oxygen was consumed by flora and fauna each night. The measurements from the Salty Creek PWQMS indicate that the DO concentration also fluctuated mostly in response to light availability.

The nutrient concentrations from samples collected on 14 January 2019 were relatively high in the samples from Salty Lagoon and many of the results did not comply with guiding values. The results that did not comply with guiding values included the TN, TP and orthophosphate concentrations from all sampled sites in Salty Lagoon and the ammonia concentration from S1. In general, bioavailable nitrogen was low at all sites. The chlorophyll-a concentrations only complied with the guiding value at S1, and the concentrations at S2 and S3 indicated an algal bloom of low to moderate proportions. The chlorophyll-a concentration in Salty Creek was equal to the guiding value. There were no blue-green algae detected in any samples. Nutrient and chlorophyll-a concentrations measured during the MPPC and post-closure monitoring programs have typically been higher during the warmer months of spring and summer. Additionally, chlorophyll-a and nutrient concentrations have also often been higher when evaporation leads to lower water levels and distils the nutrients, resulting in increased

algal growth. During this reporting period the increases in total nutrient concentrations were equivalent to the increases in conductivity, approximately twice those measured on 7 November 2018 (**Figures 4.1** and **4.2**), indicating that evaporative distillation was a key factor influencing nutrient concentrations. The increases in bioavailable nutrient concentrations were lower or non-existent, because those nutrients are available for uptake by aquatic flora (**Figure 4.3**).

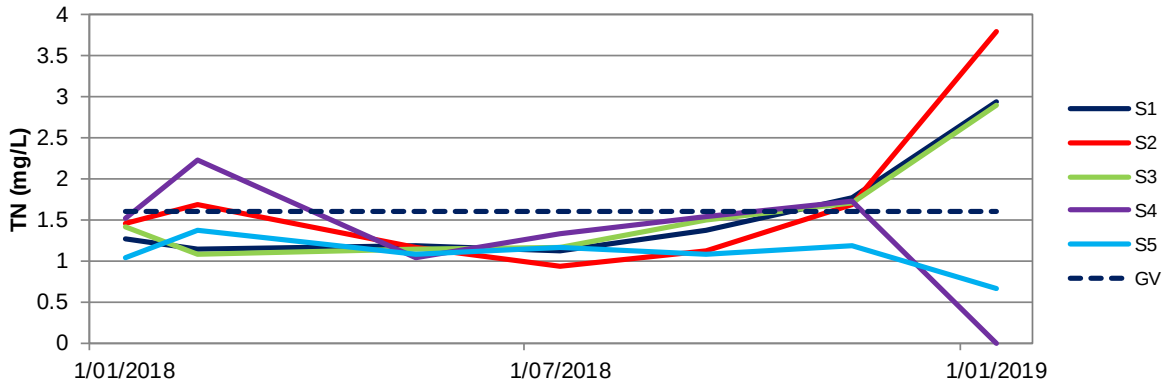


Figure 4.1 TN concentrations at all sites since January 2018

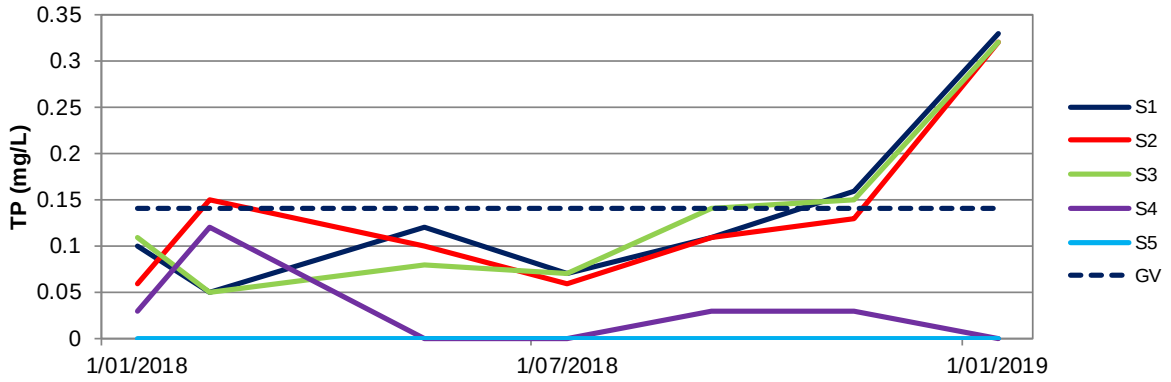


Figure 4.2 TP concentrations at all sites since January 2018

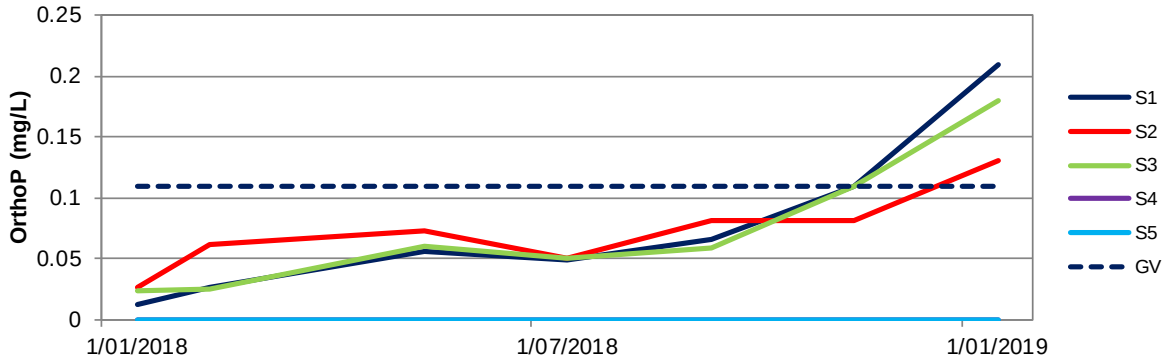


Figure 4.3 Orthophosphate concentrations at all sites since January 2018

Other results that did not comply with guiding values included the pH measurements from all sites, the temperature measurements from S1, S3 and S5, the enterococcus and faecal coliform concentrations from S2 and the turbidity measurements from S2 and S3. All other measurements complied with guiding values. There appears to be a trend towards higher pH measurements from Salty Lagoon, although historically they are more common during dry periods. The high faecal indicator organism concentrations at S2 are likely to be associated with waterbird use of that area and the lack of flow at the time of the site inspection. The high temperature measurements are seasonal and the higher than normal turbidity measurements from S2 and S3 are likely to be associated with the same microalgal concentrations that led to the higher than normal chlorophyll-a concentrations at those sites.

4.2 Other Observations

The entrance to Salty Creek was closed on 14 January 2019. A variety of birds were observed incidentally during the site inspection including Pacific Black Duck, Chestnut Teal, Australasian Grebe, Eurasian Coot, Purple Swamphen, Pelican, Great Egret, White-faced Heron, White Ibis, Royal Spoonbill, Darter, Great Cormorant, Pied Cormorant, Little Black Cormorant, Pied Stilt, Masked Lapwing, Marsh Sandpiper, Whimbrel, Whistling Kite and White-bellied Sea Eagle. The increase in the number of wading bird species observed can be attributed to the reduced water levels and increased area of exposed mud flats.

5. Key Points

1. Water levels decreased and conductivity increased in Salty Lagoon during this reporting period due mostly to evaporation. One site to the west of Salty Lagoon was dry at the time of the site inspection.

2. A relatively large number of results did not comply with the guiding values.

3. Total nutrient concentrations were very high in Salty Lagoon and there were high chlorophyll-a concentrations at two sites.

4. The erosive headcut to the east of the old channel between Salty Lagoon and Salty Creek did not advance during this reporting period.

5. The risk rating for the Salty Lagoon Response Protocol is uncertain, due to the position of the erosive headcut. An adaptive management site inspection may be advised if heavy rainfall conditions eventuate.

References

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