Salty Lagoon
Post Closure Monitoring

Project Management and Ecosystem Health Report
June 2019

GeoLINK
environmental management and design

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1. Introduction

1.1 Introduction

This document comprises the sixth and final 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 May 2019 until 30 June 2019.

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 sixth 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 3 July 2019. Water quality samples were collected between the hours of 7:30 am and 11:00 am on that day. A high tide of 1.43 metres was forecast for 7.42 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. 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. There was no aquatic weed monitoring during this reporting period.

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 Creek PWQMS were removed on 3 July 2019 and replaced by a serviced and calibrated set.

The status of the two YSI EXO3 sondes on 3 July 2019 is displayed in **Table 2.3**.

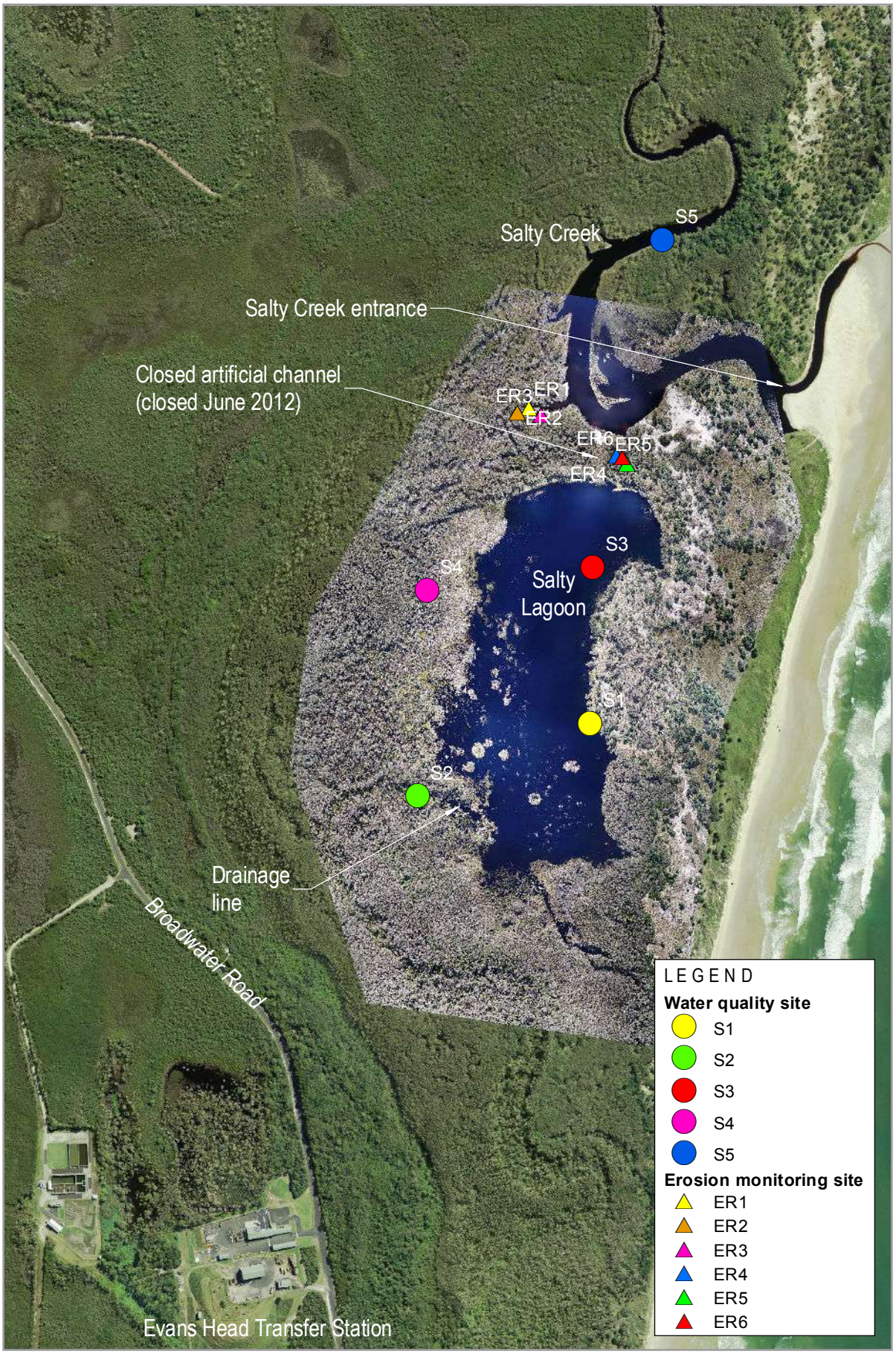
Table 2.3 YSI sonde Status on 3 July 2019

Sonde	*SN17F104100*	*SN 17H104488*	*Spare Probes*
pH (cap life expectancy 18 months)	EXO pH 17H105047 Manufactured 08/2017 New cap 05/2019	EXO pH 17H105049 Manufactured 08/2017 New cap 03/2019	EXO pH 17H105048 Manufactured 08/2017 New cap 03/2019
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 New cap 05/2019	EXO Optical DO 17H103494 Manufactured 08/2017 New cap 03/2019	EXO Optical DO 17H103495 Manufactured 08/2017 New cap 03/2019
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 08/05/2019 Sonde repaired under warranty 04/2019 Batteries installed 08/05/2019	Serviced probes installed in Salty Creek 03/07/2019 Batteries installed 08/05/2019	Awaiting calibration
Notes	- 155 days estimated battery life - Memory cleared – 50045.3 days logging available	- 147 days estimated battery life - Memory cleared – 50045.3 days logging available	- Probes Removed from Salty Creek 03/07/2019

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



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North

Water Quality and Erosion Monitoring Site Locations

3. Results

3.1 Water Quality Samples

Results of the water quality monitoring undertaken on 3 July 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 3 July 2019

Parameter	Salty Lagoon								Salty Creek		
	Guiding Value	S1	S1 (1m)	S2	S3	S3 (1m)	S3 (QA)	S4	Guiding Value	S5	S5 (1m)
Blue Green Algae ID (cells/mL)	**0**	Nil	ns	Nil	Nil	ns	Nil	Nil	**0**	Nil	ns
Nitrite Nitrogen (mg/L)	**0.01**	<0.010	ns	<0.010	<0.010	ns	<0.010	<0.010	**0.01**	<0.010	ns
Nitrate Nitrogen (mg/L)	**0.01**	<0.010	ns	<0.010	<0.010	ns	<0.010	<0.010	**0.01**	<0.010	ns
Oxidized Nitrogen (mg/L)	**-**	<0.010	ns	<0.010	<0.010	ns	<0.010	<0.010	**-**	<0.010	ns
Ammonia Nitrogen (mg/L)	**0.05**	<0.010	ns	<0.010	<0.010	ns	<0.010	<0.010	**0.11**	<0.010	ns
Total Kjeldahl Nitrogen (mg/L)	**1.6**	1.02	ns	1.32	0.97	ns	1.03	1.22	**1.63**	0.55	ns
Total Nitrogen (mg/L)	**1.6**	1.02	ns	1.32	0.97	ns	1.03	1.22	**1.63**	0.55	ns
Total Phosphorus(mg/L)	**0.14**	0.06	ns	0.1	0.05	ns	0.04	0.04	**0.04**	<0.03	ns
Orthophosphate (mg/L)	**0.11**	<0.010	ns	0.053	<0.010	ns	<0.010	<0.010	**0.01**	<0.010	ns
Chlorophyll-a (µg/L)	**5**	3	ns	<1	**7**	ns	<1	<1	**3**	<1	ns
Enterococcus (CFU/100mL)	**170**	110	ns	**250**	10	ns	15	55	**40**	10	ns
Faecal Coliforms (CFU/100mL)	**135**	120	ns	96	40	ns	30	**330**	**150**	12	ns
Temp (˚C)	**25.9**	15.79	16.98	15.4	16.45	17.29	ns	16.07	**13.1 - 28.8**	18.98	17.98
pH	**6.9**	**6.99**	**6.96**	5.8	**7.04**	**7.03**	ns	5.06	**4.3 - 6.8**	**6.82**	**6.99**
ORP (mV)	**-**	187	189	132	192	192	ns	64	**-**	145	143
Cond (mS/cm)	**8.0**	**20.6**	**23.3**	**12.7**	**22.4**	**23.5**	ns	**18**	**0.3 - 21.5**	**31**	**43.6**
Turbidity (NTU)	**13**	2.6	2.7	2.3	6.2	3.9	ns	4.7	**11**	1	0.5
DO (mg/L)	**4.09**	7.98	7.44	**1.42**	9.01	7.91	ns	**0.4**	**5.52**	6.01	**4.89**
DO (% sat)	**-**	89.1	86	15.3	102.7	92	ns	4.4	**-**	74.4	62.9
TDS (mg/L)	**-**	12.8	14.4	7.86	13.9	14.6	ns	11.1	**-**	18.9	26.6
Sal (ppt)	**-**	12.2	14	7.3	13.4	14.2	ns	10.5	**-**	19.2	28
Depth (m)	**-**	Surface	1m	Surface	Surface	1m	Surface	Surface	**-**	Surface	1m

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

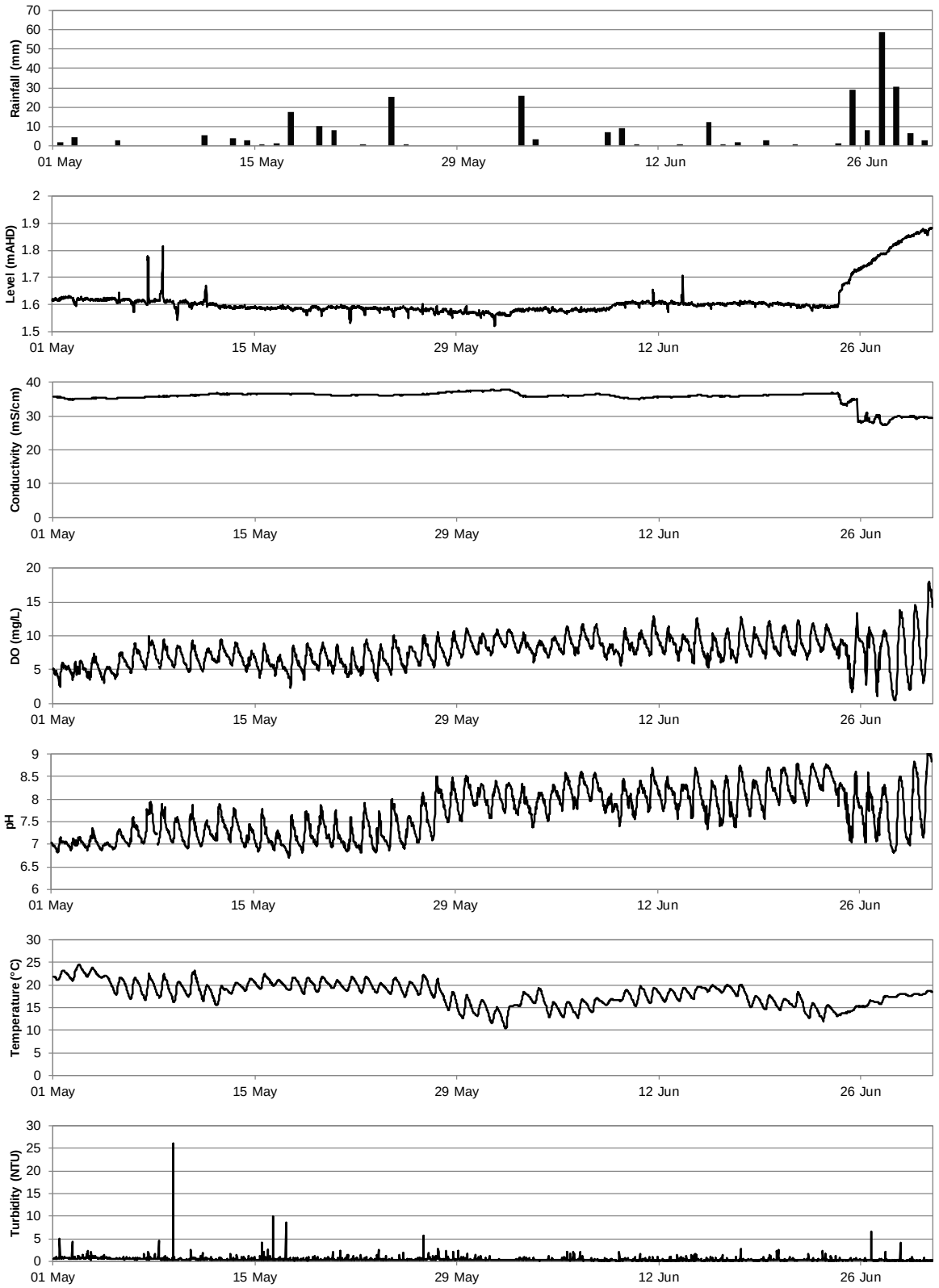

Illustration 3.1 Salty Lagoon Rainfall and Water Quality Monitoring Station Data 1 May 2019 to 30 June 2019

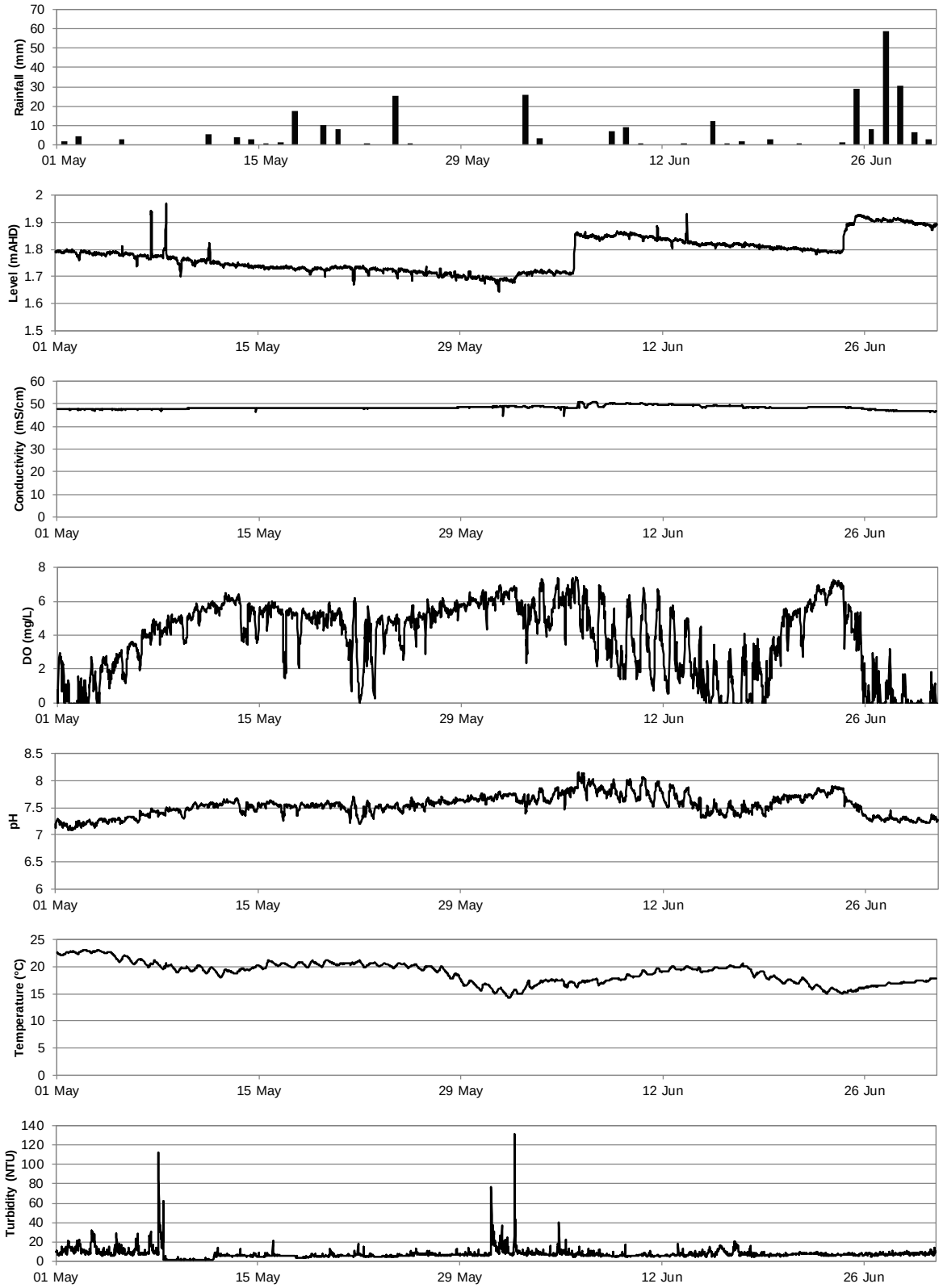

Illustration 3.2 Salty Creek Rainfall and Water Quality Monitoring Station Data 1 May 2019 to 30 June 2019

3.3 Aquatic Weed Monitoring

No aquatic weed monitoring undertaken during this reporting period.

3.4 Erosion Monitoring Stations

The data collected at the erosion monitoring stations is presented in **Table 3.2**. There was no significant advance of the head cuts at the three impact stations in relation to the previous measurements on 8 May 2019 and the head cut has been relatively stable since October 2018 (**Figure 3.3**). The head cut has advanced at least 9.55 m towards Salty Lagoon since the monitoring began in July 2017.

Table 3.2 Erosion monitoring results from 3 July 2019

Station	*Control/Impact*	*Distance 25 July 2017 (m)*	*Distance 3 July 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	6.20	2.15
ER5	Impact	12.35	2.80	9.55
ER6	Impact	10.40	8.65	1.75

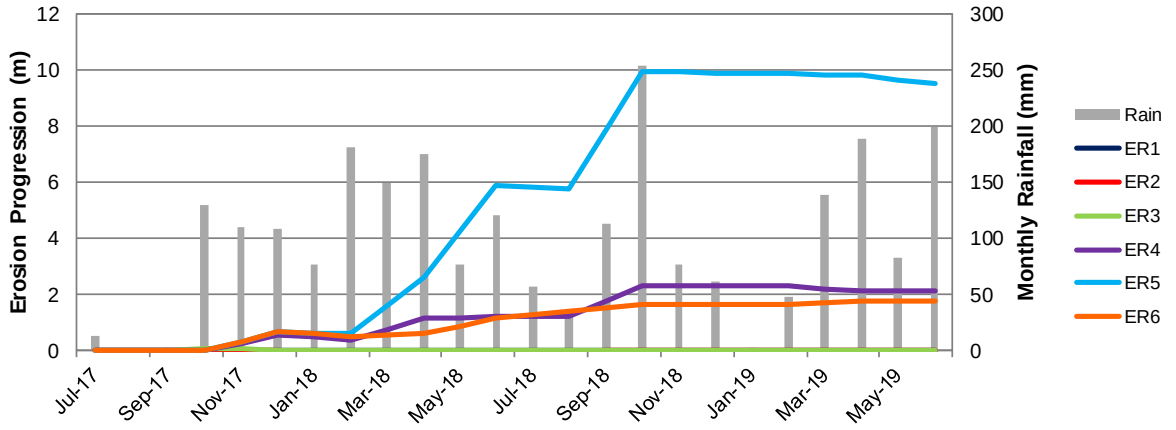

Figure 3.1 Erosion progression plotted against rainfall since July 2017

4. Discussion

4.1 Water Quality

Rainfall was average for this reporting period. There were many small and medium rainfall events evenly spaced throughout the two months. However, the majority of the rain fell in the last week of June 2019. The conductivity and level data from the Salty Creek PWQMS indicate that the entrance to Salty Creek remained closed for the entire reporting period. It also shows that the water level in Salty Creek increased in response to a seawater ingress event on 5 June 2019 and heavy rainfall in the last week of June 2019. Slow water level reductions occurred at other times, probably as a result of evaporation. At the time of the site inspection on 3 July 2019, the entrance to Salty Creek was still closed. The water level in Salty Lagoon remained relatively stable for the majority of this monitoring period but increased sharply in response to heavy rainfall in the last week of June 2019. The conductivity measured at the Salty Lagoon PWQMS remained very high for the entire monitoring period although there was a small decrease in response to heavy rainfall in the last week of June 2019. The conductivity measurements collected on 3 July 2019 were higher than the guiding values at all sites.

Erosion monitoring indicated that the head cut did not advance significantly during this reporting period and has been relatively stable since October 2018. There has been little or no measured advance of the head cuts at the three control sites. This indicates that, for the fourth consecutive bi-monthly period, there was little flow from Salty Lagoon to Salty Creek.

The DO concentrations in discrete samples collected on 3 July 2019 were relatively high all sites except the western two Salty Lagoon sites and did not comply with guiding values at site S2, S4 or in deeper water at S5. Low DO concentrations are naturally prevalent at the sites to the west of Salty Lagoon (sites S2 and S4) and in Salty Creek when brackish and saline conditions persist. The measurements from the Salty Lagoon PWQMS indicate that the diurnal fluctuations in light availability were the major source of variation during the current reporting period. The measurements from the Salty Creek PWQMS indicate that the DO concentration also fluctuated mostly in response to light availability. At the Salty Creek PWQMS DO concentrations were lowest during times of rainfall and when water levels were highest, indicating restricted benthic microalgal activity at those times.

All of the nutrient concentrations from samples collected on 3 July 2019 complied with guiding values. The key factor resulting in low nutrient concentrations was the continued influence of seawater ingress. Bioavailable nitrogen was not detected in any samples and bioavailable phosphorus was only detected at S2. In keeping with this, the chlorophyll-a concentrations were low at all sites except S3, where they did not comply with guiding values. There were no blue-green algae detected in any samples.

Other results that did not comply with guiding values included the pH measurements from all sites except S2 and S4, enterococcus concentration at S2 and faecal coliform concentration at S4. All other measurements complied with guiding values. High pH measurements are associated with the ongoing impact of seawater ingress. Seawater has a pH of approximately 8.3 and strong pH buffering capacity. The high faecal indicator organism concentrations at S2 and S4 are likely to be associated with waterbird use of that area or rainfall runoff resulting from heavy rainfall in the last week of June 2019.

4.2 Other Observations

The entrance to Salty Creek was closed on 3 July 2019. A variety of birds were observed incidentally during the site inspection including Pacific Black Duck, Pelican, Black Swan, Little Pied Cormorant, White-faced Heron and Masked Lapwing. Large areas of rushes in the open water of Salty Lagoon, mostly *Typha orientalis*, *Schoenoplectus validus* and *Phragmites australis*, were observed to be dying back. This is most likely to be in response to saline conditions. There were lots of floating rafts of green algae (species unidentified but probably of marine origin) observed in the open water of Salty Lagoon.

Plate 4.1 The closed entrance to Salty Creek on 3 July 2019

Plate 4.2 Senescing rushes in Salty Lagoon on 3 July 2019

Plate 4.3 Fixed point photo from S2 on 3 July 2019 showing higher water levels and rushes dying back

Plate 4.4 Fixed point photo from S2 on 11 March 2019 showing very low water levels and healthy rushes

5. Key Points

1. Water levels and conductivity remained stable in Salty Lagoon during this reporting period after saline water flow in from Salty Creek increased levels and conductivity in the February reporting period. Heavy rainfall in the last week of June 2019 did not result in freshwater conditions.

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

3. Nutrient concentrations and chlorophyll-a concentrations were low in Salty Lagoon and Salty Creek.

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

5. The risk rating for the Salty Lagoon Response Protocol is uncertain, due to the potential ongoing impacts of saline water in Salty Lagoon. Persistent saline conditions have had a negative impact on some of the flora around the lagoon.

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