

Salty Lagoon Post Closure Monitoring

Project Management and Ecosystem Health Report October 2019



AQUATIC SCIENCE AND MANAGEMENT

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1. Introduction

1.1 Introduction

This document comprises the second bi-monthly monitoring report for year 8 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 September 2019 until 31 October 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 second bi-monthly site visit for year 8 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 7 November 2019. Water quality samples were collected between the hours of 7:30 am and 11:00 am on that day. A low tide of 0.71 metres was forecast for 11.34 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. Aquatic weed monitoring for the 2019 spring period was completed on-foot and from a canoe on 3 September 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.

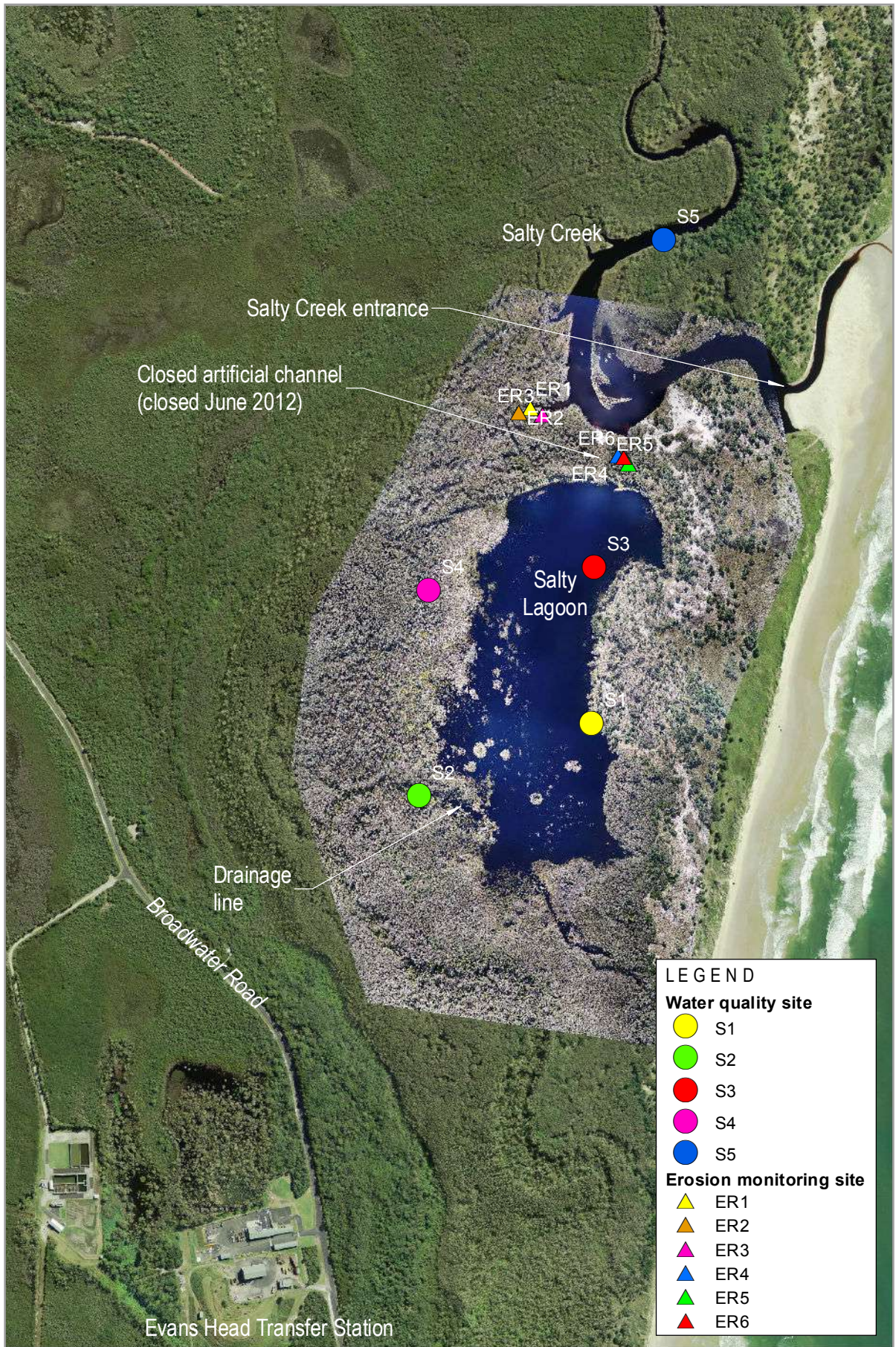
The temperature, pH, conductivity, turbidity and DO sensors on the EXO3 sonde installed at the Salty Creek PWQMS were removed on 7 November 2019 and replaced by a serviced and calibrated set. The DO sensor that was installed at the Salty Creek PWQMS between 3 September and 7 November 2019 was found to be malfunctioning. At the time of writing the fault is still being investigated.

The status of the two deployed YSI EXO3 sondes on 7 November 2019 is displayed in **Table 2.3**.

Table 2.3 YSI Sonde Status on 7 November 2019

Sonde	SN17F104100	SN 17H104488	Spare Probes
pH (cap life expectancy 18 months)	EXO pH 17H105048 Manufactured 08/2017 New cap 03/2019	EXO pH 17H105047 Manufactured 08/2017 New cap 05/2019	EXO pH 17H105049 Manufactured 08/2017 New cap 03/2019
Temp/ cond (life expectancy 7-10 years)	EXO Wiped CT 17F103252 Manufactured 06/2017	EXO Wiped CT 17F102047 Manufactured 06/2017	EXO Wiped CT 17F102685 Manufactured 06/2017
DO (cap life expectancy 18 months)	EXO Optical DO 17H103495 Manufactured 08/2017 New cap 03/2019	EXO Optical DO 17H103493 Manufactured 08/2017 New cap 05/2019	EXO Optical DO 17H103494 Manufactured 08/2017 New cap 03/2019
Turbidity (life expectancy 7-10 years)	YSI EXO Turbidity 17H101468 Manufactured 08/2017	YSI EXO Turbidity 17H101465 Manufactured 08/2017	YSI EXO Turbidity 17H103513 Manufactured 08/2017
Wiper	YSI Exo Wiper 17G101952	YSI Exo Wiper 17G101954	No Spare Wiper
Status	Serviced probes installed in Salty Lagoon 03/09/2019 Sonde repaired under warranty 04/2019 New batteries installed 03/09/2019	Serviced probes installed in Salty Creek 07/11/2019 New Batteries installed 07/11/2019	Awaiting calibration. DO probe being assessed for faulty operation.
Notes	<ul style="list-style-type: none"> - 161 days estimated battery life - Memory cleared – 50045.3 days logging available 	<ul style="list-style-type: none"> - 207 days estimated battery life - Memory cleared – 50045.3 days logging available 	<ul style="list-style-type: none"> - Probes Removed from Salty Creek 07/11/2019

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).



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Water Quality and Erosion Monitoring Site Locations



3. Results

3.1 Water Quality Samples

Results of the water quality monitoring undertaken on 7 November 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 7 November 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	1.14	ns	1.79	1.09	ns	1.08	1.81	1.63	0.81	ns
Total Nitrogen (mg/L)	1.6	1.14	ns	1.79	1.09	ns	1.08	1.81	1.63	0.81	ns
Total Phosphorus(mg/L)	0.14	<0.03	ns	0.06	<0.03	ns	<0.03	0.06	0.04	<0.03	ns
Orthophosphate (mg/L)	0.11	<0.010	ns	0.015	<0.010	ns	<0.010	0.011	0.01	<0.010	ns
Chlorophyll-a (µg/L)	5	<1	ns	17	<1	ns	<1	28	3	<1	ns
Enterococcus (CFU/100mL)	170	26	ns	304	36	ns	24	158	40	16	ns
Faecal Coliforms (CFU/100mL)	135	18	ns	36	4	ns	4	12	150	0	ns
Temp (°C)	25.9	21.06	21.02	21.41	21.24	21.17	ns	18.61	13.1 - 28.8	23.79	22.84
pH	6.9	7.52	7.51	6.77	8.21	8.05	ns	6.17	4.3 - 6.8	7.4	7.33
ORP (mV)	-	133	128	186	115	120	ns	202	-	179	174
Cond (mS/cm)	8.0	25.2	25.2	27.1	25.1	25.1	ns	20.1	0.3 - 21.5	31.4	31.4
Turbidity (NTU)	13	1.5	1.3	17.8	1.6	2	ns	11.5	11	2.4	4.1
DO (mg/L)	4.09	4.26	3.98	3.81	6.24	5.17	ns	0.88	5.52	5.27	4.36
DO (% sat)	-	53.5	49.9	48.6	78.6	65.1	ns	10.4	-	71.1	58
TDS (mg/L)	-	15.6	15.6	16.8	15.6	15.6	ns	12.4	-	19.2	19.2
Sal (ppt)	-	15.3	15.3	16.6	15.2	15.3	ns	11.9	-	19.5	19.5
Depth (m)	-	Surface	0.7	Surface	Surface	0.7	Surface	Surface	-	Surface	0.8

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

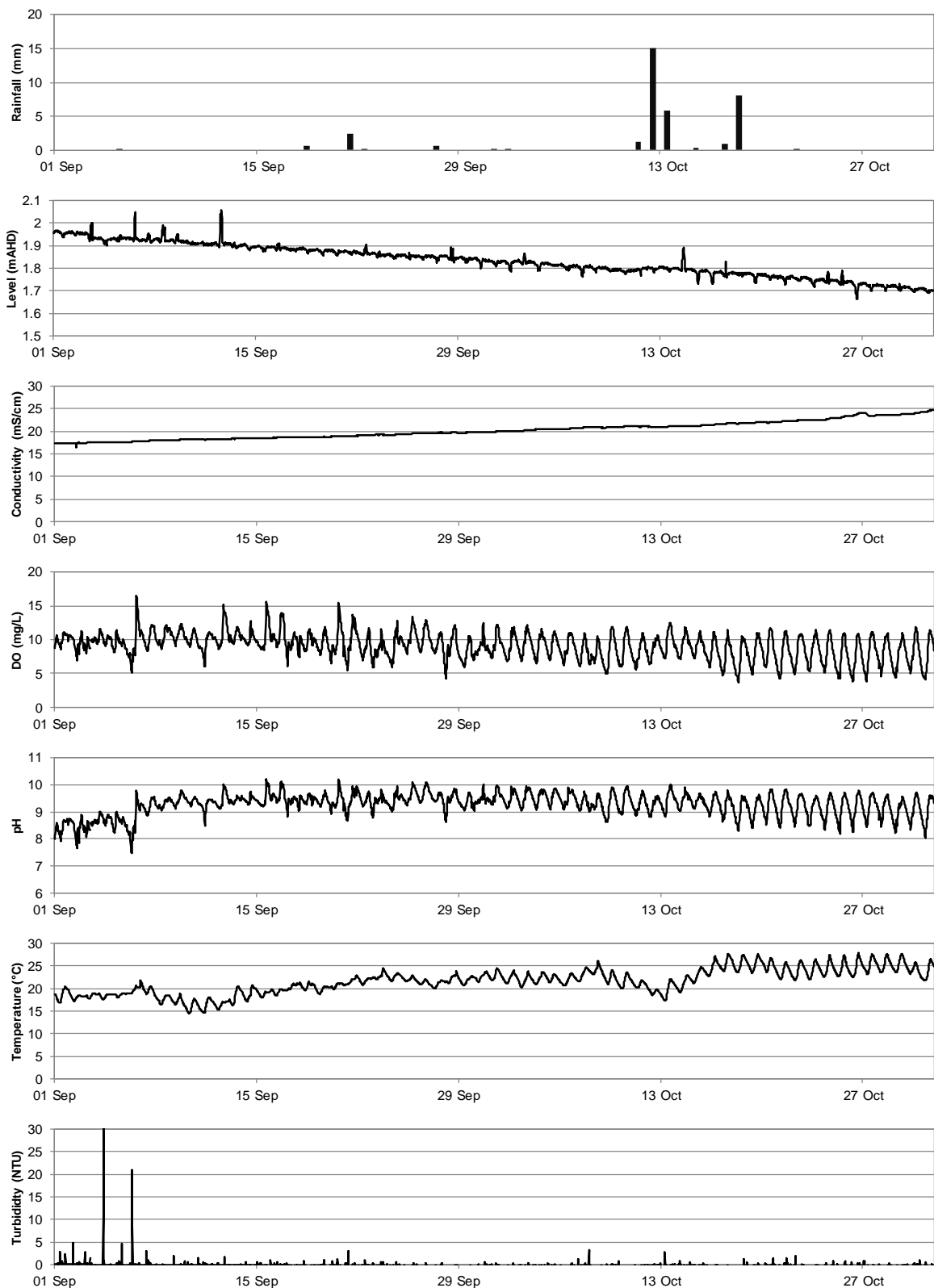


Illustration 3.1 Salty Lagoon Rainfall and Water Quality Monitoring Station Data 1 September 2019 to 31 October 2019

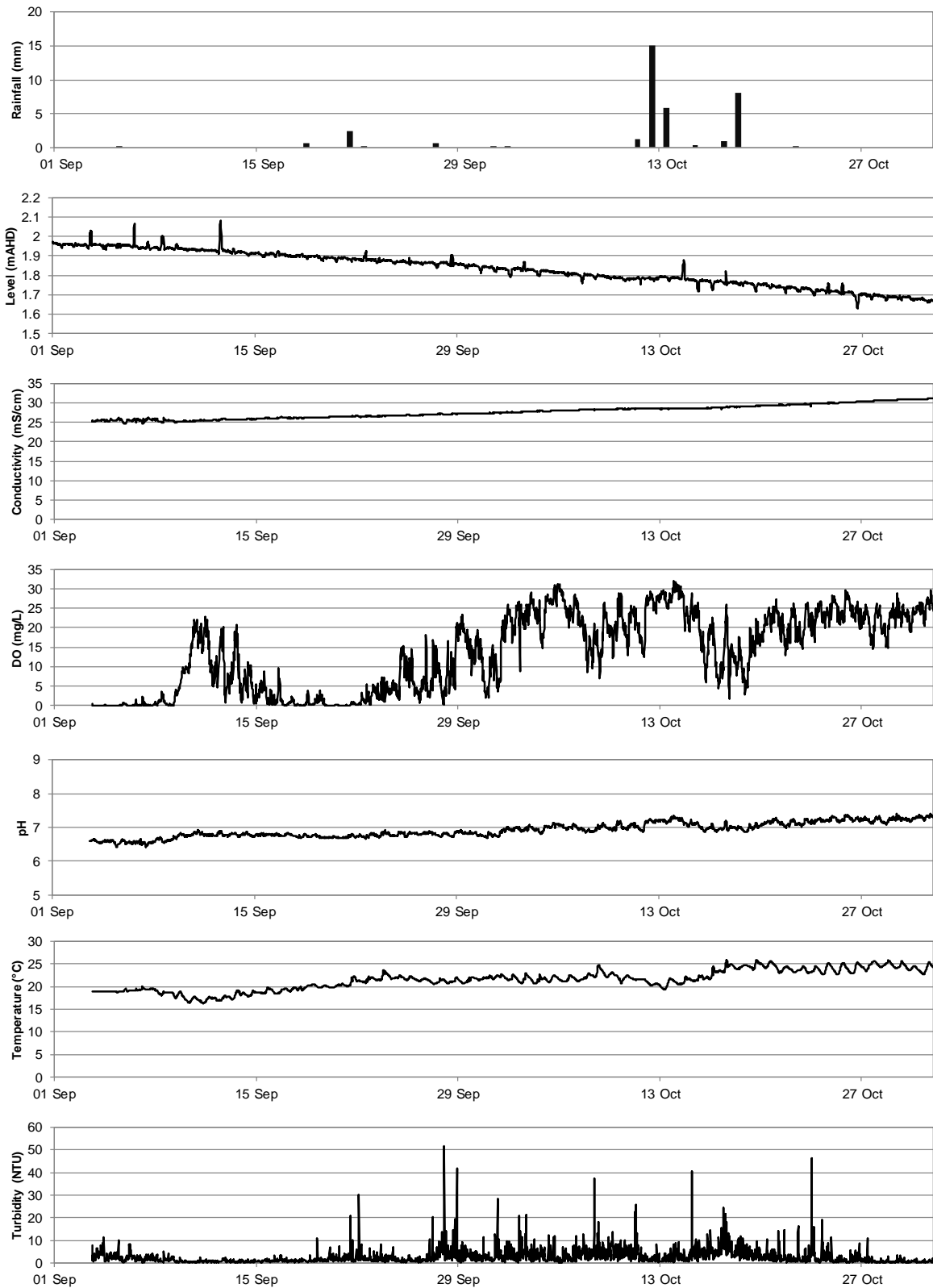


Illustration 3.2 Salty Creek Rainfall and Water Quality Monitoring Station Data 1 September 2019 to 31 October 2019

3.3 Aquatic Weed Monitoring

No significant aquatic weeds were identified during the aquatic weed survey on 3 September 2019.

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 3 September 2019 and the head cut has been relatively stable since October 2018. 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 7 November 2019

Station	Control/ Impact	Distance 25 July 2017 (m)	Distance 3 September 2019 (m)	Cut Movement (m)
ER1	Control	7.55	7.55	0.00
ER2	Control	10.20	10.20	0.00
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	8.70	1.70



4. Discussion

4.1 Water Quality

Total rainfall for this reporting period was 26% of the long-term average (1998 - 2019). The rain fell in two small to moderate events and a few small events. 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 reduced consistently throughout the monitoring period and that rainfall had little impact. At the time of the site inspection on 7 November 2019, the entrance to Salty Creek was still closed. The water level in Salty Lagoon also reduced consistently over the course of this monitoring period. The levels in both waterways fell by almost 0.3 m between 1 September and 31 October 2019. At the time of the site inspection there was very little water at S4, present as a series of small disconnected ponds. The conductivity measured at the Salty Lagoon and Salty Creek PWQMS increased steadily over the course of the monitoring period, indicating that evaporation was a major factor driving water quality. At the time of the site inspection on 7 November 2019 the salinity in Salty Lagoon was approximately 50% seawater. The conductivity measurements collected on 7 November 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 sixth consecutive bi-monthly period, there was little flow from Salty Lagoon to Salty Creek.

The DO concentrations in discrete samples collected on 7 November 2019 were relatively high all sites except the western two Salty Lagoon sites and did not comply with guiding values at sites S2, S4 or S5. This pattern has been observed on most site visits over the past two years (**Illustration 4.1**). Low DO concentrations are naturally prevalent at the sites to the west of Salty Lagoon (sites S2 and S4) and, also, often 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 diurnal fluctuations became more regular and more pronounced as water levels reduced. At the time of the site inspection on 7 November 2019 there was significant growth of a green macroalgae in the open water of Salty Lagoon. This may have contributed to the strength and regularity of diurnal DO fluctuations. The measurements from the Salty Creek PWQMS do not vary according to a pattern. However, the maximum and minimum values measured at the Salty Creek PWQMS indicate that the DO probe was malfunctioning and that the data should be discounted.

Most of the nutrient concentrations from samples collected on 7 November 2019 complied with guiding values. The exceptions were the TN concentrations from S2 and S4. Bioavailable nitrogen was not detected in any samples and bioavailable phosphorus was only detected at S2 and S4, and only at low concentrations there. Chlorophyll-a was also only detected at S2 and S4, where the measured concentrations did not comply with guiding values and indicated an algal bloom of moderate to large proportions. 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, and the enterococcus concentration at S2. 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 concentration at S2 is likely to be associated with waterbird use of that area.

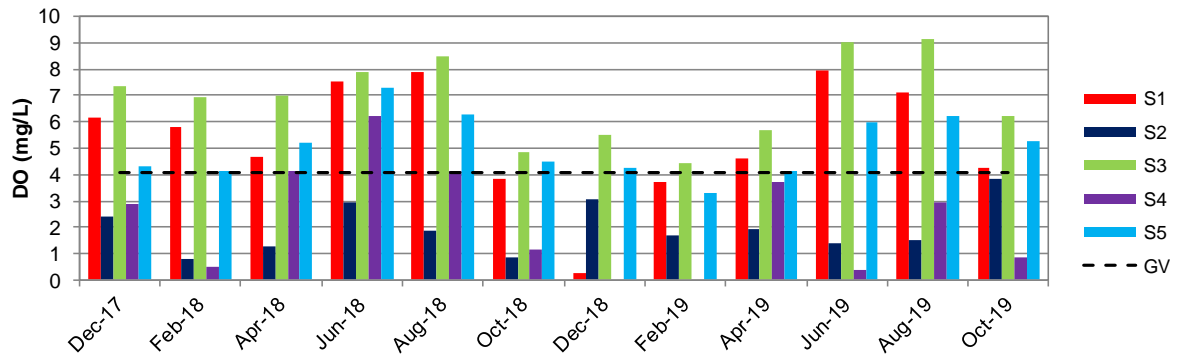


Illustration 4.1 Discrete Measurements of Dissolved Oxygen at all Sites Since December 2017 Plotted Against the Salty Lagoon Guiding Value

4.2 Other Observations

The entrance to Salty Creek was closed on 7 November 2019. A large number and wide variety of birds were observed incidentally during the site inspection including Pacific Black Duck, Grey Teal, Eurasian Coot, Pelican, Black Swan, Little Pied Cormorant, Little Black Cormorant, Darter, Australasian Grebe, Royal Spoonbill, White Ibis, Glossy Ibis, Great Egret, Little Egret, Masked Lapwing, Pied Stilt, Whimbrel, Black-Fronted Dotterel, Sharp-Tailed Sandpiper and White-bellied Sea Eagle. Large areas of rushes in the open water of Salty Lagoon, mostly *Typha orientalis*, *Schoenoplectus validus* and *Phragmites australis*, have continued dying back in response to saline conditions.



Plate 4.1 The closed entrance to Salty Creek on 7 November 2019



Plate 4.2 Senescing rushes due to ongoing saline water quality



5. Key Points

1. Water levels fell in Salty Lagoon and Salty Creek during this reporting period due to evaporation. Rainfall was very low.
2. A small number of results did not comply with the guiding values.
3. Nutrient concentrations and chlorophyll-a concentrations were low in the open water of Salty Lagoon and in Salty Creek, but higher to the west of Salty Lagoon.
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. To date there has not been a poor water quality event associated with these persistent saline conditions.



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