Salty Lagoon
Post Closure Monitoring

Project Management and Ecosystem Health Report
August 2021

GeoLINK
environmental management and design

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1. Introduction

1.1 Introduction

This document comprises the first bi-monthly monitoring report for year 10 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 July 2021 until 31 August 2021.

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 first bi-monthly site visit for year 10 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 12 September 2021. Water quality samples were collected between the hours of 6:00 am and 10:00 am on that day. A low tide of 0.41 metres was forecast for 5.37 am.

Discrete water quality samples were taken from surface water (approximately 0.2 metre depth) at four sites in Salty Lagoon and a single site (S5) in Salty Creek. An additional quality assurance (QA) replicate sample was collected at S5. 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	*S1*	*S2*	*S3*	*S4*	*S5*
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 following 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. Weed monitoring was not undertaken during this monitoring event. The spring 2021 monitoring will be undertaken in November 2021.

2.4 Erosion Monitoring

A series of reference stations have been set up around the 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**. Repairs to the control structure installed by NSW National Parks and Wildlife Service (NPWS) in late 2020 were undertaken in June and July 2021. Erosion monitoring is continuing to confirm if the headcut has stabilised.

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. In March 2020 site ER5 had to be extended because the fixed peg was overtaken by the erosion. A new site, ER5A was created but allows erosion progression to be measured from the same initial reference point as ER5.

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
ER5A	Impact	542128	6783245
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 12 September 2021 and replaced by a serviced and calibrated set.

The status of the two deployed YSI EXO3 sondes on 12 September 2021 is displayed in **Table 2.3**.

Table 2.3 YSI Sonde Status on 12 September 2021

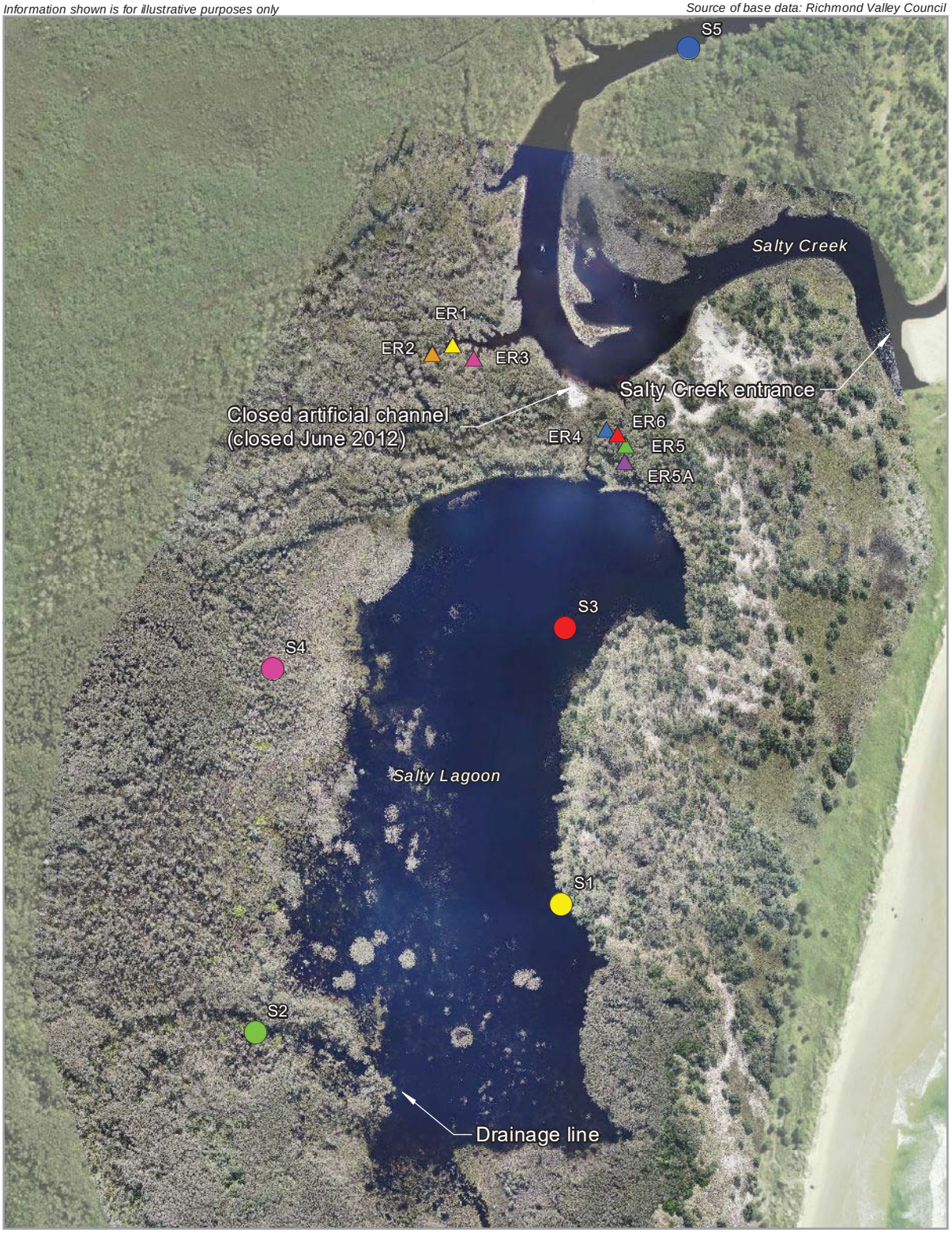
Sonde	*SN17F104100*	*SN 17H104488*	*Spare Probes*
pH (cap life expectancy 18 months)	EXO pH 17H105047 Manufactured 08/2017 New cap 01/2021	EXO pH 17H105049 Manufactured 08/2017 New cap 02/2021	EXO pH 17H105048 Manufactured 08/2017 New cap 10/2020
Temp/ cond (life expectancy 7-10 years)	EXO Wiped CT 17F102047 Manufactured 06/2017	EXO Wiped CT 17F103252 Manufactured 06/2017	EXO Wiped CT 17F102685 Manufactured 06/2017
DO (cap life expectancy 24 months)	EXO Optical DO 17H103493 Manufactured 08/2017 New cap 06/2021	EXO Optical DO 17H103495 Manufactured 08/2017 New cap 03/2021	EXO Optical DO 17H103494 Manufactured 08/2017 New cap 04/2021
Turbidity (life expectancy 7-10 years)	YSI EXO Turbidity 17H101465 Manufactured 08/2017	YSI EXO Turbidity 17H101468 Manufactured 08/2017	YSI EXO Turbidity 17H103513 Manufactured 08/2017
Wiper	YSI Exo Wiper 17G101952 New wiper brush installed 07/2020	YSI Exo Wiper 17G101954 New wiper brush installed 03/2020	No Spare Wiper
Status	- Serviced probes installed in Salty Lagoon 30/06/2021 - New batteries installed 12/09/2021	- Serviced probes installed in Salty Creek 12/09/2021 - New Batteries installed 12/09/2021	- Awaiting service and calibration. - Probes Removed from Salty Creek 12/09/2021
Notes	- 218 days estimated battery life - Memory cleared – 49082 days logging available	- 218 days estimated battery life - Memory cleared – 49082 days logging available	

Climate information was sourced from the Evans Head bombing range weather station on the Bureau of Meteorology website (BOM 2021). Evans Head Sewage Treatment Plant (STP) facility routine sampling information was provided by Richmond Valley Council (RVC).

Drawn by: DSA Checked by: AB Reviewed by: AB Date: 27/10/2020

Information shown is for illustrative purposes only

Source of base data: Richmond Valley Council



LEGEND

Water Quality Site

- S1
- S2
- S3
- S4
- S5

Erosion Monitoring Site

- ER1
- ER2
- ER3
- ER4
- ER5
- ER5A
- ER6

0 120

Location of Water Quality and Erosion Monitoring Sites

3. Results

3.1 Water Quality Samples

Results of the water quality monitoring undertaken on 12 September 2021 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 12 September 2021

Parameter	Salty Lagoon							Salty Creek		
	Guiding Value	S1	S1 (1m)	S2	S3	S3 (1m)	S4	Guiding Value	S5	S5 (QA)*
Blue Green Algae ID (cells/mL)	**0**	nil	ns	**<100**	nil	ns	**<1000**	**0**	nil	nil
Nitrite Nitrogen (mg/L)	**0.01**	<0.010	ns	<0.010	<0.010	ns	<0.010	**0.01**	<0.010	<0.010
Nitrate Nitrogen (mg/L)	**0.01**	<0.010	ns	<0.010	<0.010	ns	<0.010	**0.01**	<0.010	<0.010
Oxidized Nitrogen (mg/L)	**-**	<0.010	ns	<0.010	<0.010	ns	<0.010	**-**	<0.010	<0.010
Ammonia Nitrogen (mg/L)	**0.05**	0.018	ns	0.012	0.024	ns	<0.010	**0.11**	<0.010	<0.010
Total Kjeldahl Nitrogen (mg/L)	**1.6**	1.24	ns	0.97	1.29	ns	**1.98**	**1.63**	0.92	0.92
Total Nitrogen (mg/L)	**1.6**	1.24	ns	0.97	1.29	ns	**1.98**	**1.63**	0.92	0.92
Total Phosphorus(mg/L)	**0.14**	0.06	ns	0.05	0.06	ns	<0.03	**0.04**	<0.03	<0.03
Orthophosphate (mg/L)	**0.11**	0.038	ns	0.031	0.033	ns	<0.010	**0.01**	<0.010	<0.010
Chlorophyll-a (µg/L)	**5**	<1	ns	**6**	2	ns	**22**	**3**	**5**	<1
Enterococcus (CFU/100mL)	**170**	6	ns	116	2	ns	2	**40**	14	10
Faecal Coliforms (CFU/100mL)	**135**	4	ns	30	10	ns	<2	**150**	24	18
Temp (˚C)	**25.9**	18.18	18.16	15.25	19.01	19.2	14.13	**13.1 - 28.8**	16.85	ns
pH	**6.9**	**7.03**	**7.03**	6.71	**7.1**	**7.07**	5.33	**4.3 - 6.8**	6.73	ns
ORP (mV)	**-**	215	216	168	187	199	202	**-**	208	ns
Cond (mS/cm)	**8.0**	2.82	2.82	0.707	2.81	2.82	4.86	**0.3 - 21.5**	17.1	ns
Turbidity (NTU)	**13**	0.3	3.9	6.8	1.7	3.3	8.6	**11**	0.2	ns
DO (mg/L)	**4.09**	6.36	6.15	**3.09**	7.19	7.51	**1.88**	**5.52**	5.92	ns
DO (% sat)	**-**	70.1	67.7	31.9	80.4	84.3	19.2	**-**	66.7	ns
TDS (mg/L)	**-**	1.81	1.81	0.453	1.8	1.8	3.11	**-**	10.6	ns
Sal (ppt)	**-**	1.5	1.5	0.3	1.5	1.5	2.6	**-**	10	ns
Depth (m)	**-**	Surface	1	Surface	Surface	1	Surface	**-**	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

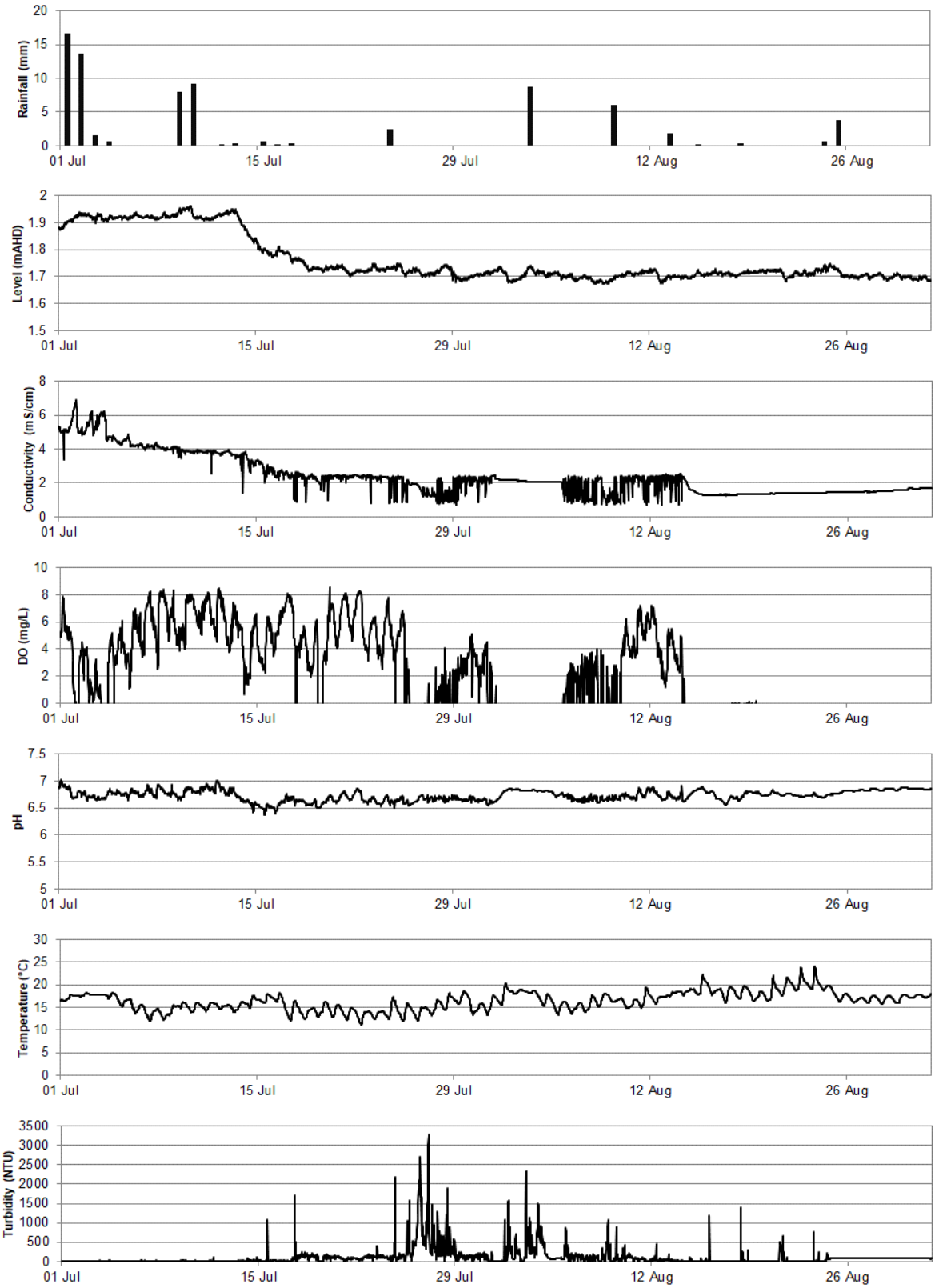


Illustration 3.1 Salty Lagoon Rainfall and Water Quality Monitoring Station Data 1 July 2021 to 31 August 2021

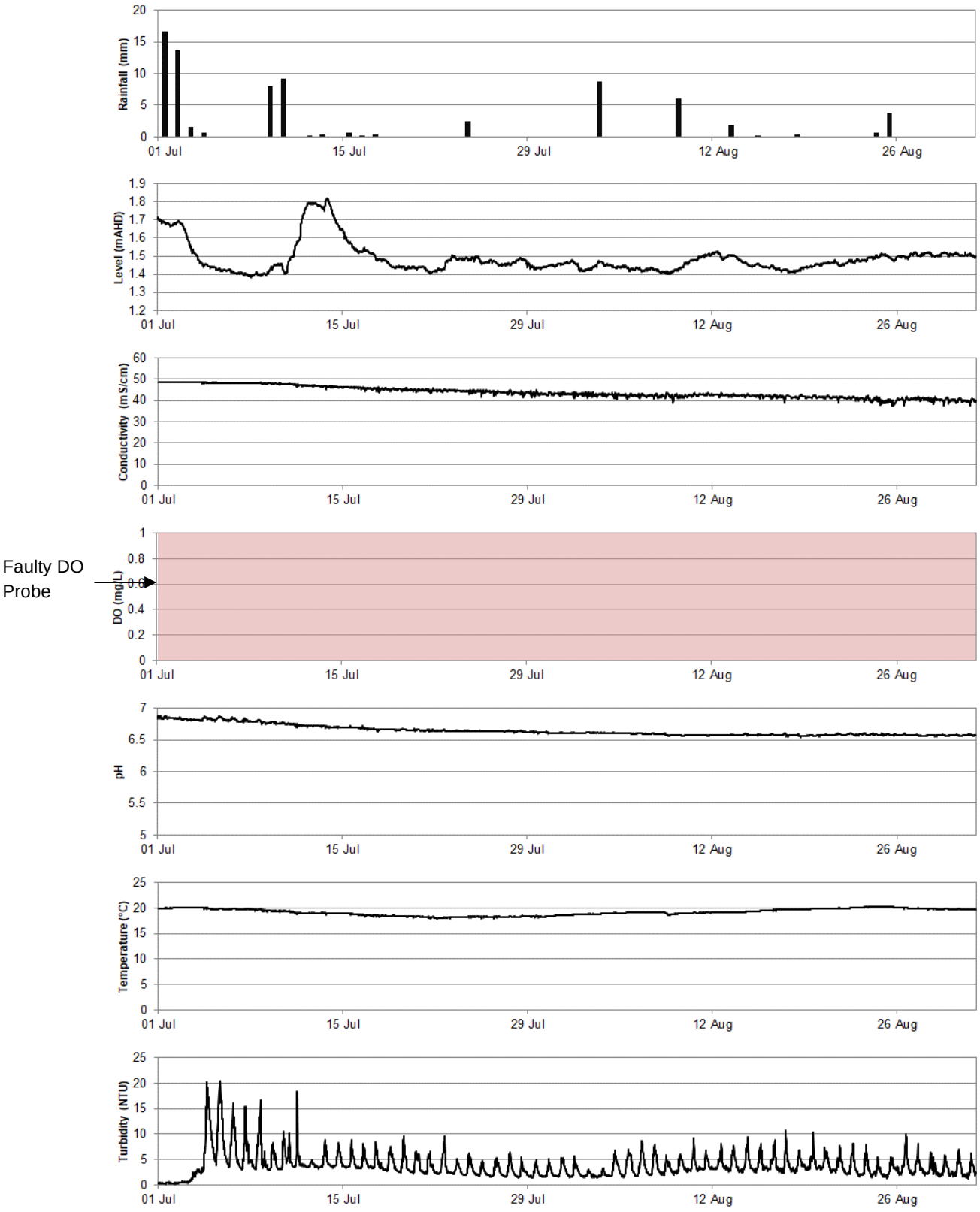


Illustration 3.2 Salty Creek Rainfall and Water Quality Monitoring Station Data 1 July 2021 to 31 August 2021

3.3 Aquatic Weed Monitoring

No significant aquatic weeds were identified during the aquatic weed survey on 30 April 2021. The next survey is due in November 2021.

3.4 Erosion Monitoring Stations

The data collected at the erosion monitoring stations is presented in **Table 3.2** and **Illustration 3.3**. There was a significant advance of the head cut at ER51 in relation to the previous measurements on 30 April 2021. The head cut has advanced almost 60 m towards Salty Lagoon since the monitoring began in July 2017.

Table 3.2 Erosion Monitoring Results from 12 September 2021

Station	*Control/ Impact*	*Distance 25 July 2017 (m)*	*Distance 12 Sept 2021 (m)*	*Cut Movement (m)*
ER1	Control	7.55	7.50	0.05
ER2	Control	10.20	7.70	2.50
ER3	Control	9.95	9.80	0.15
ER4	Impact	8.35	-5.75	14.10
ER5	Impact	12.35	-45.5	57.85
ER6	Impact	10.40	6.15	4.25

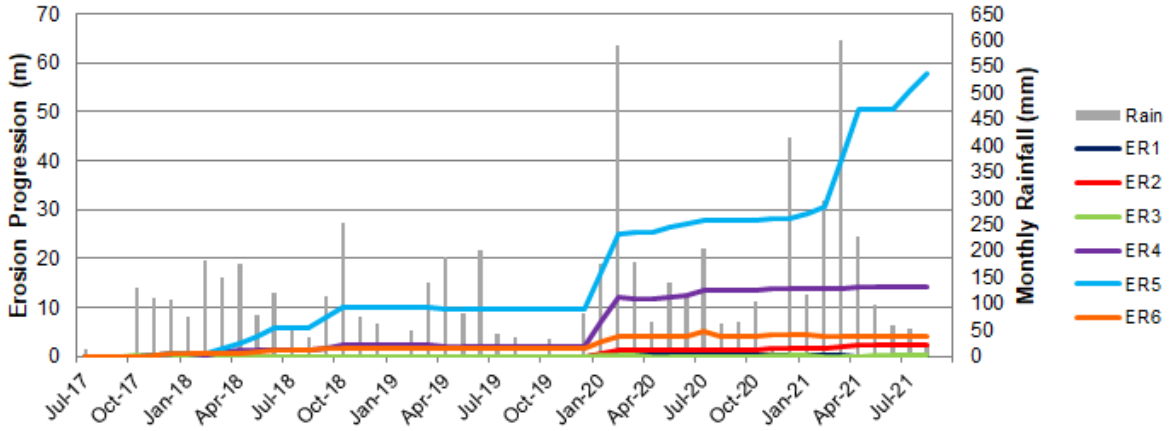


Illustration 3.3 Erosion Progression Plotted against Monthly Rainfall since July 2017

4. Discussion

4.1 Water Quality

Rainfall for this reporting period comprised of several relatively evenly spaced small to medium events. The total rainfall for this reporting period was approximately 51 percent of the average amount. This was the second consecutive reporting period with very low total rainfall.

The water level data from the Salty Creek PWQMS indicates that the entrance to Salty Creek was closed at the beginning of the reporting period before opening on 3 July 2021 in response to moderate rainfall event. The entrance to Salty Creek closed again shortly afterwards before opening again after the repairs to the erosion control structure completed on 13th July 2021 and the water levels in Salty Lagoon adjusted to the lower level. At the time of the site inspection on 12 September 2021, the entrance to Salty Creek was closed (**Plate 4.1**). The water level in Salty Lagoon was relatively high at the beginning of this reporting period before dropping approximately 20 cm over 4-5 days when the repairs to the erosion control structure were completed and the associated bund structure was removed. The water level in Salty Lagoon is currently in a transitional stage, influenced by the repaired spillway height and erosion of the headcut at the northern bank of the lagoon.

The conductivity measured at the Salty Lagoon PWQMS decreased overall during this reporting period, probably mostly in response to saline water flowing out in to Salty Creek and being replaced by fresher water from around the catchment. The conductivity measurements from the Salty Lagoon PWQMS show rapid variations in the conductivity indicating that unmixed water was moving around the lagoon prior to mixing well on approximately 14 August 2021. The conductivity measurements from the Salty Creek PWQMS show a steady and continual decrease in the conductivity over the course of the reporting period. At the time of the site inspection on 12 September 2021 the water in Salty Lagoon was well mixed and brackish, and the water in Salty Creek was stratified into a slightly brackish surface layer and a strongly saline, heavier bottom layer. The conductivity measurements collected on 12 September 2021 complied with guiding values at all sites.

Erosion monitoring showed further movement of the primary head cut towards Salty Lagoon since the previous measurements taken on 30 April 2021. It is not certain if the movement occurred prior to or after the repairs to the erosion control structure.

The DO concentrations in discrete samples collected on 12 September 2021 were below the guiding values at the two western sites in Salty Lagoon (sites S2 and S4). Low DO concentrations are naturally prevalent at the sites to the west of Salty Lagoon. Logged data from the Salty Lagoon PWQMS indicates that the DO concentrations fluctuated mostly in response to a combination of mixing conditions and diurnal patterns of light availability. At the bottom of the water column the DO concentrations at the Salty Lagoon PWQMS varied between healthy and anoxic. At the Salty Creek PWQMS there was a problem with the DO probe for the entire monitoring period.

Almost all of the nutrient concentrations from samples collected on 12 September 2021 complied with guiding values. The exception was the TN concentration from S4. Chlorophyll-a concentrations from S2, S4 and S5 did not comply with the guiding values. The sample from S4 indicated an algal bloom of moderate proportions, while the samples from S2 and S5 indicated an algal bloom of small proportions.

Blue-green algae were recorded from S2 and S4, but in very low concentrations. The blue-green algae detected were from the genera *Oscillatoria*, *Planktolyngbya*, *Synechoccus* and *Aphanocapsa*. *Oscillatoria* and *Synechoccus* are not genii known to form toxic blooms, though some species of *Planktolyngyba* have been associated with toxic blooms. *Aphanocapsa* is not a genus known from Australian freshwater environments but does have some species that inhabit marine waters. The detection of *Aphanocapsa* at S4 is likely to be a result of saltwater ingress.

All other results complied with guiding values with the exception of the pH measurements from S1 and S3. Higher than normal pH values around Salty Lagoon often occur after extended dry periods, or after seawater ingress, which occurred in the previous reporting period.

4.2 Other Observations

The entrance to Salty Creek was closed on 12 September 2021. A variety of birds were observed incidentally during the site inspection including Pacific Black Duck, Australasian Grebe, Great Cormorant and Buff-banded Rail.

Plate 4.1 The closed entrance to Salty Creek on 12 September 2021

Plate 4.2 Buff-banded Rail on the margins of Salty Lagoon

5. Key Points

1. Water levels dropped in Salty Lagoon when repairs to the erosion control structure were completed and the water drained over the new structure. Maximum levels under normal conditions are expected to transition and stabilise based on the repaired spillway height.

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

3. Chlorophyll-a concentrations were relatively high at S4, along with total nutrient concentrations, but relatively low at the other sites.

4. Blue-green algae were detected for the sixth consecutive reporting period. Concentrations and the number of sites remain low and the taxa represented have varied over time.

5. The water level in Salty Lagoon is currently in a transitional stage, influenced by the repaired spillway height and recent erosion of the headcut at the northern bank of the lagoon. It is unknown if the headcut advanced recorded during this monitoring event occurred before or after the repair works to the erosion control structure were completed.

6. The risk rating for the Salty Lagoon Response Protocol is unknown due to the advance of the headcut. Adaptive management site visits may be required.

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