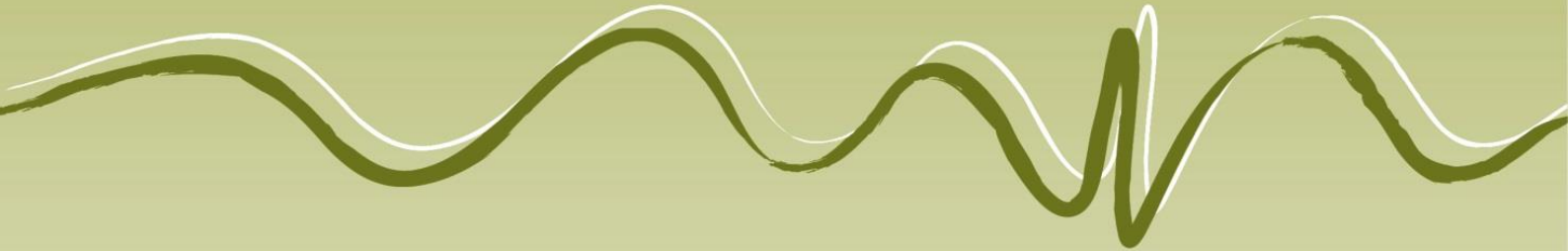


Salty Lagoon

Post Closure Monitoring

Project Management and Ecosystem Health Report

April 2022



AQUATIC SCIENCE AND MANAGEMENT

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1. Introduction

1.1 Introduction

This document comprises the fifth 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 March 2022 until 30 April 2022.

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 fifth 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 9 May 2022. Water quality samples were collected between the hours of 10:00 am and 2:00 pm on that day. A high tide of 1.23 metres was forecast for 3.10 pm.

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 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	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. The autumn aquatic weed survey was undertaken during the site inspection on 9 May 2022.

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. The repairs were noted to have failed following flooding that occurred during this reporting period which was reported to Richmond Valley Council (RVC) and NPWS. 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.

HOB0 U20 water level loggers were installed in the water at each PWQMS and a third HOB0 was installed above the water at S1 to collect barometric pressure data for offsetting atmospheric variability.

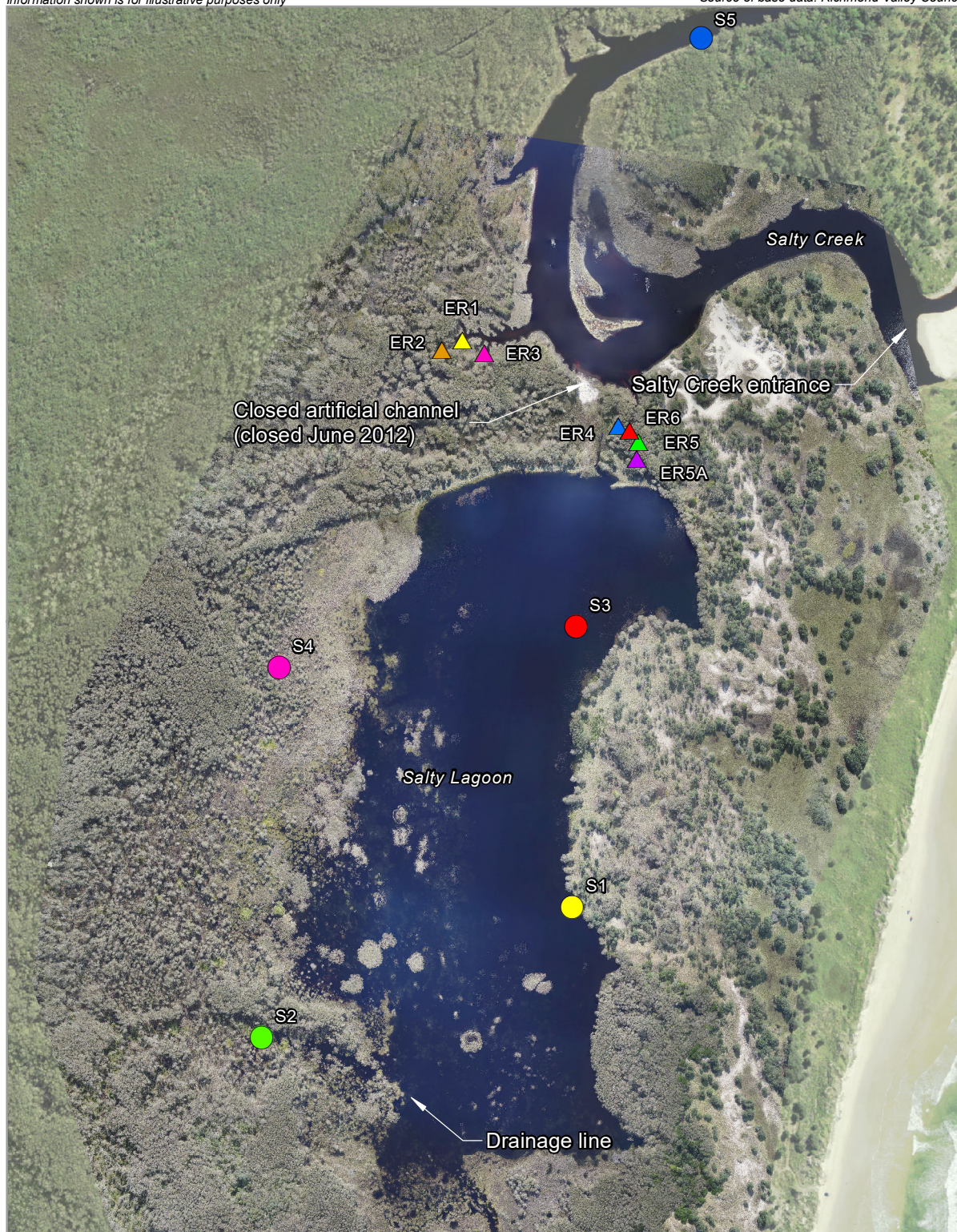
The temperature, pH, conductivity, turbidity and DO sensors on the EXO3 sonde installed at the Salty Lagoon PWQMS were removed on 9 May 2022 and replaced by a serviced and calibrated set.

The status of the two deployed YSI EXO3 sondes on 9 May 2022 is displayed in **Table 2.3**.

Table 2.3 YSI Sonde Status on 9 May 2022

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 Malfunction. Removed for service	YSI Exo Wiper 17G101954 New wiper brush installed 03/2020	No Spare Wiper
Status	<ul style="list-style-type: none"> - Serviced probes installed in Salty Lagoon 9/05/2022 - New batteries installed 9/05/2022 	<ul style="list-style-type: none"> - Serviced probes installed in Salty Creek 15/03/2022 - New Batteries installed 9/05/2022 	<ul style="list-style-type: none"> - Awaiting service and calibration. - Probes Removed from Salty Lagoon 9/05/2022
Notes	<ul style="list-style-type: none"> - 218 days estimated battery life - Memory cleared – 49082 days logging available 	<ul style="list-style-type: none"> - 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 2022). Evans Head Sewage Treatment Plant (STP) facility routine sampling information was provided by RVC.



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 9 May 2022 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**.

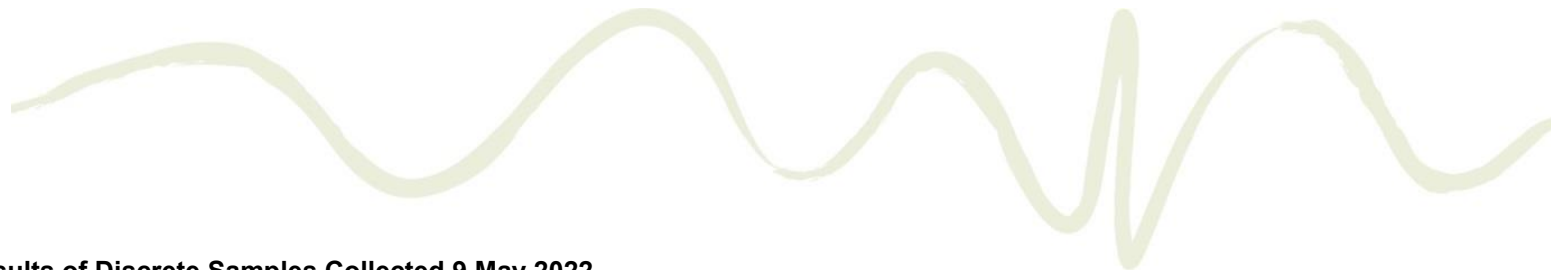


Table 3.1 Results of Discrete Samples Collected 9 May 2022

Parameter	Salty Lagoon								Salty Creek	
	Guiding Value	S1	S1 (1m)	S2	S3	S3 (1m)	S4	S4 (QA)*	Guiding Value	S5
Blue Green Algae ID (cells/mL)	0	<100	<100	<100	<100	<100	<100	<100	0	<100
Nitrite Nitrogen (mg/L)	0.01	0.011	ns	<0.010	<0.010	ns	<0.010	<0.010	0.01	<0.010
Nitrate Nitrogen (mg/L)	0.01	0.026	ns	<0.010	0.027	ns	<0.010	<0.010	0.01	<0.010
Oxidized Nitrogen (mg/L)	-	0.037	ns	<0.010	0.036	ns	0.014	0.012	-	<0.010
Ammonia Nitrogen (mg/L)	0.05	0.01	ns	<0.010	0.011	ns	<0.010	<0.010	0.11	<0.010
Total Kjeldahl Nitrogen (mg/L)	1.6	1.08	ns	1.07	1.19	ns	1.49	1.63	1.63	1.04
Total Nitrogen (mg/L)	1.6	1.12	ns	1.07	1.22	ns	1.5	1.64	1.63	1.05
Total Phosphorus(mg/L)	0.14	0.04	ns	0.07	0.05	ns	<0.03	<0.03	0.04	<0.03
Orthophosphate (mg/L)	0.11	0.014	ns	0.03	0.015	ns	<0.010	<0.010	0.01	<0.010
Chlorophyll-a (µg/L)	5	<1	ns	<1	<1	ns	6	4	3	2
Enterococcus (CFU/100mL)	170	35	ns	85	60	ns	<5	565	40	45
Faecal Coliforms (CFU/100mL)	135	20	ns	60	20	ns	10	10	150	20
Temp (°C)	25.9	18.82	18.85	18.44	18.87	18.54	18.26	ns	13.1 - 28.8	18.49
pH	6.9	6.38	6.5	6.01	5.96	5.83	5.1	ns	4.3 - 6.8	4.12
ORP (mV)	-	242	238	176	256	264	243	ns	-	337
Cond (mS/cm)	8.0	0.459	0.461	0.245	0.437	0.444	1.12	ns	0.3 - 21.5	0.18
Turbidity (NTU)	13	1.7	5.9	1	0.9	1	2.6	ns	11	1.5
DO (mg/L)	4.09	6.32	6.22	2.61	6.18	6.14	2.62	ns	5.52	4.23
DO (% sat)	-	70	69	28.6	68.5	67.6	28.8	ns	-	46.6
TDS (mg/L)	-	0.299	0.299	0.159	0.284	0.288	0.715	ns	-	0.117
Sal (ppt)	-	0.2	0.2	0.1	0.2	0.2	0.6	ns	-	0.1
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

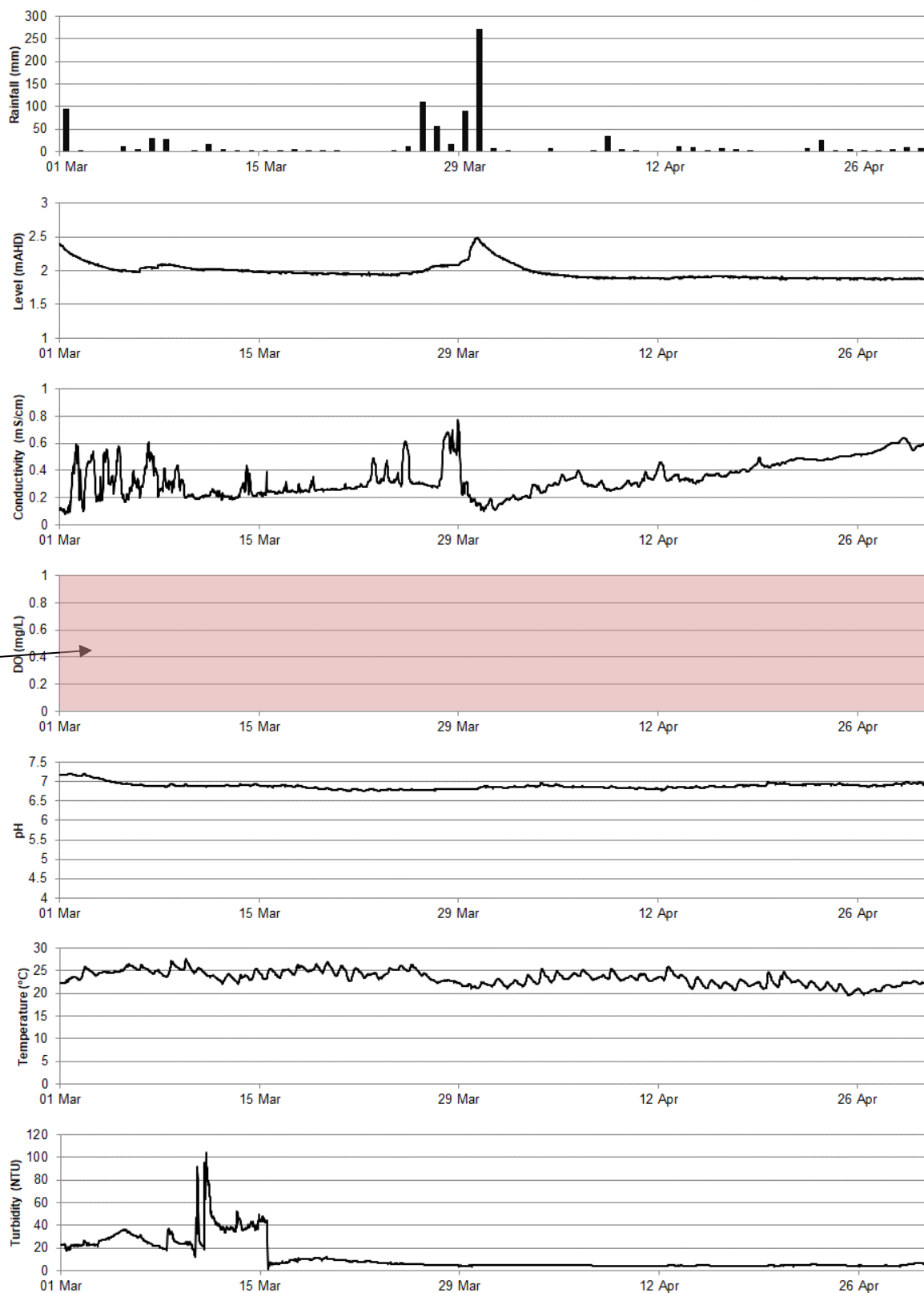


Illustration 3.1 Salty Lagoon Rainfall and Water Quality Monitoring Station Data 1
March 2022 to 30 April 2022

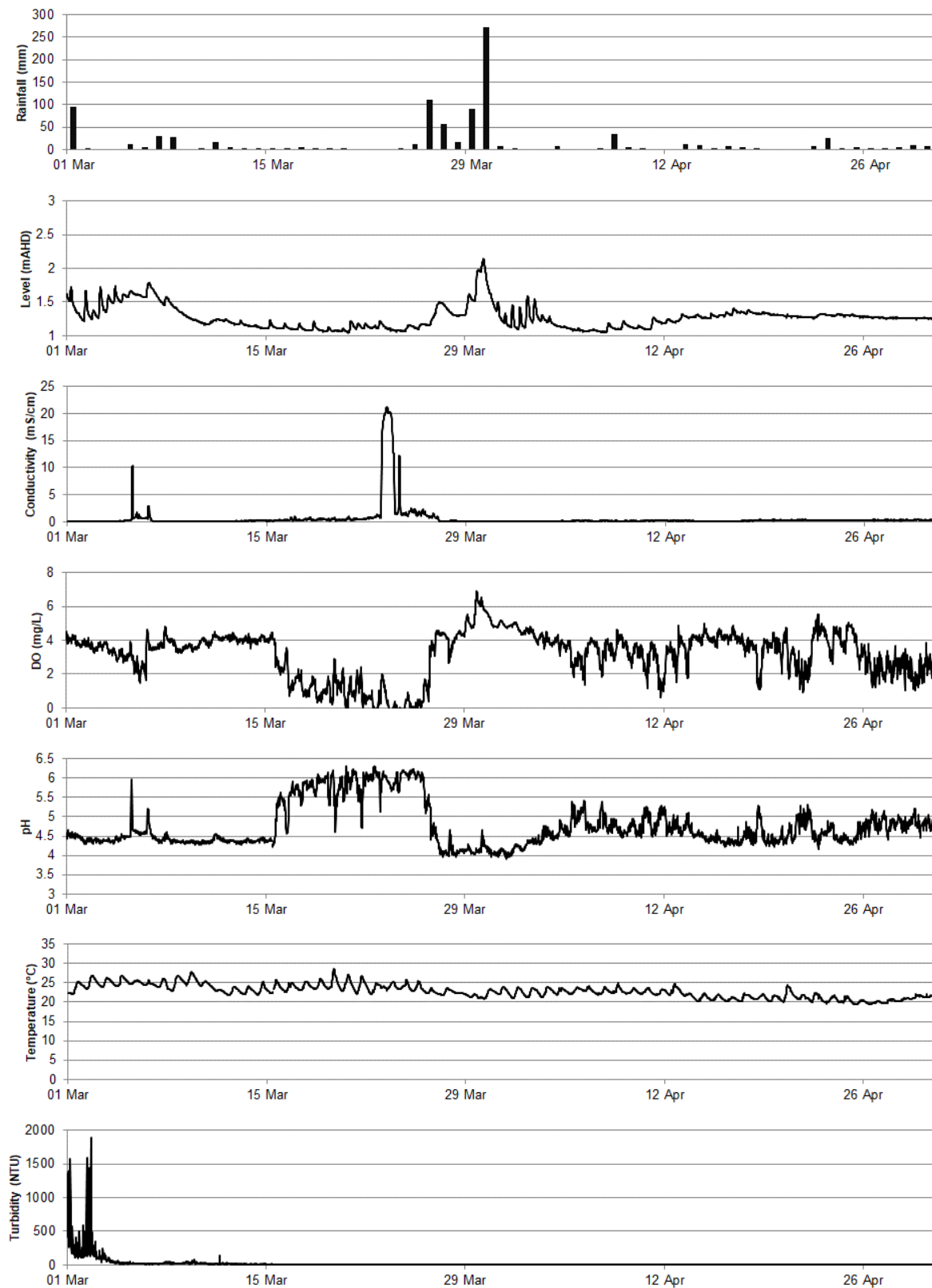


Illustration 3.2 Salty Creek Rainfall and Water Quality Monitoring Station Data 1 March 2022 to 30 April 2022

3.3 Aquatic Weed Monitoring

No significant aquatic weeds were identified during the aquatic weed survey on 9 May 2022.

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 moderate advance of the head cut at ER5 in relation to the previous measurements on 15 March 2022. The head cut has advanced more than 50 m towards Salty Lagoon since the monitoring began in July 2017.

Table 3.2 Erosion Monitoring Results from 15 March 2022

Station	Control/ Impact	Distance 25 July 2017 (m)	Distance 9 May 2022 (m)	Cut Movement (m)
ER1	Control	7.55	7.35	0.20
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	-39.7	52.05
ER6	Impact	10.40	6.15	4.25

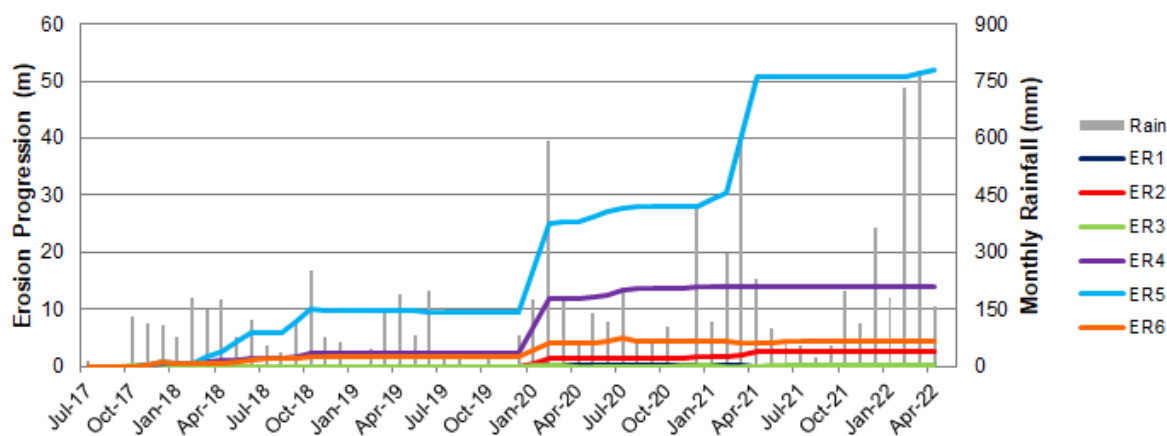


Illustration 3.3 Erosion Progression Plotted against Monthly Rainfall since July 2017

4. Discussion

4.1 Water Quality

There was consistent rainfall during this reporting period including a flood event, several large events and a number of small events. Rainfall was recorded on approximately 3/4 of the days of the reporting period. The total rainfall for this reporting period was approximately 280 percent of the average amount. This is the fourth consecutive bi-monthly reporting period where rainfall exceeded the average amount (**Illustration 4.1**) and for the previous 12 months rainfall in the area was more than twice the average amount.

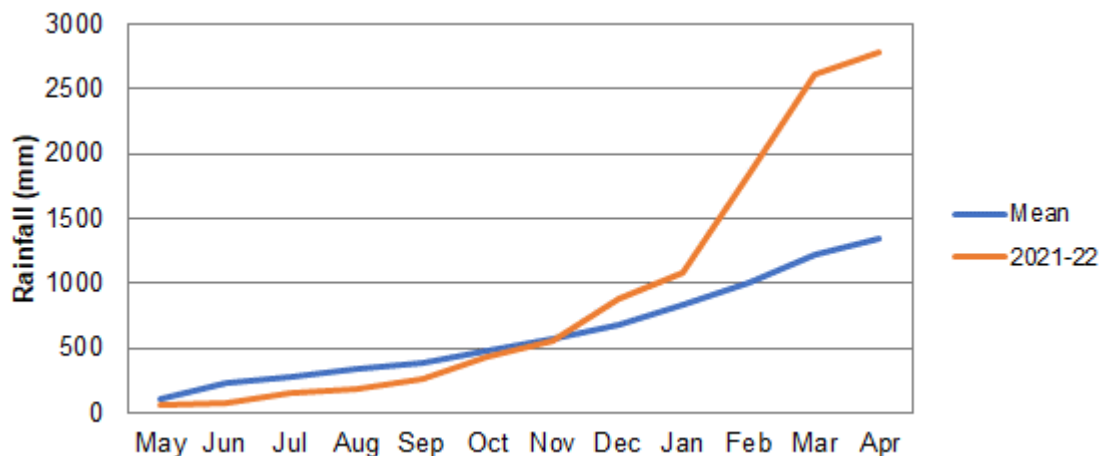
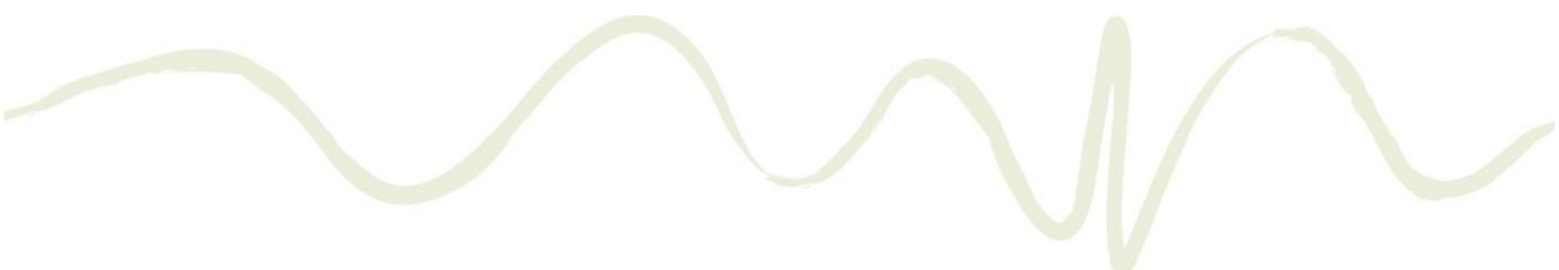


Illustration 4.1 Cumulative rainfall since May 2021 plotted against cumulative average rainfall

The water level at the Salty Creek PWQMS was particularly dynamic again during this reporting period, in response to rainfall runoff, seawater ingress, the entrance opening on at least one occasion and tidal movements. Although water levels became very high on one occasion, they were moderately low for the majority of the reporting period. The data indicates that the entrance to Salty Creek was open for most of the reporting period, and operating tidally for approximately half of it. Water levels in Salty Lagoon remained high for the majority of the reporting period, increasing to very high levels in response to a flood event in the middle of the reporting period. Water would have flowed from Salty Lagoon into Salty Creek for the entire reporting period. This flow led to an advance of the eroding head cut (refer to **Illustration 3.3**) and also caused the erosion control structure to fail.

The conductivity measured at the Salty Lagoon PWQMS remained very low during this reporting period in response to consistent rainfall runoff. Small fluctuations detected at the Salty Lagoon PWQMS probably indicate variability of wind and flow driven mixing conditions. The conductivity measurements from the Salty Creek PWQMS remained low for the majority of the reporting period in response to heavy rainfall runoff, although tidal movements caused a short spike before flooding saw a return to freshwater dominance. At the end of the reporting period (and at the time of the site inspection on 9 May 2022) the water in Salty Lagoon and Salty Creek was fresh. The conductivity measurements collected on 9 May 2022 complied with guiding values at all sites except S5, where the results were below the lower guideline limit as a result of the very strong influence from rainfall runoff.

Erosion monitoring showed a moderate movement of the primary head cut towards Salty Lagoon since the previous measurements taken on 15 March 2022. Although the advance towards Salty



Lagoon was approximately 1.3 m during this reporting period, the eroding channel extended approximately 3-4 m.

The DO concentrations in discrete samples collected on 9 May 2022 were below the guiding values at the two western sites in Salty Lagoon and at the Salty Creek site. Low DO concentrations are naturally prevalent at the sites to the west of Salty Lagoon. Logged data from the Salty Creek PWQMS indicates that the DO concentration at the bottom of the water column in Salty Creek improved when freshwater conditions prevailed but was still variable in response to light availability.

Some of the nutrient concentrations from samples collected on 9 May 2022 did not comply with guiding values. Specifically, the nitrite concentration from S1, the nitrate concentrations from S1 and S3, and the TN concentration in the duplicate sample from S4 exceeded guiding values. The chlorophyll-a concentration from S4 also exceeded the guiding value. Blue-green algae were recorded from all sites, but in very low numbers. The blue-green algae detected were from the genera *Psuedanabeana* and *Geitlerinema*.

All other results complied with guiding values with the exception of the enterococcus concentrations at S4 and S5 and the pH value from S5. Low pH recorded at S5 is typical in times of exceptionally high rainfall runoff and elevated faecal indicator organisms are also often associated with rainfall, as animal faeces are washed in from the wider catchment. There were no indications of impacts from the Evans Head sewage treatment plant.

4.2 Other Observations

The entrance to Salty Creek was open and flowing on 9 May 2022 (refer to **Plate 4.1**). Few birds were observed incidentally during the site inspection. The species observed were Pacific Black Duck, White-eyed Duck, Little Pied Cormorant, Little Black Cormorant, Australasian Grebe, Black Swan and Great Egret. A native aquatic plant, hornwort (*Ceratophyllum demersum*), was observed throughout Salty Lagoon in unusually high densities.



Plate 4.1 The open entrance to Salty Creek on 9 May 2022



Plate 4.2 The damaged erosion control structure.



Plate 4.3 The position of the headcut on 15 March 2022



Plate 4.4 The position of the headcut on 9 May 2022 showing a westwards and southwards advance



5. Key Points

1. Levels in Salty Lagoon were relatively high during this reporting period in response to above average rainfall.
2. A moderate number of results from a variety of parameters did not comply with the guiding values.
3. Chlorophyll-a concentrations were low to very low.
4. Blue-green algae were detected for the tenth consecutive reporting period, but at very low levels.
5. Following 6 months of rainfall that greatly exceeded average conditions the erosive headcut has advanced since the measurements on 15 March 2022. The erosion control structure has been damaged and is no longer functional.
6. *In accordance with the project Environmental Response Protocol (GeoLINK 2017b), the risk rating for the Salty Lagoon Response Protocol is uncertain. Adaptive management site visits are recommended for periods of potential head cut progression, with the following triggers:*
 - >50 mm of rainfall with 24 hrs.
 - >200 mm of rainfall within a week.
 - Other high risk events, for example >100 mm of rainfall within 72 hours, significant storm surge, atypically large tides, etc. Due consideration would be given to rainfall intensity and volume, and the Salty Creek entrance status when known as appropriate.



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