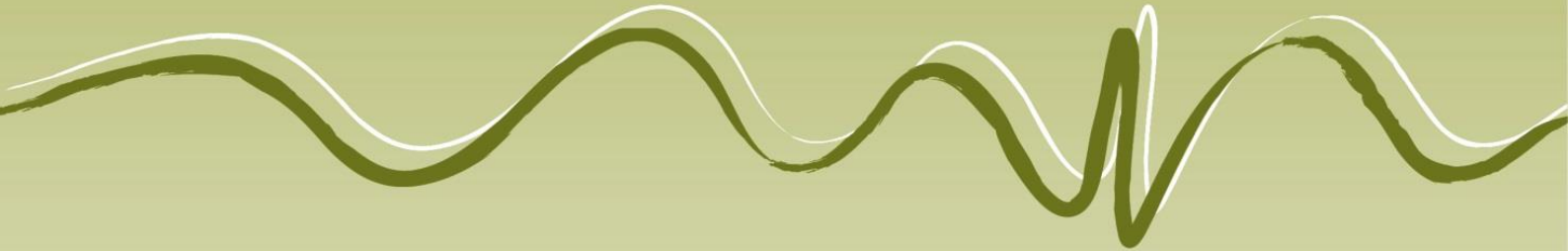


Salty Lagoon

Post Closure Monitoring

Project Management and Ecosystem Health Report

June 2021



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
© GeoLINK, 2021

<i>UPR</i>	<i>Description</i>	<i>Date Issued</i>	<i>Issued By</i>
1731-1340	First issue	23/07/2021	David Andrighetto



Table of Contents

1.	Introduction	1
1.1	Introduction	1
1.2	Guiding Values	1
2.	Methodology	2
2.1	Discrete Sampling	2
2.2	Fixed Point Photo Monitoring	2
2.3	Aquatic Weed Monitoring	2
2.4	Erosion Monitoring	3
2.5	Permanent Water Quality Monitoring Stations	3
3.	Results	6
3.1	Water Quality Samples	6
3.2	Permanent Water Quality Monitoring Stations	6
3.3	Erosion Monitoring Stations	10
4.	Discussion	11
4.1	Water Quality	11
4.2	Other Observations	12
5.	Key Points	13

Illustrations

Illustration 2.1	Water Quality and Erosion Monitoring Site Locations	5
Illustration 3.1	Salty Lagoon Rainfall and Water Quality Monitoring Station Data 1 May 2021 to 30 June 2021	8
Illustration 3.2	Salty Creek Rainfall and Water Quality Monitoring Station Data 1 May 2021 to 30 June 2021	9
Illustration 3.3	Erosion Progression Plotted against Monthly Rainfall since July 2017	10

Plates

Plate 4.1	The open entrance to Salty Creek on 30 June 2021	12
Plate 4.2	Work progressing on the repairs to the erosion control structure	12



Tables

<u>Table 2.1</u>	<u>Locations of Water Quality Sample Sites in Salty Lagoon and Salty Creek (WGS84)</u>	<u>2</u>
<u>Table 2.2</u>	<u>Type and Locations (WGS84) of Erosion Monitoring Sites</u>	<u>3</u>
<u>Table 2.3</u>	<u>YSI Sonde Status on 30 June 2021</u>	<u>4</u>
<u>Table 3.1</u>	<u>Results of Discrete Samples Collected 30 June 2021</u>	<u>7</u>
<u>Table 3.2</u>	<u>Erosion Monitoring Results from 30 June 2021</u>	<u>10</u>



1. Introduction

1.1 Introduction

This document comprises the sixth bi-monthly monitoring report for year 9 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 2021 until 30 June 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 sixth bi-monthly site visit for year 9 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 30 June 2021. Water quality samples were collected between the hours of 7:00 am and 12:00 pm on that day. A low tide of 0.47 metres was forecast for 6.58 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 S1. 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. The autumn 2021 aquatic weed monitoring was undertaken during the site inspection on 30 April 2021.

2.4 Erosion Monitoring

A series of 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 erosion control structure (a spillway) installed by NSW National Parks and Wildlife Service (NPWS) in late 2020 were being undertaken at the time of the site inspection on 30 June 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.

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.

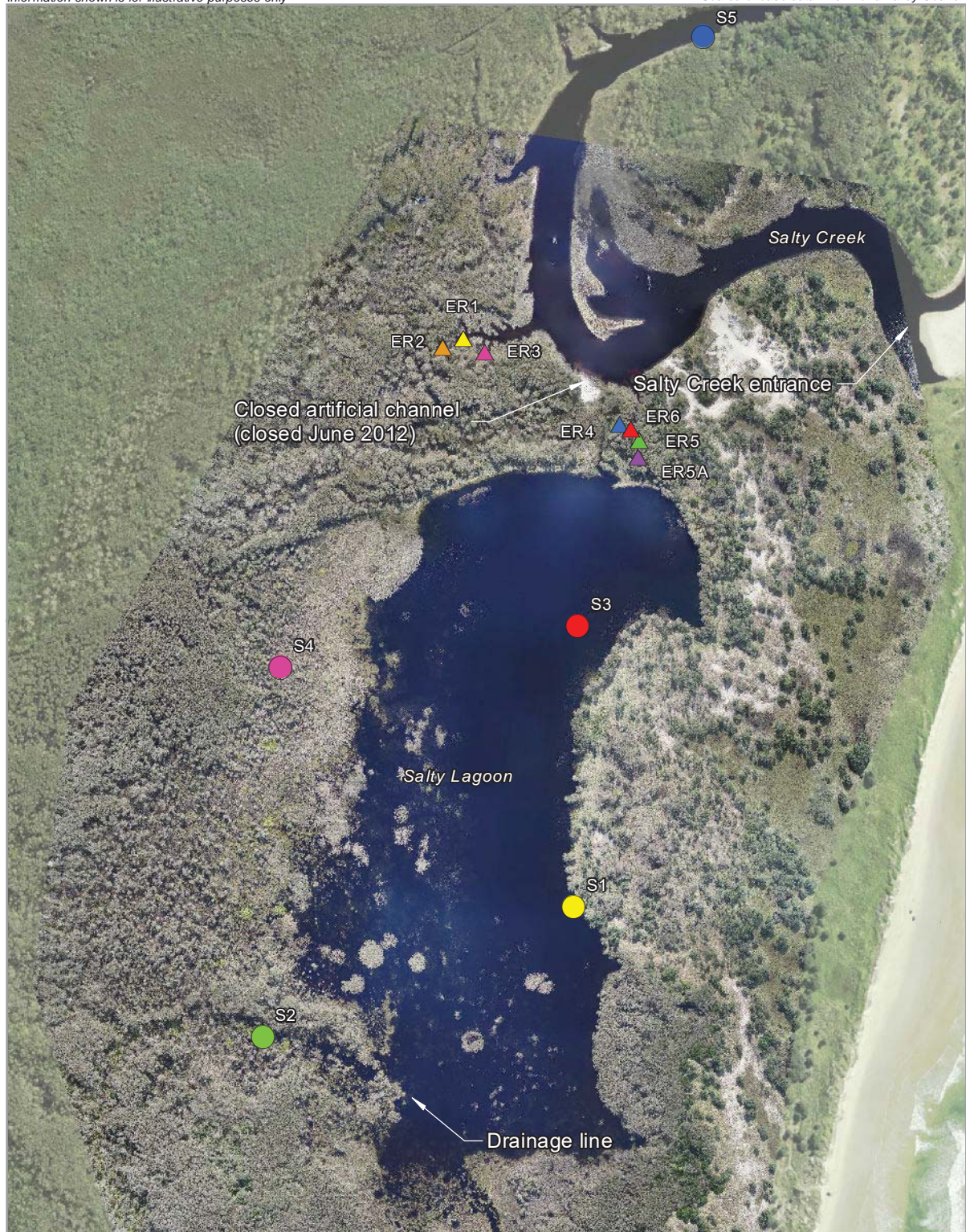
The temperature, pH, conductivity, turbidity and DO sensors on the EXO3 sonde installed at the Salty Lagoon PWQMS were removed on 30 June 2021 and replaced by a serviced and calibrated set.

The status of the two deployed YSI EXO3 sondes on 30 June 2021 is displayed in **Table 2.3**.

Table 2.3 YSI Sonde Status on 30 June 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 17H105048 Manufactured 08/2017 New cap 10/2020	EXO pH 17H105049 Manufactured 08/2017 New cap 02/2021
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 24 months)	EXO Optical DO 17H103493 Manufactured 08/2017 New cap 06/2021	EXO Optical DO 17H103494 Manufactured 08/2017 New cap 04/2021	EXO Optical DO 17H103495 Manufactured 08/2017 New cap 03/2021
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 New wiper brush installed 07/2020	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 30/06/2021 - New batteries installed 30/06/2021 	<ul style="list-style-type: none"> - Serviced probes installed in Salty Creek 30/04/2021 - New Batteries installed 30/06/2021 	<ul style="list-style-type: none"> - Awaiting service and calibration. - Probes Removed from Salty Lagoon 30/06/2021
Notes	<ul style="list-style-type: none"> - 218 days estimated battery life - Memory cleared – 47861 days logging available 	<ul style="list-style-type: none"> - 218 days estimated battery life - Memory cleared – 50045.3 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).



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 30 June 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 30 June 2021

Parameter	Salty Lagoon								Salty Creek		
	Guiding Value	S1	S1 (1m)	S1 (QA)*	S2	S3	S3 (1m)	S4	Guiding Value	S5	S5 (1m)
Blue Green Algae ID (cells/mL)	0	nil	ns	<1000	<100	nil	ns	nil	0	nil	ns
Nitrite Nitrogen (mg/L)	0.01	<0.010	ns	<0.010	<0.010	<0.010	ns	<0.010	0.01	<0.010	ns
Nitrate Nitrogen (mg/L)	0.01	0.045	ns	0.044	<0.010	0.048	ns	<0.010	0.01	<0.010	ns
Oxidized Nitrogen (mg/L)	-	0.047	ns	0.047	<0.010	0.05	ns	<0.010	-	<0.010	ns
Ammonia Nitrogen (mg/L)	0.05	0.015	ns	0.019	0.012	0.011	ns	0.018	0.11	0.01	ns
Total Kjeldahl Nitrogen (mg/L)	1.6	1.16	ns	1.14	0.98	1.12	ns	1.37	1.63	1.18	ns
Total Nitrogen (mg/L)	1.6	1.21	ns	1.19	0.98	1.17	ns	1.37	1.63	1.18	ns
Total Phosphorus(mg/L)	0.14	0.05	ns	0.05	0.05	0.05	ns	<0.03	0.04	<0.03	ns
Orthophosphate (mg/L)	0.11	0.03	ns	0.03	0.037	0.028	ns	<0.010	0.01	<0.010	ns
Chlorophyll-a (µg/L)	5	8	ns	3	<1	7	ns	1	3	<1	ns
Enterococcus (CFU/100mL)	170	70	ns	60	150	50	ns	75	40	120	ns
Faecal Coliforms (CFU/100mL)	135	90	ns	95	35	75	ns	15	150	510	ns
Temp (°C)	25.9	15.2	15.18	ns	13.78	15.63	15.63	14.17	13.1 - 28.8	15.26	18.47
pH	6.9	6.91	6.81	ns	6.3	6.99	6.93	4.83	4.3 - 6.8	5.12	6.18
ORP (mV)	-	216	223	ns	230	172	187	114	-	240	-72
Cond (mS/cm)	8.0	5.21	5.21	ns	0.444	5.34	5.33	3.87	0.3 - 21.5	0.996	44.7
Turbidity (NTU)	13	0.9	1	ns	1.2	1.2	1.2	2	11	1.9	5.4
DO (mg/L)	4.09	9.83	9.54	ns	2.53	10.19	10.6	1.15	5.52	6.15	0.03
DO (% sat)	-	102.7	99.6	ns	25.3	107.5	111.7	11.7	-	63.5	0.4
TDS (mg/L)	-	3.28	3.28	ns	0.288	3.36	3.36	2.47	-	0.638	27.3
Sal (ppt)	-	2.8	2.8	ns	0.2	2.9	2.9	2	-	0.5	28.8
Depth (m)	-	Surface	1	Surface	Surface	Surface	1	Surface	-	Surface	1

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

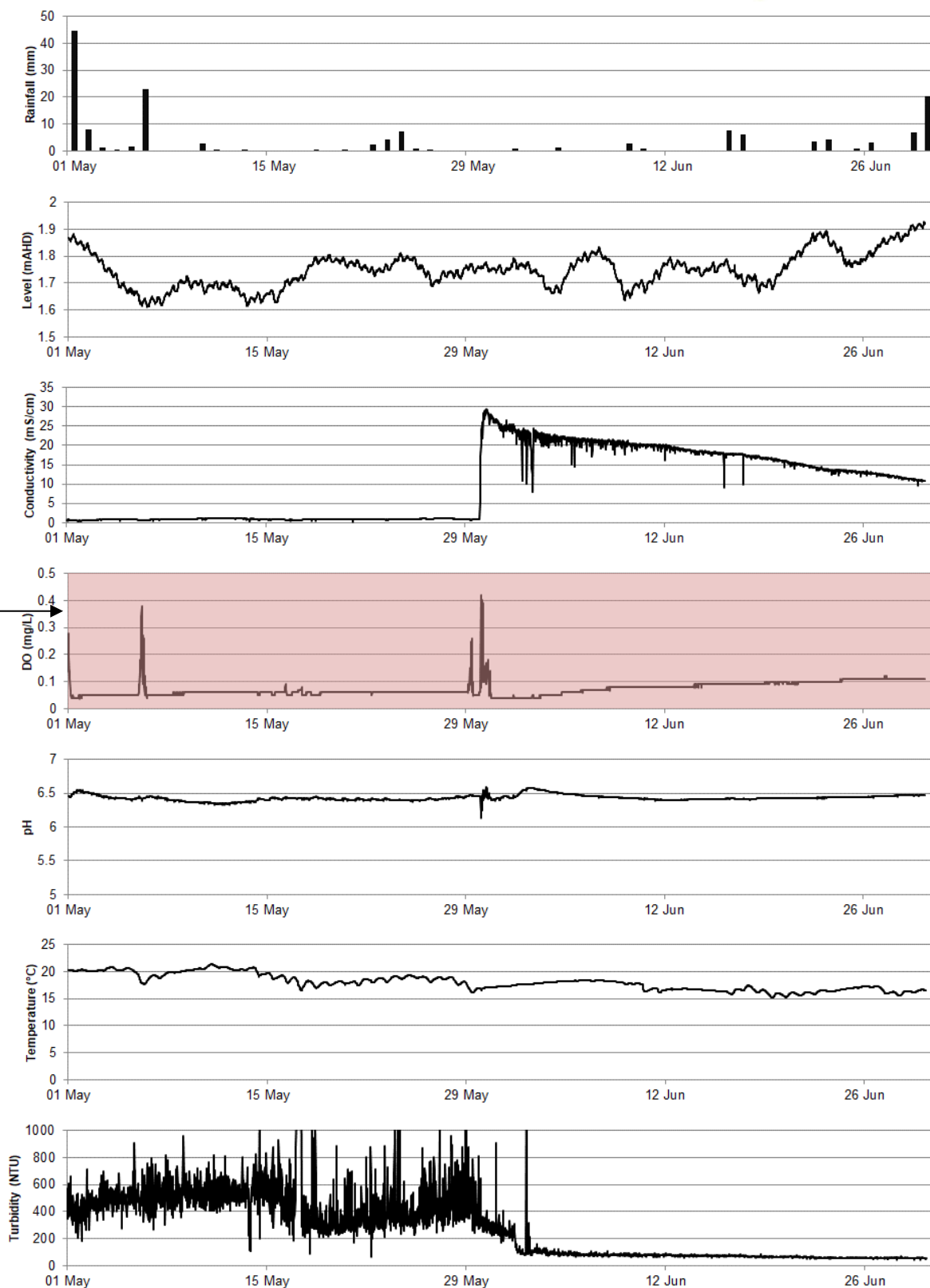


Illustration 3.1 Salty Lagoon Rainfall and Water Quality Monitoring Station Data 1 May 2021 to 30 June 2021

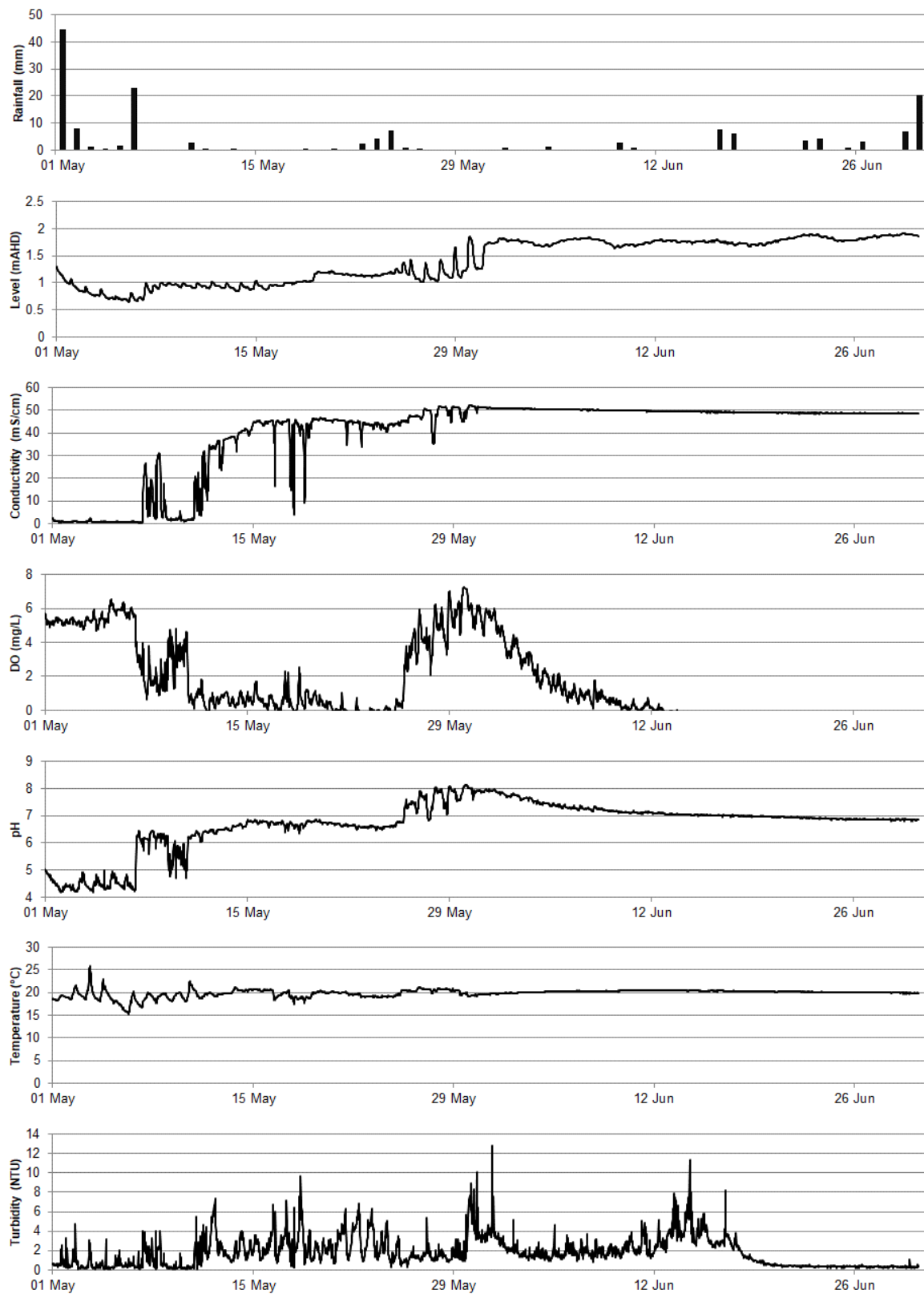


Illustration 3.2 Salty Creek Rainfall and Water Quality Monitoring Station Data 1 May 2021 to 30 June 2021

3.3 Erosion Monitoring Stations

The data collected at the erosion monitoring stations is presented in **Table 3.2** and **Illustration 3.3**. There was no significant advance of the head cut at any station in relation to the previous measurements on 30 April 2021. However, no measurement could be collected at Station ER5a, due to the high level of the water and poor visibility. The head cut has advanced at least 50 m towards Salty Lagoon since the monitoring began in July 2017.

Table 3.2 Erosion Monitoring Results from 30 June 2021

Station	Control/ Impact	Distance 25 July 2017 (m)	Distance 30 June 2021 (m)	Cut Movement (m)
ER1	Control	7.55	7.50	0.05
ER2	Control	10.20	7.70	2.40
ER3	Control	9.95	9.80	0.15
ER4	Impact	8.35	-5.75	14.10
ER5	Impact	12.35	-38.30 (30/4/21)	50.65 (30/4/21)
ER6	Impact	10.40	6.15	4.25

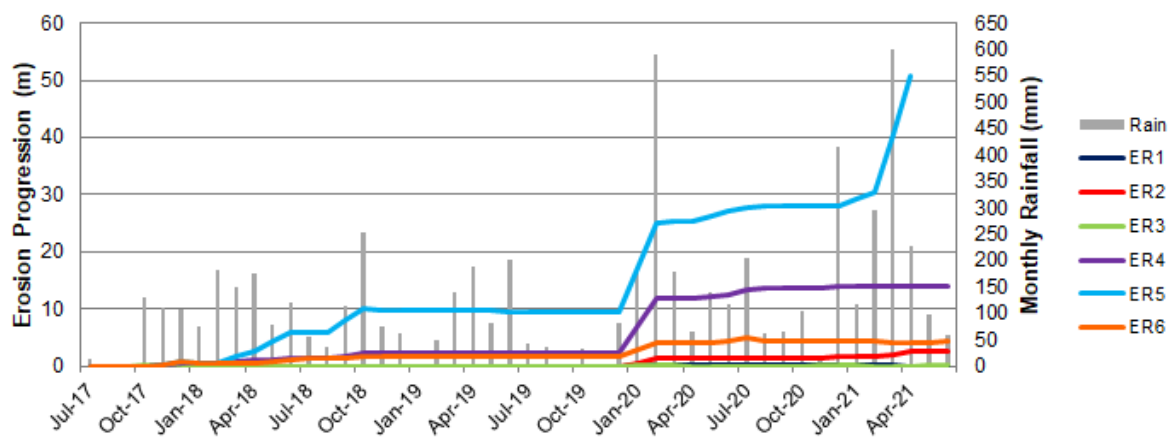


Illustration 3.3 Erosion Progression Plotted against Monthly Rainfall since July 2017



4. Discussion

4.1 Water Quality

Total rainfall for this reporting period comprised of one large event at the start of May 2021 and several small to medium events. The total rainfall for both months of this reporting period was approximately 55 percent of the average amount.

The water level data from the Salty Creek PWQMS indicates that the entrance to Salty Creek was open at the beginning of the reporting period before partially closing and remaining partially closed for the majority of the reporting period, with the exception of the days between 26 May 2021 and 31 May 2021 when spring tides led to seawater ingress and a higher entrance berm. At the time of the site inspection on 30 June 2021, the entrance to Salty Creek was slightly open and flowing out (**Plate 4.1**). The water level in Salty Lagoon remained high throughout most of this reporting period. The water levels and conductivity measurements from the Salty Lagoon PWQMS indicate that saline water from Salty Creek would have flowed into Salty Lagoon when spring tides led to very high levels around 30 May 2021.

The conductivity measured at the Salty Lagoon PWQMS increased dramatically during this reporting period in response to saline water flowing in from Salty Creek on 30 May 2021. The conductivity measurements from the Salty Creek PWQMS show that the water quality in Salty Creek fluctuated mostly in response to seawater ingress. At the time of the site inspection on 30 June 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 30 June 2021 complied with guiding values at all sites except S5, where the measurement from deeper water showed the influence of seawater ingress.

Erosion monitoring was undertaken during this reporting period but was inconclusive with respect to the movement of the head cut towards Salty Lagoon. At the time of the site visit on 30 June 2021 works to repair slumping in the erosion control structure were underway.

The DO concentrations in discrete samples collected on 30 June 2021 were below the guiding values at the two western sites in Salty Lagoon and in deeper water at S5. Low DO concentrations are naturally prevalent at the sites to the west of Salty Lagoon (sites S2 and S4). Discrete measurements and logged data from the Salty Creek PWQMS indicate that DO concentrations were fluctuating in response to shifts in the salinity of the water for the entire monitoring period with low concentrations measured at times of saline water dominance. This is a common pattern in Salty Creek.

Almost all of the nutrient concentrations from samples collected on 30 June 2021 complied with guiding values. The exceptions were the nitrate concentrations from S1 and S3. The chlorophyll-a concentrations at S1 and S3 did not comply with guiding values either and indicated an algal bloom of small proportions. Blue-green algae were recorded from S1 and S2, but in very low concentrations. The blue-green algae detected were from the genera *Lyngbya* and *Aphanocapsa*. *Lyngbya* is a moderately common genus in freshwater systems capable of forming 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 S1 is likely to be a result of saltwater ingress.

All other results complied with guiding values with the exception of the enterococcus and faecal coliform measurements from Salty Creek and the pH measurements from S1 and S3. The high faecal indicator organism measurements from S5 are likely to have been associated with waterbird use of the

area or faecal material from terrestrial animals washed in with rainfall runoff. The higher pH values within the main waterbody at Salty Lagoon is associated with the brackish conditions.

4.2 Other Observations

The entrance to Salty Creek was slightly open on 30 June 2021. A variety of birds were observed incidentally during the site inspection including Pacific Black Duck, Grey Teal, Australasian Grebe, Pelican, Little Pied Cormorant, Little Black Cormorant and Pied Cormorant.



Plate 4.1 The open entrance to Salty Creek on 30 June 2021



Plate 4.2 Work progressing on the repairs to the erosion control structure



5. Key Points

1. Water levels remained relatively high in Salty Lagoon throughout the current monitoring period. Water levels in Salty Creek were variable in response to entrance conditions and seawater ingress.
2. A small number of results did not comply with the guiding values.
3. Nutrient and chlorophyll-a concentrations were similar to the previous report.
4. Blue-green algae were detected for the fifth consecutive reporting period. Concentrations and the number of sites remain low and the taxa represented have varied over time.
5. The status of the erosive headcut is somewhat unknown as a result of difficulty locating it. Repairs to the erosion control structure were ongoing at the time of the site inspection on 30 June 2021 (**Plate 4.2**).
6. The risk rating for the Salty Lagoon Response Protocol is unknown due to the advance of the headcut and the final output of the current remediation works. Adaptive management site visits may be required.



References

- Bureau of Meteorology (2021). <http://www.bom.gov.au/>. Accessed 02/06/2021.
- Entwistle, T., Sonneman, J. and Lewis, S. (1997) *Freshwater Algae in Australia*.
- GeoLINK (2012). *Salty Lagoon Monitoring: Pre-Post Closure of Artificial Channel – Project Management and Ecosystem Health Monthly Report – September 2012*. Report to Richmond Valley Council.
- GeoLINK (2017). *Final Evaluation Report - Salty Lagoon Monitoring: Pre-Post Closure of Artificial Channel – Project Finalisation Report*. Report to Richmond Valley Council.
- Hydrosphere (2010). *Salty Lagoon Monitoring Program Pre/Post Closure of the Artificial Channel*. Unpublished report to Richmond Valley Council. Hydrosphere Consulting, Ballina.



Copyright and Usage

©GeoLINK, 2021

This document, including associated illustrations and drawings, was prepared for the exclusive use of Richmond Valley Council. It is not to be used for any other purpose or by any other person, corporation or organisation without the prior consent of GeoLINK. GeoLINK accepts no responsibility for any loss or damage suffered howsoever arising to any person or corporation who may use or rely on this document for a purpose other than that described above.

This document, including associated illustrations and drawings, may not be reproduced, stored, or transmitted in any form without the prior consent of GeoLINK. This includes extracts of texts or parts of illustrations and drawings.