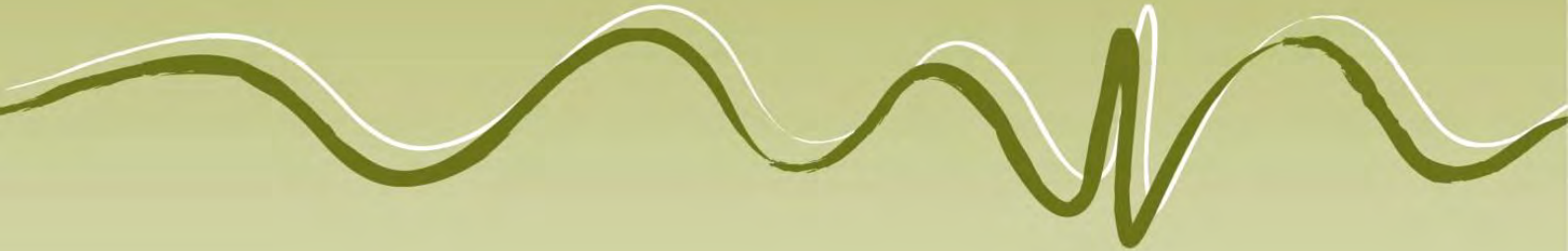


Salty Lagoon Post Closure Monitoring

Project Management and Ecosystem Health Report October 2021



AQUATIC SCIENCE AND MANAGEMENT

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1. Introduction

1.1 Introduction

This document comprises the second 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 September 2021 until 31 October 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 second 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 15 November 2021. Water quality samples were collected between the hours of 7:00 am and 12:00 pm on that day. A high tide of 1.47 metres was forecast for 6.33 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 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	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 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. Weed monitoring was undertaken during the site inspection on 15 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 head-cut 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 Lagoon PWQMS were removed on 15 November 2021 and replaced by a serviced and calibrated set.

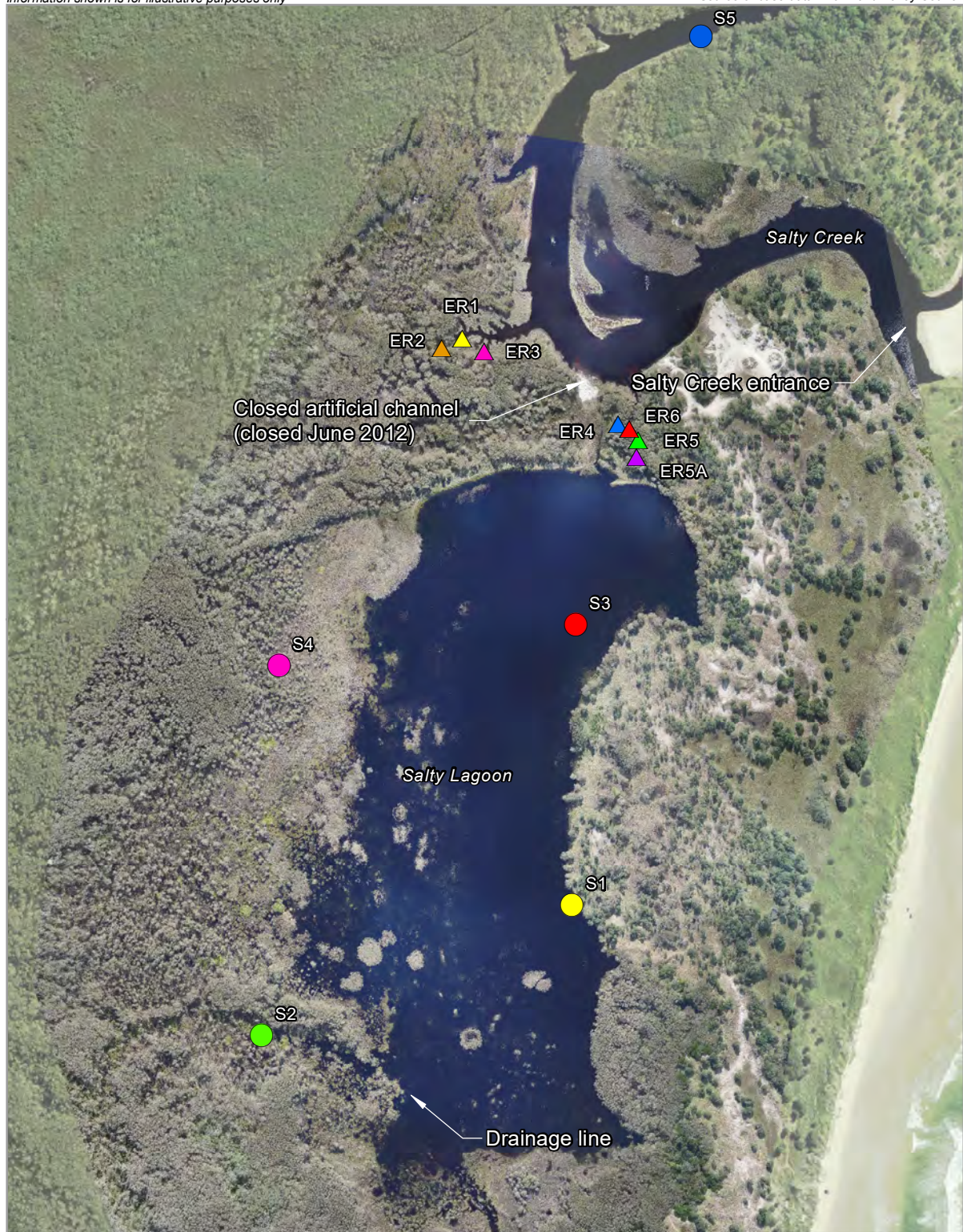
The status of the two deployed YSI EXO3 sondes on 15 November 2021 is displayed in **Table 2.3**.

Table 2.3 YSI Sonde Status on 15 November 2021

Sonde	SN17F104100	SN 17H104488	Spare Probes
pH (cap life expectancy 18 months)	EXO pH 17H105048 Manufactured 08/2017 New cap 10/2020	EXO pH 17H105049 Manufactured 08/2017 New cap 02/2021	EXO pH 17H105047 Manufactured 08/2017 New cap 01/2021
Temp/ cond (life expectancy 7-10 years)	EXO Wiped CT 17F102685 Manufactured 06/2017	EXO Wiped CT 17F103252 Manufactured 06/2017	EXO Wiped CT 17F102047 Manufactured 06/2017
DO (cap life expectancy 24 months)	EXO Optical DO 17H103494 Manufactured 08/2017 New cap 04/2021	EXO Optical DO 17H103495 Manufactured 08/2017 New cap 03/2021	EXO Optical DO 17H103493 Manufactured 08/2017 New cap 06/2021
Turbidity (life expectancy 7-10 years)	YSI EXO Turbidity 17H103513 Manufactured 08/2017	YSI EXO Turbidity 17H101468 Manufactured 08/2017	YSI EXO Turbidity 17H101465 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 15/11/2021 - New batteries installed 15/11/2021 	<ul style="list-style-type: none"> - Serviced probes installed in Salty Creek 12/09/2021 - New Batteries installed 15/11/2021 	<ul style="list-style-type: none"> - Awaiting service and calibration. - Probes Removed from Salty Lagoon 15/11/2021
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 2021). Evans Head Sewage Treatment Plant (STP) facility routine sampling information was provided by Richmond Valley Council (RVC).

Information shown is for illustrative purposes only



LEGEND

Water Quality Site

- S1
- S2
- S3
- S4
- S5

Erosion Monitoring Site

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



Location of Water Quality and Erosion Monitoring Sites





3. Results

3.1 Water Quality Samples

Results of the water quality monitoring undertaken on 15 November 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 15 November 2021

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	<100	nil	ns	nil	>100000	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	0.018	ns	0.023	<0.010	ns	<0.010	<0.010	0.11	0.018	ns
Total Kjeldahl Nitrogen (mg/L)	1.6	1.3	ns	1.24	1.22	ns	1.24	1.98	1.63	1.04	ns
Total Nitrogen (mg/L)	1.6	1.3	ns	1.24	1.22	ns	1.24	1.98	1.63	1.04	ns
Total Phosphorus(mg/L)	0.14	<0.03	ns	0.07	<0.03	ns	0.04	0.06	0.04	<0.03	ns
Orthophosphate (mg/L)	0.11	<0.010	ns	0.05	<0.010	ns	0.017	0.016	0.01	<0.010	ns
Chlorophyll-a (µg/L)	5	2	ns	<1	5	ns	2	54	3	2	ns
Enterococcus (CFU/100mL)	170	<5	ns	60	5	ns	5	250	40	<5	ns
Faecal Coliforms (CFU/100mL)	135	6	ns	40	4	ns	10	<2	150	18	ns
Temp (°C)	25.9	20.86	20.86	19.76	23.61	23.5	ns	20.57	13.1 - 28.8	25.1	23.66
pH	6.9	6.64	6.63	6.08	6.7	6.69	ns	4.88	4.3 - 6.8	6.55	6.53
ORP (mV)	-	241	220	16	170	173	ns	215	-	156	157
Cond (mS/cm)	8.0	3.14	3.14	0.598	3.16	3.16	ns	4.6	0.3 - 21.5	9.69	27.3
Turbidity (NTU)	13	0.6	2.5	5	1.2	1.7	ns	1.7	11	0.1	0
DO (mg/L)	4.09	9.97	10.26	0.71	7.25	6.83	ns	2.5	5.52	6.8	4.11
DO (% sat)	-	115.5	118.9	8	88.1	82.8	ns	28.9	-	86.5	54.4
TDS (mg/L)	-	2.01	2.01	0.382	2.02	2.02	ns	2.94	-	6.1	17
Sal (ppt)	-	1.6	1.6	0.3	1.6	1.6	ns	2.5	-	5.4	16.7
Depth (m)	-	Surface	1	Surface	Surface	1	Surface	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

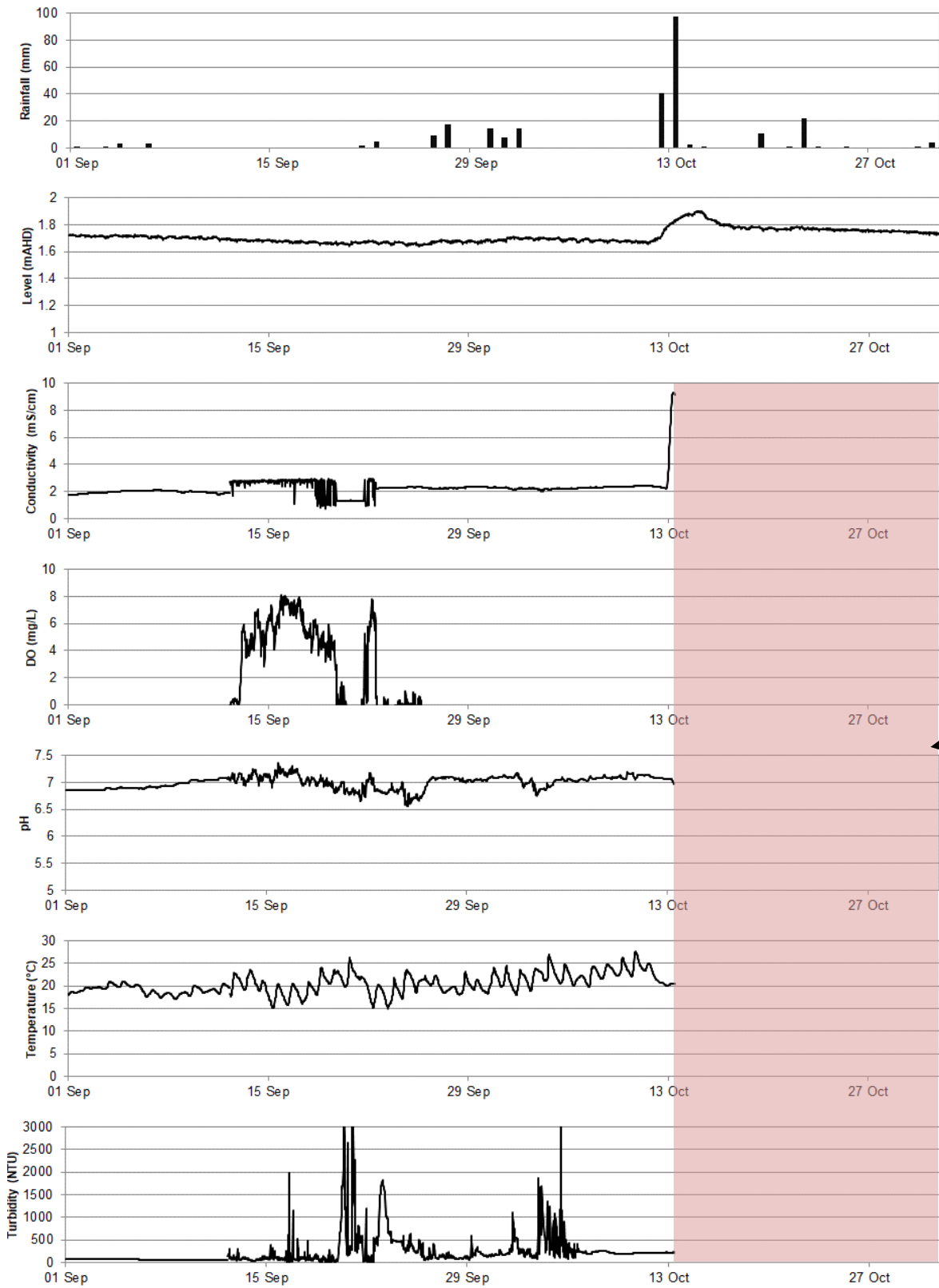


Illustration 3-1 Salty Lagoon Rainfall and Water Quality Monitoring Station Data 1 September 2021 to 31 October 2021

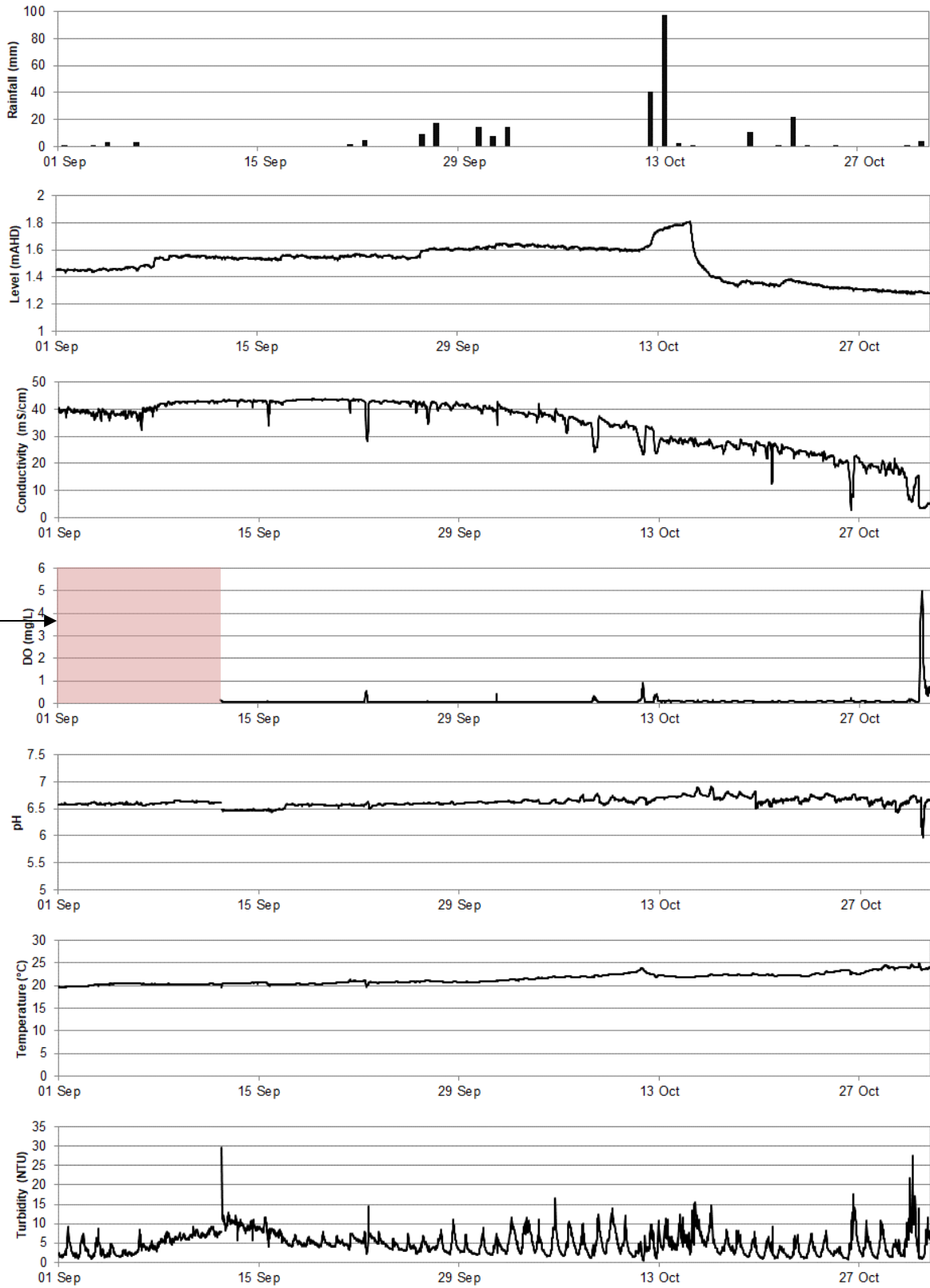


Illustration 3-2 Salty Creek Rainfall and Water Quality Monitoring Station Data 1 September 2021 to 31 October 2021

3.3 Aquatic Weed Monitoring

No significant aquatic weeds were identified during the aquatic weed survey on 15 November 2021. The next survey is due in January 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 no significant advance of the head-cut at ER5 in relation to the previous measurements on 12 September 2021. The results reported in the previous bi-monthly report from ER5 were erroneous, and appear to have been based on an observational error. 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 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	-38.4	50.75
ER6	Impact	10.40	6.15	4.25

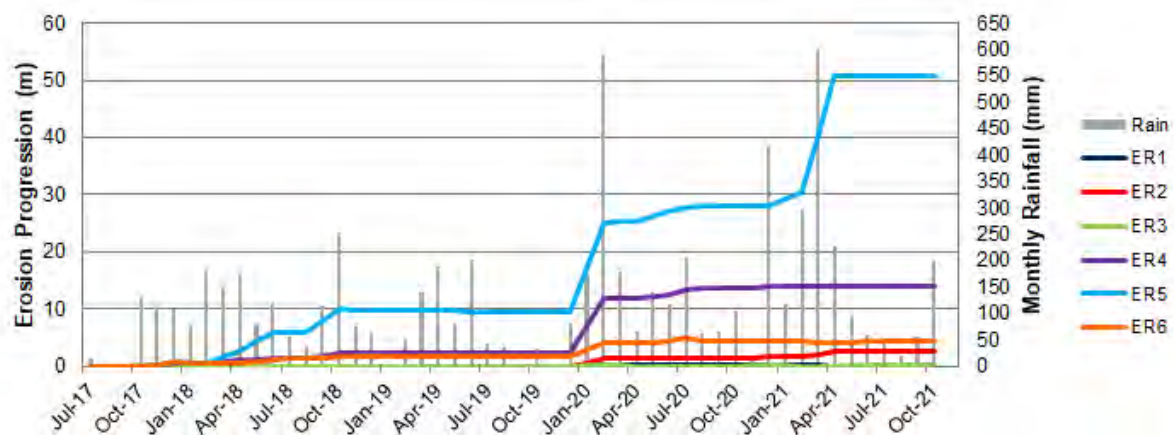


Illustration 3-3 Erosion Progression Plotted against Monthly Rainfall since July 2017



4. Discussion

4.1 Water Quality

Rainfall for this reporting period comprised of several small to medium events and one large event that occurred on 12-13 October 2021. The total rainfall for this reporting period was approximately 170 percent of the average amount.

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 and remained closed until 15 October 2021 when it opened in response to a large rainfall event and water levels in Salty Creek became very low. The entrance to Salty Creek appeared to have remained slightly open until the end of the reporting period but was closed again by the time of the site inspection on 15 November 2021 (**Plate**). The water levels in Salty Lagoon remained relatively constant at approximately 1.7 mAHD before increasing in response to heavy rainfall and draining to approximately 1.7 mAHD again by the end of the reporting period.

The conductivity measured at the Salty Lagoon PWQMS increased overall during this reporting period, probably mostly in response to saline water inflow from Salty Creek at the time of the heavy rainfall event on 12 – 13 October 2021. The conductivity measurements from the Salty Lagoon PWQMS show a significant and rapid increase at that time before a probe error occurred immediately afterwards. The conductivity measurements from the Salty Creek PWQMS show a steady and continual decrease over most of the reporting period indicating that saline water was gradually replaced with freshwater from the catchment. However, at the time of the site inspection on 15 November 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 more saline, heavier bottom layer, indicating that further seawater ingress may have occurred after 31 October 2021. The conductivity measurements collected on 15 November 2021 complied with guiding values at all sites except S5, where the sample collected from deeper water indicated the conductivity had increased in response to seawater ingress.

The DO concentrations in discrete samples collected on 15 November 2021 were below the guiding values at the two western sites in Salty Lagoon (sites S2 and S4) and in deeper water at S5. Low DO concentrations are naturally prevalent at the sites to the west of Salty Lagoon. The low DO concentration in deeper water at S5 is further indication of stratification resulting from low mixing of seawater and freshwater runoff. Logged data from the Salty Lagoon PWQMS indicates that the DO concentrations at the bottom of the water column in Salty Lagoon only increased in response to strong mixing and remained low at other times. Logged data from the Salty Creek PWQMS indicates that the DO concentration at the bottom of the water column in Salty Creek remained low for the entire reporting period.

Almost all of the nutrient concentrations from samples collected on 15 November 2021 complied with guiding values. The exception, for the second consecutive bi-monthly sampling event, was the TN concentration from S4. Similarly, all of the chlorophyll-a concentrations from samples collected on 15 November 2021 complied with the guiding values, with the exception of the sample from S4, where the chlorophyll-a concentration indicated an algal bloom of very large proportions.

Blue-green algae were recorded from S2 and S4. At S2 the concentrations were very low but at S4 they were very high. The blue-green algae detected at S2 were from the genera and *Lyngyba* and *Synechoccus*. Some species of *Lyngyba* are known to form toxic blooms but this is not the case for

Synechococcus. At S4 a bloom of *Microcystis sp.* was detected with concentrations indicating an algal bloom of concern. Some species of *Microcystis* are known to form toxic blooms in freshwaters. The concentrations of *Microcystis sp.* in the sample from S4 would require an alert of NSW water if the area was used for recreational purposes. However, the area around S4 is not used for recreational purposes and no blue-green algae were detected from the open water of Salty Lagoon or Salty Creek, so no official notification is required (Water NSW, undated).

All other results complied with guiding values with the exception of the enterococcus measurement from S4. The elevated enterococcus concentration at S4 is likely to be associated with natural processes, such as waterbird use of the area or rainfall runoff carrying animal faecal material into the waterbody.

Erosion monitoring showed no further movement of the primary head-cut towards Salty Lagoon since the previous measurements taken on 12 September 2021. The results also indicate that the previous measurement was erroneous. The erosion progression chart displayed in **Illustration 3-3** contains rectified data.

4.2 Other Observations

The entrance to Salty Creek was closed on 15 November 2021 (**Plate 4-1**). A variety of birds were observed incidentally during the site inspection including Pacific Black Duck, Chestnut Teal, Black Swan, Little Pied Cormorant, Little Black Cormorant, Pied Cormorant, Great Cormorant and Royal Spoonbill. There was a bloom of *Azolla fimbriatilis* at S2 that covered the entire pool (**Plate 4-2**). Such blooms have occurred irregularly between October and December throughout the years of monitoring at Salty Lagoon.



Plate 4-1 The closed entrance to Salty Creek on 15 November 2021



Plate 4-2 The pool at S2 was completely covered in Azolla on 15 November 2021



5. Key Points

1. Levels in Salty Lagoon generally fluctuated around a level of approximately 1.7 mAHD during this reporting period.
2. A small number of results did not comply with the guiding values.
3. Chlorophyll-a concentrations were high at S4, along with total nutrient concentrations, but relatively low at the other sites.
4. Blue-green algae were detected for the seventh consecutive reporting period. The concentration at S4 of *Microcystis sp.* indicated a bloom of very large proportions. However, because the site is unlikely to be used for recreational purposes and no blooms were detected elsewhere, notification of Water NSW is not required.
5. The erosive head-cut has not advanced since the previous measurements on 12 September 2021. The results presented in the previous bi-monthly report were erroneous as a result of an observational error.
6. The risk rating for the Salty Lagoon Response Protocol is unknown due to the advance of the head-cut and the algal bloom detected at S4. Adaptive management site visits may be required.



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