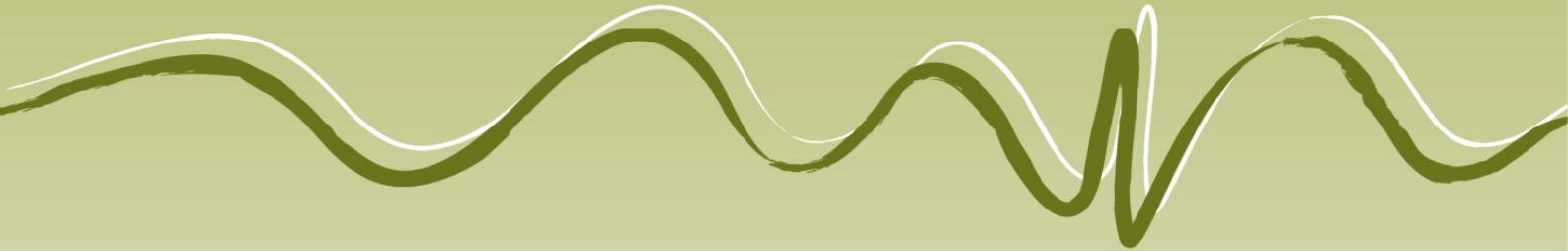


Salty Lagoon

Post Closure Monitoring

Project Management and Ecosystem Health Report

April 2020



AQUATIC SCIENCE AND MANAGEMENT

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1. Introduction

1.1 Introduction

This document comprises the fifth 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 March 2020 until 30 April 2020.

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 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 4 May 2020. Water quality samples were collected between the hours of 8:30 am and 12:00 am on that day. A low tide of 0.35 metres was forecast for 11.43 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 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	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 handheld 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. Maps of the monitoring meander and detailed data are provided in the annual reports. Aquatic weed monitoring for the 2019 – 2020 autumn period was completed on-foot during the site visit on 4 May 2020.

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. 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
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.

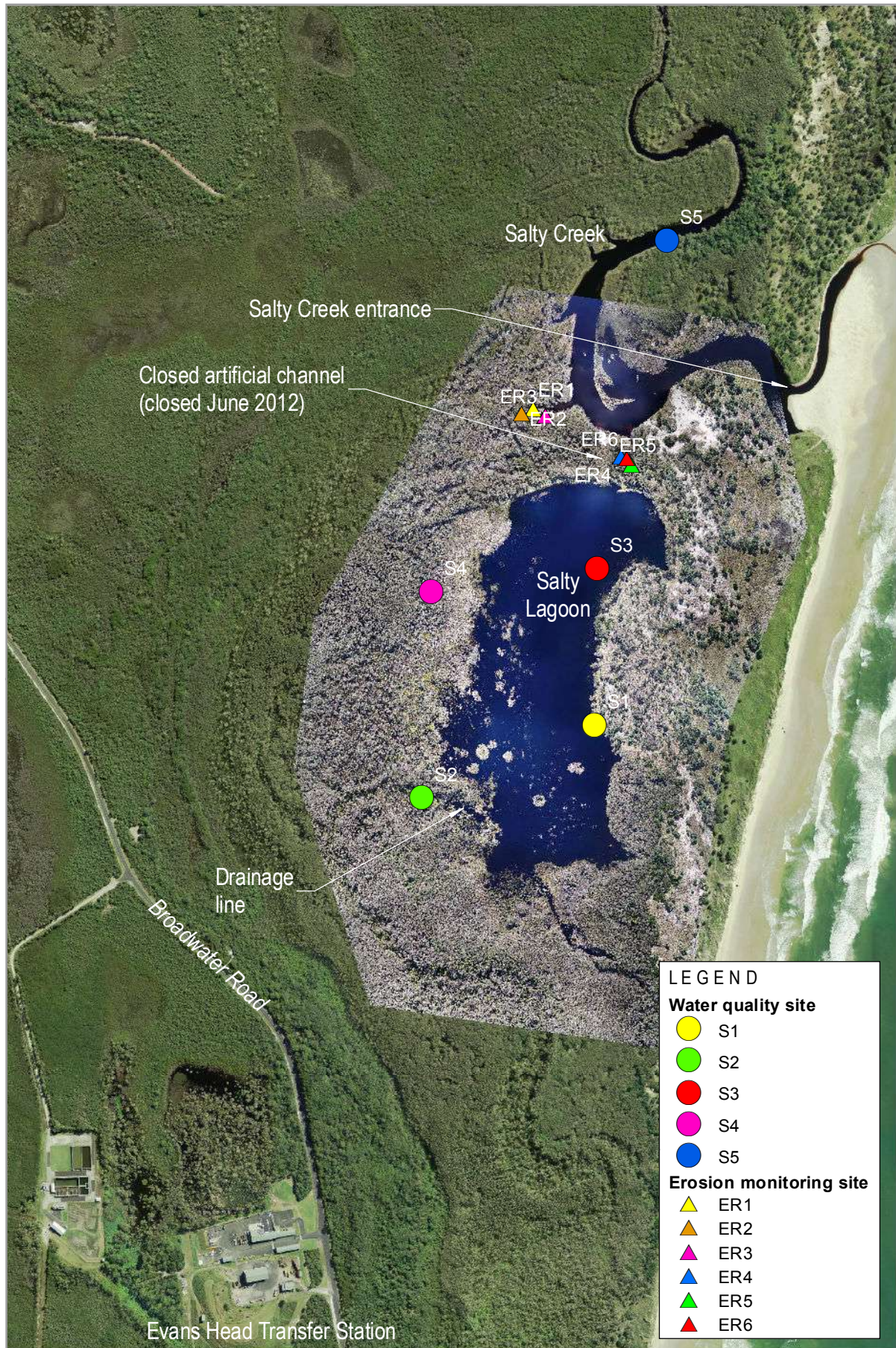
The temperature, pH, conductivity, turbidity and DO sensors on the EXO3 sonde installed at the Salty Creek PWQMS were removed on 4 May 2020 and replaced by a serviced and calibrated set.

The status of the two deployed YSI EXO3 sondes on 4 May 2020 is displayed in **Table 2.3**.

Table 2.3 YSI Sonde Status on 4 May 2020

Sonde	SN17F104100	SN 17H104488	Spare Probes
pH (cap life expectancy 18 months)	EXO pH 17H105048 Manufactured 08/2017 New cap 03/2019	EXO pH 17H105049 Manufactured 08/2017 New cap 03/2019	EXO pH 17H105047 Manufactured 08/2017 New cap 05/2019
Temp/ cond (life expectancy 7-10 years)	EXO Wiped CT 17F103252 Manufactured 06/2017	EXO Wiped CT 17F102685 Manufactured 06/2017	EXO Wiped CT 17F102047 Manufactured 06/2017
DO (cap life expectancy 18 months)	EXO Optical DO 17H103495 Manufactured 08/2017 New cap 03/2019	EXO Optical DO 17H103494 Manufactured 08/2017 New cap 03/2019	EXO Optical DO 17H103493 Manufactured 08/2017 New cap 05/2019
Turbidity (life expectancy 7-10 years)	YSI EXO Turbidity 17H101468 Manufactured 08/2017	YSI EXO Turbidity 17H103513 Manufactured 08/2017	YSI EXO Turbidity 17H101465 Manufactured 08/2017
Wiper	YSI Exo Wiper 17G101952	YSI Exo Wiper 17G101954 New wiper brush installed 03/2020	No Spare Wiper
Status	Serviced probes installed in Salty Lagoon 4/03/2020 Sonde repaired under warranty 04/2019 New batteries installed 22/01/2020	Serviced probes installed in Salty Creek 04/05/2020 New Batteries installed 04/03/2020	Awaiting service and calibration.
Notes	<ul style="list-style-type: none"> – 180 days estimated battery life – Memory cleared – 50045.3 days logging available 	<ul style="list-style-type: none"> – 218 days estimated battery life – Memory cleared – 50045.3 days logging available 	<ul style="list-style-type: none"> – Probes Removed from Salty Creek 4/05/2020

Climate information was sourced from the Evans Head bombing range weather station on the Bureau of Meteorology website (BOM 2020). Evans Head Sewage Treatment Plant (STP) facility routine sampling information was provided by Richmond Valley Council (RVC).



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GeoLINK
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Water Quality and Erosion Monitoring Site Locations

Salty Lagoon Project Management & Ecosystem Health Report, April 2020
1731-1297

Illustration 2.1



3. Results

3.1 Water Quality Samples

Results of the water quality monitoring undertaken on 4 May 2020 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 4 May 2020

Parameter	Salty Lagoon							Salty Creek	
	Guiding Value	S1	S1 (1m)	S2	S3	S4	S4 (QA)*	Guiding Value	S5
Blue Green Algae ID (cells/mL)	0	Nil	ns	Nil	Nil	Nil	Nil	0	Nil
Nitrite Nitrogen (mg/L)	0.01	<0.010	ns	<0.010	<0.010	<0.010	<0.010	0.01	<0.010
Nitrate Nitrogen (mg/L)	0.01	0.062	ns	<0.010	0.056	<0.010	<0.010	0.01	<0.010
Oxidized Nitrogen (mg/L)	-	0.062	ns	<0.010	0.056	<0.010	<0.010	-	<0.010
Ammonia Nitrogen (mg/L)	0.05	0.018	ns	0.063	0.021	0.074	0.046	0.11	<0.010
Total Kjeldahl Nitrogen (mg/L)	1.6	2.01	ns	1.55	2.17	1.67	1.59	1.63	1.34
Total Nitrogen (mg/L)	1.6	2.07	ns	1.55	2.23	1.67	1.59	1.63	1.34
Total Phosphorus(mg/L)	0.14	0.17	ns	0.06	0.23	<0.03	<0.03	0.04	0.04
Orthophosphate (mg/L)	0.11	0.11	ns	0.038	0.11	<0.010	<0.010	0.01	<0.010
Chlorophyll-a (µg/L)	5	21	ns	2	21	13	7	3	19
Enterococcus (CFU/100mL)	170	20	ns	25	25	105	110	40	50
Faecal Coliforms (CFU/100mL)	135	5	ns	<5	10	<5	<5	150	225
Temp (°C)	25.9	16.07	15.93	13.54	16.07	13.3	ns	13.1 - 28.8	20.11
pH	6.9	7.08	7.01	6.23	6.99	5.44	ns	4.3 - 6.8	6.51
ORP (mV)	-	241	239	242	244	260	ns	-	241
Cond (mS/cm)	8.0	2.27	2.27	0.71	2.26	2.31	ns	0.3 - 21.5	8.06
Turbidity (NTU)	13	3.4	4.9	0	3.4	0	ns	11	2.7
DO (mg/L)	4.09	7.93	7.73	1.12	7.15	3.3	ns	5.52	8.21
DO (% sat)	-	83.6	81.2	11.1	75.4	32.8	ns	-	95.3
TDS (mg/L)	-	1.45	1.45	0.455	1.45	1.48	ns	-	5.08
Sal (ppt)	-	1.2	1.2	0.3	1.2	1.2	ns	-	4.5
Depth (m)	-	Surface	1	Surface	Surface	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

TNTC = too numerous to count

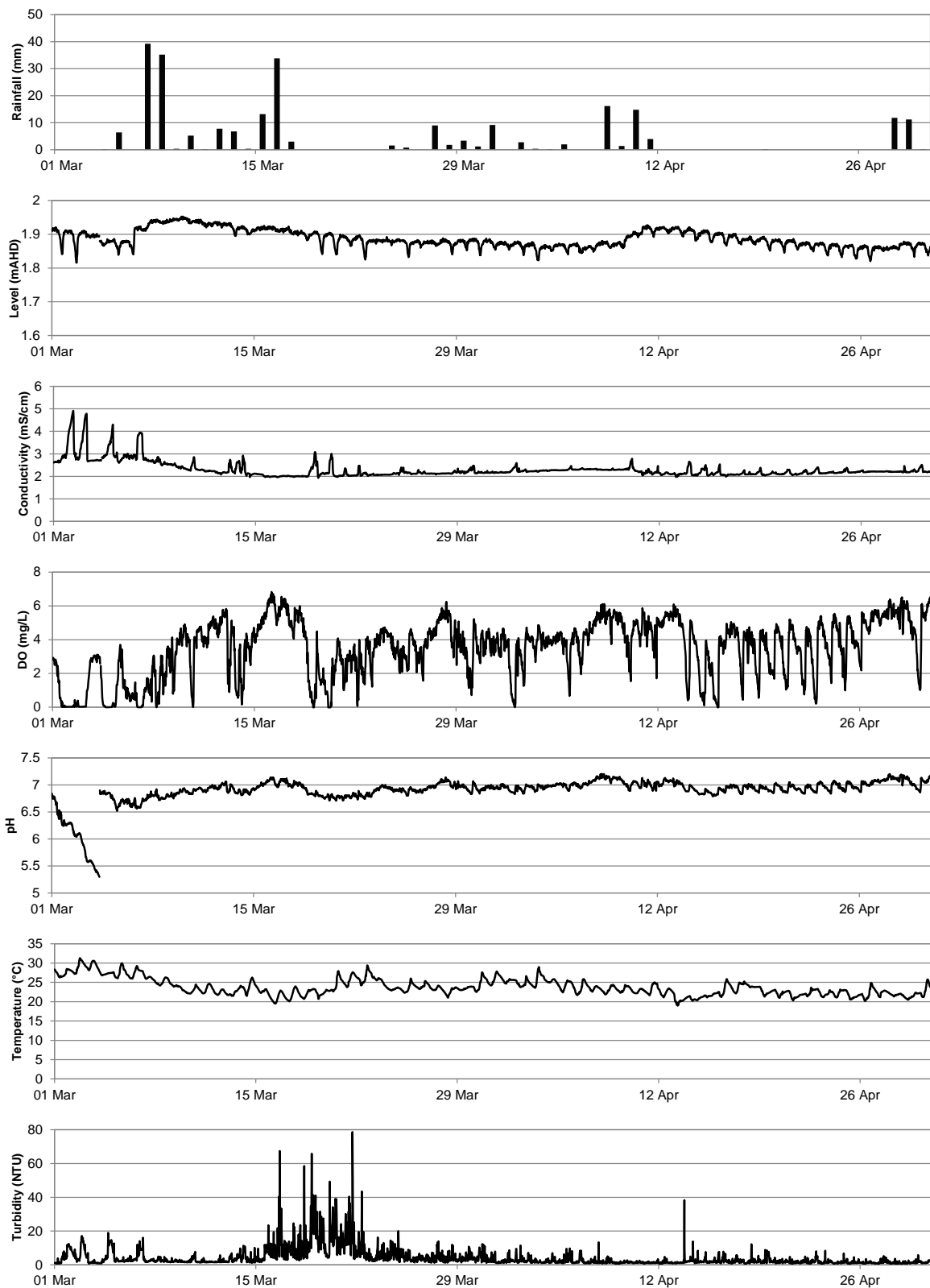


Illustration 3.1 Salty Lagoon Rainfall and Water Quality Monitoring Station Data 1 March 2020 to 30 April 2020

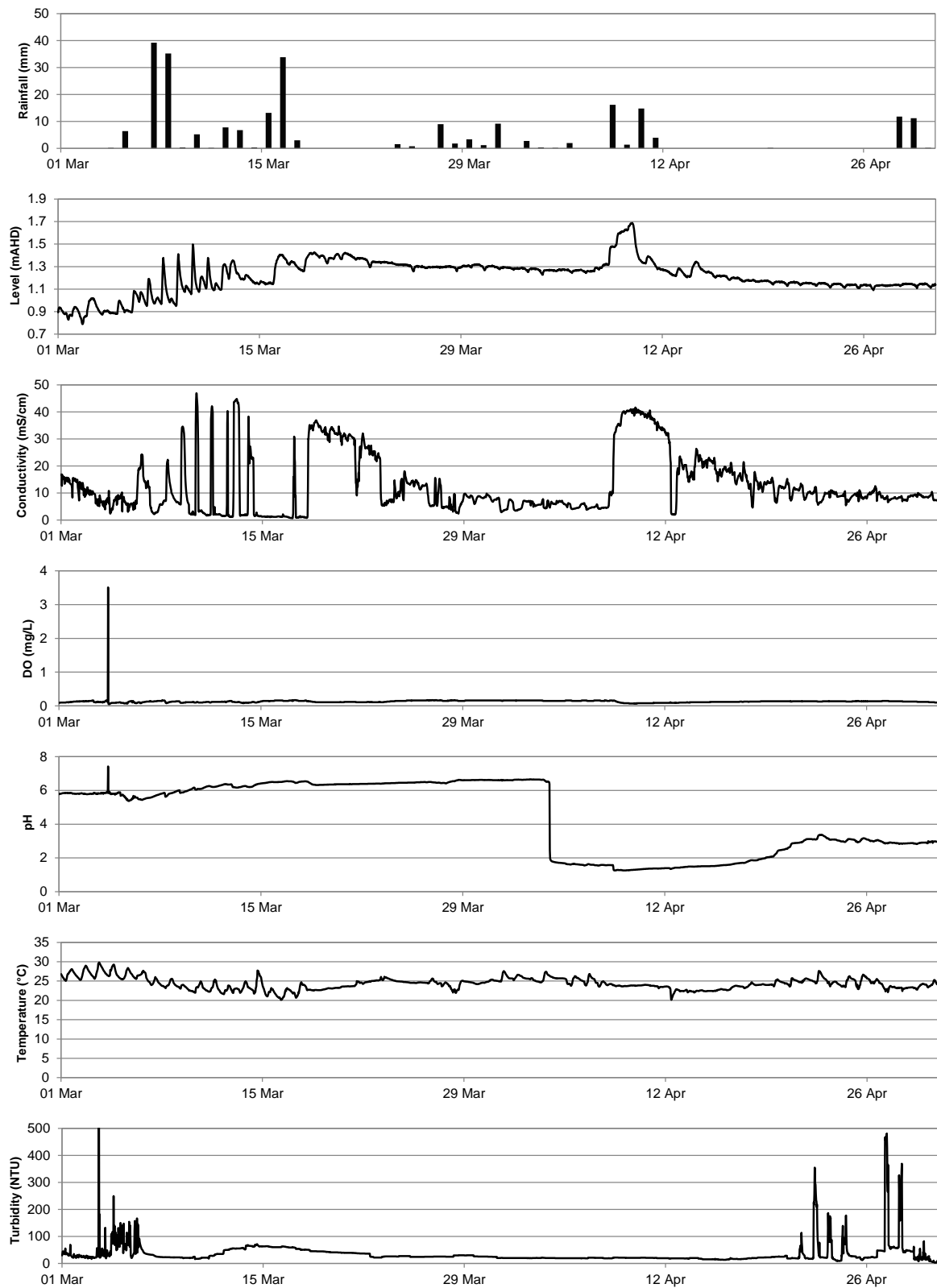


Illustration 3.2 Salty Creek Rainfall and Water Quality Monitoring Station Data 1 March 2020 to 30 April 2020

3.3 Aquatic Weed Monitoring

No significant aquatic weeds were identified during the aquatic weed survey on 4 May 2020.

3.4 Erosion Monitoring Stations

The data collected at the erosion monitoring stations is presented in **Table 3.2**. There was a small advance of the head cuts at two of the three impact stations in relation to the previous measurements on 4 March 2020. The head cut has advanced at least 25 m towards Salty Lagoon since the monitoring began in July 2017.

Table 3.2 Erosion Monitoring Results from 4 May 2020

Station	Control/ Impact	Distance 25 July 2017 (m)	Distance 4 May 2020 (m)	Cut Movement (m)
ER1	Control	7.55	7.35	0.20
ER2	Control	10.20	8.90	1.30
ER3	Control	9.95	9.90	0.05
ER4	Impact	8.35	-3.50	11.85
ER5	Impact	12.35	-13.10	25.45
ER6	Impact	10.40	6.20	4.20



4. Discussion

4.1 Water Quality

Total rainfall for this reporting period was below average. However, rain fell throughout the reporting period in a variety of small and medium sized events. The conductivity and level data from the Salty Creek PWQMS indicate that the entrance to Salty Creek was open and tidal for the first two weeks of the reporting period but that it was substantially constricted from then onwards, with the exception of a short period following seawater ingress on 9 April 2020. The water level in Salty Creek increased over the course of the reporting period, having started at very low levels. At the time of the site inspection on 4 May 2020, the status of the entrance to Salty Creek was unknown, due to restricted access to Airforce Beach. The water level in Salty Lagoon remained relatively high throughout this monitoring period. The key factors causing variation in the water levels of Salty Lagoon during this reporting period appear to have been rainfall, runoff to Salty Creek and daily temperature fluctuations. Aside from the response to rainfall, daily water level fluctuations of more than 5 cm were measured in Salty Lagoon and Salty Creek on the hottest days when water temperatures were fluctuating by as much as 10 °C. It is likely that the dark tannin staining and large surface area to depth ratio of the water contributes to these fluctuations through expansion and contraction but also that they may reflect groundwater fluctuations in response to evapotranspiration.

The conductivities measured at the Salty Lagoon and Salty Creek PWQMS both decreased over the course of the monitoring period, indicating that dilution by rainfall runoff was a major factor driving water quality. However, the conductivity measurements at the Salty Creek PWQMS did reach very high levels during times when tidal movements were registered and during two seawater ingress events. At the time of the site inspection on 4 May 2020 the water in Salty Lagoon and Salty Creek was brackish. The conductivity measurements collected on 4 May 2020 complied with guiding values at all sites.

Erosion monitoring indicated that the head cut advanced slightly during this reporting period at two of the three impact sites. This was in response to sustained low level runoff from Salty Lagoon into Salty Creek. There was no advance of the head cuts at the control sites. The head cut is now approximately 20 m from the current banks of Salty Lagoon. If it reaches Salty Lagoon, the channel formed is highly likely to increase in size when tidal movements occur and some of the conditions that previously led to fish kills will be restored.

The DO concentrations in discrete samples collected on 4 May 2020 were below the guiding values at the two westernmost sites in Salty Lagoon. The DO concentrations measured at the other sites were healthy. Low DO concentrations are naturally prevalent at the sites to the west of Salty Lagoon (sites S2 and S4). The data from the Salty Lagoon PWQMS indicates that the DO concentrations in Salty Lagoon were mostly healthy during this reporting period but that diurnal fluctuations were strong during the periods of no rainfall. The data from the Salty Creek indicate that low DO concentrations persisted at the bottom of the water column for the entire monitoring period. This may have been a response to the regular changes in conductivity resulting from changes to the status of the entrance and seawater ingress. Historically, similar changes have led to low DO conditions.

Most of the nutrient concentrations in samples collected on 4 May 2020 complied with guiding values. The exceptions were the TN, TP, nitrate and orthophosphate concentrations from S1 and S3, ammonia concentrations from S2 and S4 and TN concentration from S4. The TN and TP concentrations from most sites were reduced from the previous samples collected on 4 March 2020

(Illustrations 4.1 and 4.2). It is likely that dilution from rainfall resulted in lower nutrient concentrations, in the same way it resulted in lower conductivity measurements. Chlorophyll-a concentrations did not comply with guiding values at S1, S3, S4 or S5. At S1, S3 and S5 they indicated an algal bloom of moderate proportions and at S4 an algal bloom of small proportions. There were no blue-green algae detected in any samples.

A small number of other results did not comply with guiding values, including

- The pH measurements from S1 and S3, where pH measurements very slightly exceeded the guiding value.
- The enterococcus and faecal coliform concentrations at S5, probably related to bird use of the area.

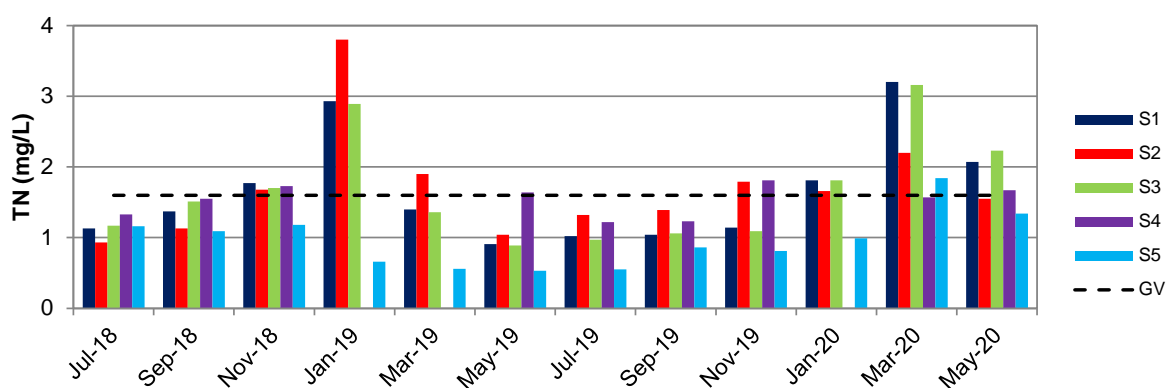


Illustration 4.1 TN concentration at all sites since July 2018, plotted against the Salty Lagoon guiding value

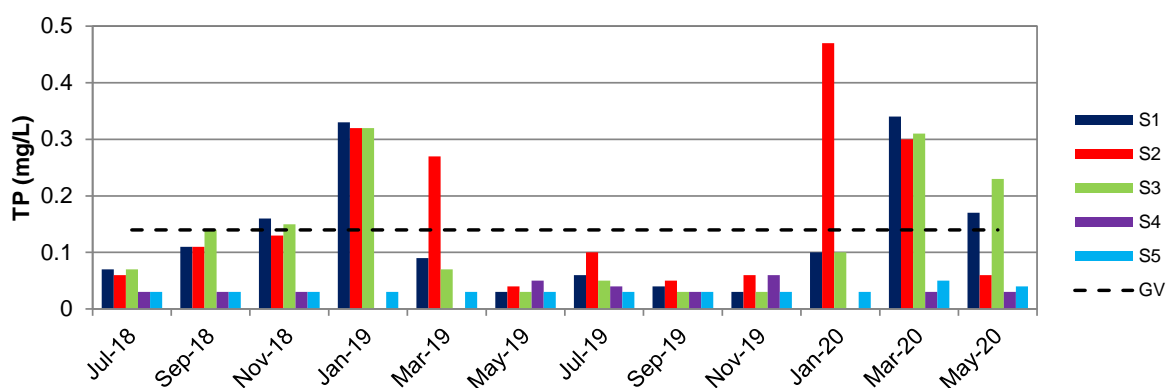


Illustration 4.2 TP concentration at all sites since July 2018, plotted against the Salty Lagoon guiding value

4.2 Other Observations

The entrance to Salty Creek was not observed on 4 May 2020. A variety of birds were observed incidentally during the site inspection including Pacific Black Duck, Chestnut Teal, Black Swan, Pied Cormorant, Little Black Cormorant, White-faced Heron and White-bellied Sea Eagle. Large fish were observed on several occasions.



Plate 4.1 River Club Rush (*Schoenoplectus validus*) survived the very saline conditions of the previous four months. Other emergent rushes, such as Cumbungi (*Typha sp.*) did not.



Plate 4.2 Water levels in Salty Lagoon remained high throughout the current monitoring period.



5. Key Points

1. Water levels remained high in Salty Lagoon throughout the current monitoring period. Water levels in Salty Creek were variable in response to rainfall conditions, entrance status and seawater ingress.
2. A moderate number of results did not comply with the guiding values, after very poor results in the previous monitoring period. Results from the previous monitoring period are likely to have resulted from extreme environmental conditions rather than operation of the Evans Head STP.
3. Nutrient concentrations were reduced in comparison to the previous reporting period but chlorophyll-a concentrations remained high at most sites.
4. The erosive headcut to the east of the old channel between Salty Lagoon and Salty Creek advanced slightly towards Salty Lagoon during this reporting period. There is a continued risk that the eroding channel will break into Salty Lagoon during the next heavy rainfall, or if moderate rainfall conditions persist for an extended period.
5. The risk rating for the Salty Lagoon Response Protocol is uncertain, due to the potential for the erosive channel to break into Salty Lagoon. Heavy rainfall may lead to a high risk rating and require site a site inspection in the coming months.



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