Salty Lagoon
Post Closure Monitoring

Project Management and Ecosystem Health Report
February 2022

GeoLINK
environmental management and design

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

UPR	*Description*	*Date Issued*	*Issued By*
1731-1350	First issue	19/04/2022	David Andrighetto

Table of Contents

Illustrations

Plates

Tables

1. Introduction

1.1 Introduction

This document comprises the fourth 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 January 2022 until 28 February 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 fourth 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 March 2022. Water quality samples were collected between the hours of 7:00 am and 12:00 noon on that day. A high tide of 1.64 metres was forecast for 7.18 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 S2. 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. The summer aquatic weed survey was undertaken during the site inspection on 12 January 2022. The autumn aquatic weed survey is planned for 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. 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 15 March 2022 and replaced by a serviced and calibrated set.

The status of the two deployed YSI EXO3 sondes on 15 March 2022 is displayed in **Table 2.3**.

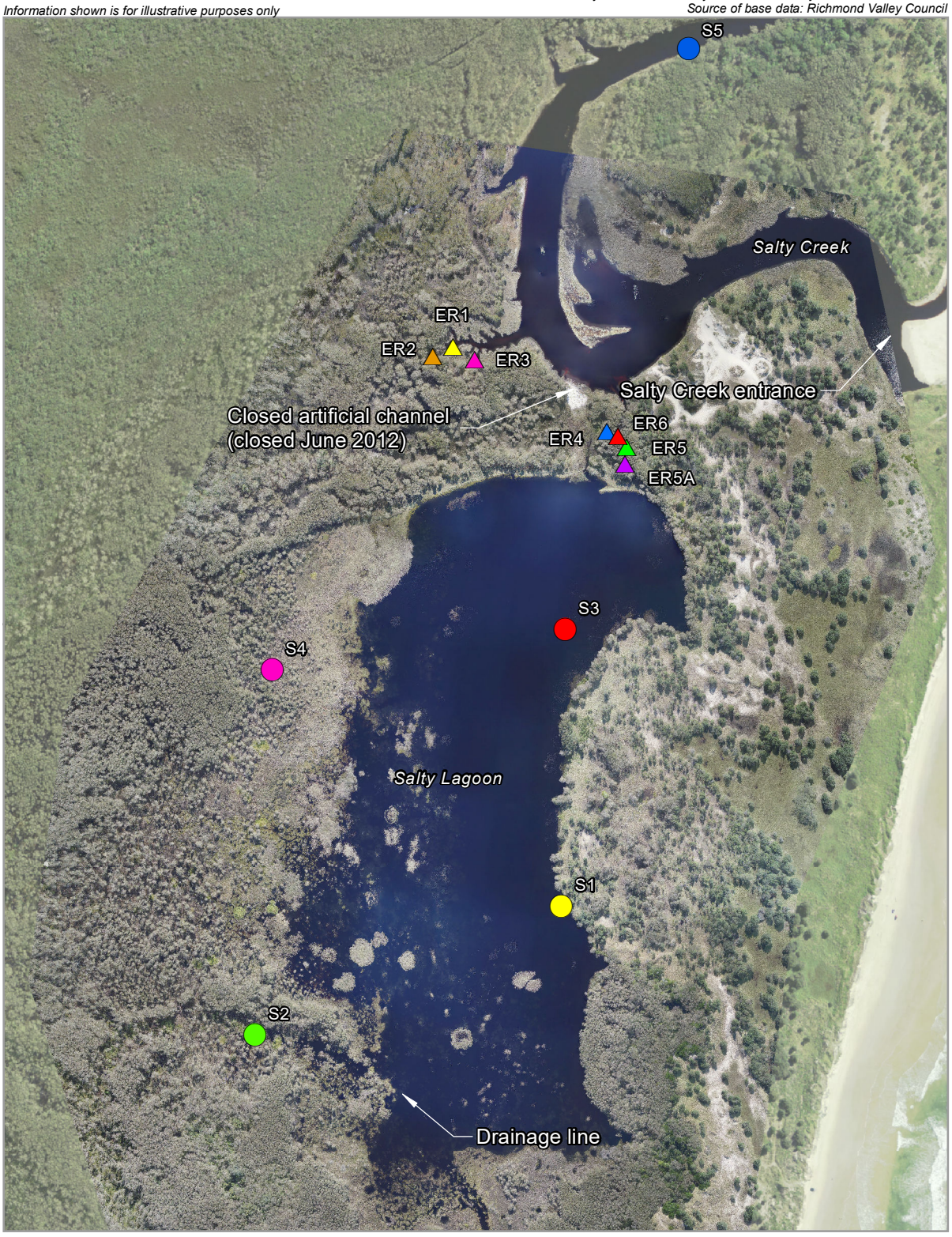
Table 2.3 YSI Sonde Status on 15 March 2022

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 Malfunction. Removed for service	YSI Exo Wiper 17G101954 New wiper brush installed 03/2020	No Spare Wiper
Status	- Serviced probes installed in Salty Lagoon 12/01/2022 - New batteries installed 15/03/2022	- Serviced probes installed in Salty Creek 1**5**/0**3**/2022 - New Batteries installed 1**5**/03/2022	- Awaiting service and calibration. - Probes Removed from Salty Creek 15/03/2022
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 2022). 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
Source of base data: Richmond Valley Council

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

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 15 March 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 15 March 2022

Parameter	Salty Lagoon								Salty Creek		
	Guiding Value	S1	S1 (1m)	S2	S2 (QA)*	S3	S3 (1m)	S4	Guiding Value	S5	S5 (1m)
Blue Green Algae ID (cells/mL)	**0**	**<100**	**<100**	**<100**	**<100**	**<100**	**<100**	**<100**	**0**	**<100**	ns
Nitrite Nitrogen (mg/L)	**0.01**	**0.03**	ns	**0.018**	**0.018**	**0.022**	ns	**0.035**	**0.01**	**0.026**	ns
Nitrate Nitrogen (mg/L)	**0.01**	<0.010	ns	<0.010	<0.010	**0.027**	ns	<0.010	**0.01**	<0.010	ns
Oxidized Nitrogen (mg/L)	**-**	0.036	ns	0.018	0.023	0.049	ns	0.038	**-**	<0.010	ns
Ammonia Nitrogen (mg/L)	**0.05**	<0.010	ns	<0.010	<0.010	<0.010	ns	<0.010	**0.11**	<0.010	ns
Total Kjeldahl Nitrogen (mg/L)	**1.6**	1	ns	1.07	1.05	1.12	ns	1.28	**1.63**	0.95	ns
Total Nitrogen (mg/L)	**1.6**	1.04	ns	1.09	1.07	1.17	ns	1.32	**1.63**	0.98	ns
Total Phosphorus(mg/L)	**0.14**	0.05	ns	0.09	0.08	0.05	ns	<0.03	**0.04**	<0.03	ns
Orthophosphate (mg/L)	**0.11**	0.034	ns	0.072	0.07	0.035	ns	<0.010	**0.01**	<0.010	ns
Chlorophyll-a (µg/L)	**5**	<1	ns	<1	<1	<1	ns	<1	**3**	<1	ns
Enterococcus (CFU/100mL)	**170**	25	ns	50	50	30	ns	5	**40**	15	ns
Faecal Coliforms (CFU/100mL)	**135**	<5	ns	10	5	<5	ns	<5	**150**	120	ns
Temp (˚C)	**25.9**	24.34	24.01	23.97	ns	24.54	24.57	23.48	**13.1 - 28.8**	22.52	21.93
pH	**6.9**	6.4	6.17	5.91	ns	6.15	6.13	4.41	**4.3 - 6.8**	**4.14**	**4.08**
ORP (mV)	**-**	187	203	181	ns	133	152	302	**-**	333	330
Cond (mS/cm)	**8.0**	0.2	0.201	0.172	ns	0.198	0.196	0.223	**0.3 - 21.5**	**0.138**	**0.148**
Turbidity (NTU)	**13**	1.1	10.1	0.4	ns	1.4	0.7	1.5	**11**	1.1	0.7
DO (mg/L)	**4.09**	6.86	5.75	**1.65**	ns	7.53	7.26	**1.32**	**5.52**	**4.95**	**4.27**
DO (% sat)	**-**	83.7	69.7	20	ns	92.1	88.9	15.9	**-**	58.6	50.1
TDS (mg/L)	**-**	0.13	0.131	0.112	ns	0.128	0.128	0.145	**-**	0.09	0.096
Sal (ppt)	**-**	0.1	0.1	0.1	ns	0.1	0.1	0.1	**-**	0.1	0.1
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

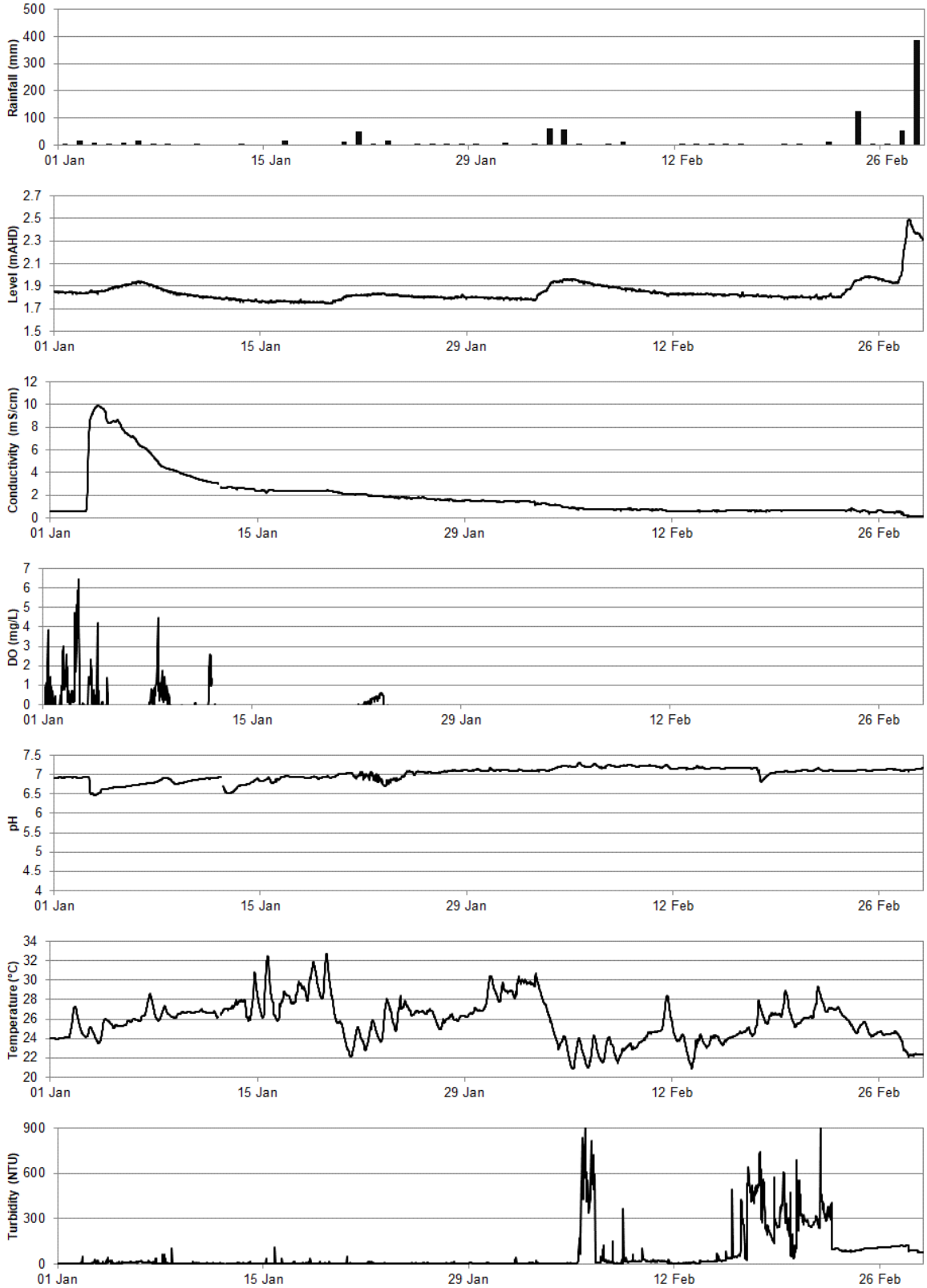


Illustration 3.1 Salty Lagoon Rainfall and Water Quality Monitoring Station Data 1 January 2022 to 28 February 2022

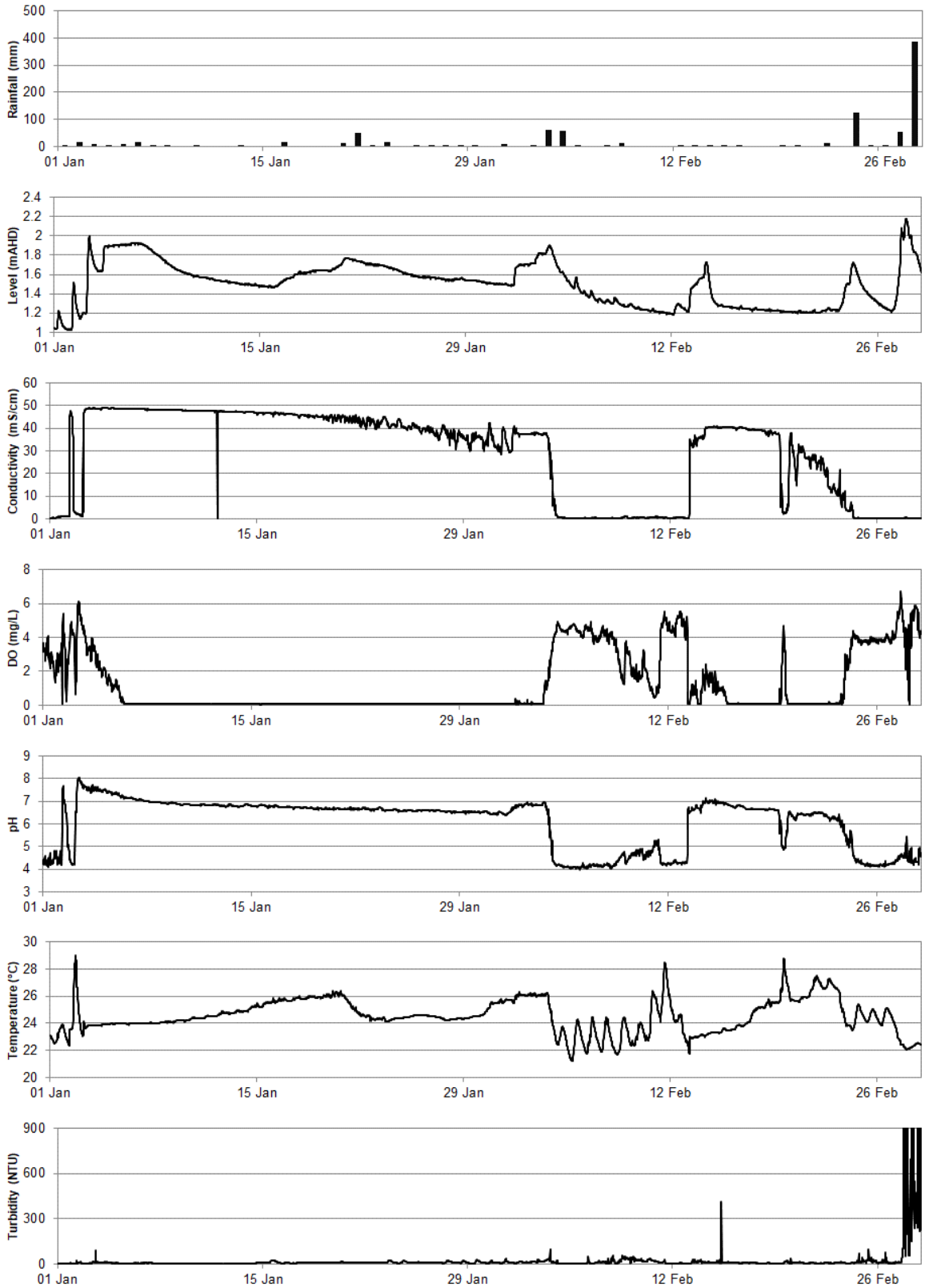


Illustration 3.2 Salty Creek Rainfall and Water Quality Monitoring Station Data 1 January 2022 to 28 February 2022

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 ER5 in relation to the previous measurements on 12 January 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 15 March 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	-38.4	50.75
ER6	Impact	10.40	6.15	4.25

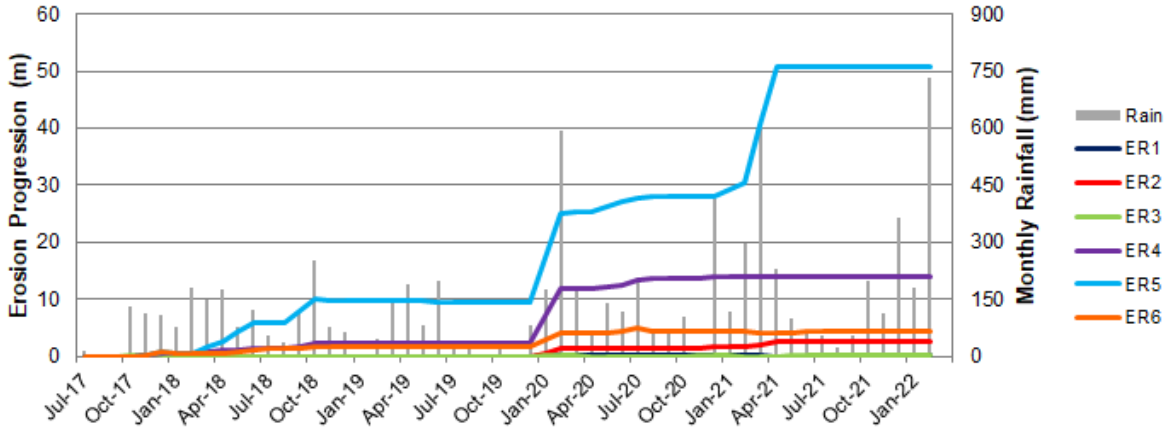


Illustration 3.3 Erosion Progression Plotted against Monthly Rainfall since July 2017

4. Discussion

4.1 Water Quality

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 2/3 of the days of the reporting period. The total rainfall for this reporting period was approximately 290 percent of the average amount. This is the third consecutive bi-monthly reporting period where rainfall far exceeded the average amount (**Illustration 4.1**) and for the previous 12 months rainfall in the area was approximately 180 percent of the average.

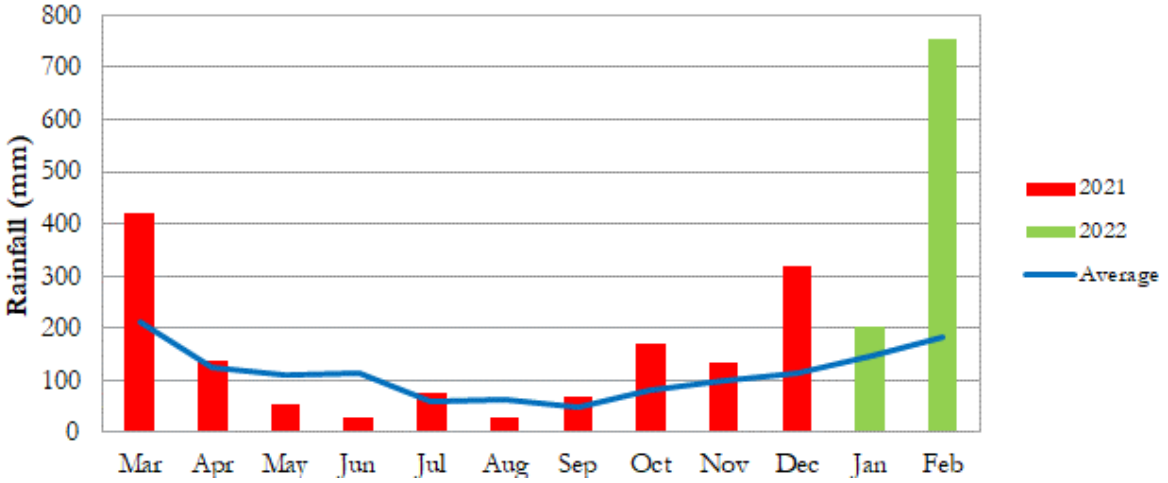


Illustration 4.1 Previous 12 months of rainfall from New Italy plotted against average rainfall

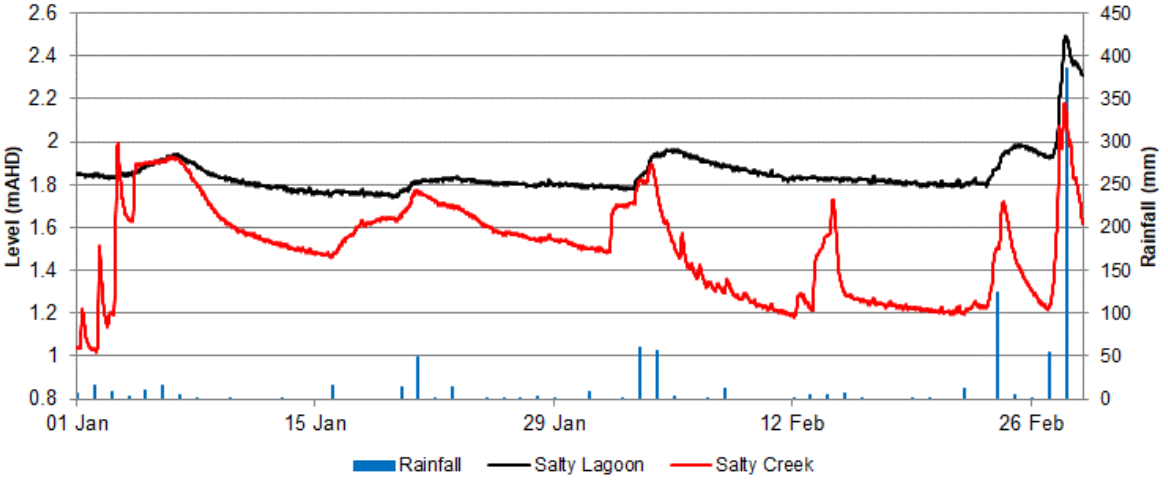


Illustration 4.2 Water level from Salty Lagoon and Salty Creek for this reporting period

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 two separate occasions and tidal movements. Although water levels became very high on three occasions, they were low at the beginning of the reporting period and rapidly falling at the end. The data indicates that the entrance to Salty Creek was open and flowing out for the final two weeks of the reporting period, with flood conditions occurring twice in the last week. Water levels in Salty Lagoon remained relatively high for the majority of the reporting period, increasing to very high levels in response to a flood event at the end of the reporting period. Water would have flowed from Salty Lagoon into Salty Creek for the majority of the reporting period, with the exception of a reversal of flow on 3 January 2022 after very high tides and large surf associated with ex-tropical cyclone Seth led to a large seawater ingress event and very high levels in Salty Creek (**Illustration 4.2**).

The conductivity measured at the Salty Lagoon PWQMS decreased overall during this reporting period in response to consistent rainfall runoff. The flow reversal around 3 January 2022 resulted in saline water entering Salty Lagoon but consistent rainfall after that date let to the return of freshwater conditions by early February. The conductivity measurements from the Salty Creek PWQMS were very dynamic in response to seawater ingress, rainfall runoff and tidal movements. At the end of the reporting period (and at the time of the site inspection on 15 March 2022) the water in Salty Lagoon and Salty Creek was fresh. The conductivity measurements collected on 15 March 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 no further movement of the primary head cut towards Salty Lagoon since the previous measurements taken on 12 January 2022, despite consistent flow from Salty Lagoon into Salty Creek and a hydraulic head of up to over 0.6 m on several occasions (**Illustration 4.1**). This is an indication that the repairs to the erosion control structure in the eroding channel have functioned well during this reporting period.

The DO concentrations in discrete samples collected on 15 March 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 Lagoon PWQMS indicates that the DO concentrations at the bottom of the water column in Salty Lagoon were very low for most of this reporting period. 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 15 March 2022 did not comply with guiding values. Specifically, all of the nitrite concentrations measured and the nitrate concentration from S3 exceeded guiding values. For the first time since May 2018, chlorophyll-a concentrations from all sites were below the level of detection. Blue-green algae were recorded from all sites, but in very low numbers. The blue-green algae detected were from the genera *Synechococcus*, *Planktolyngbya*, *Limnothrix* and *Dolichospermum*. The blooms observed in the recent reporting periods appear to have dispersed naturally, probably in response to the very strong influence of rainfall runoff recorded.

All other results complied with guiding values with the exception the pH values from S5. Low pH recorded at S5 is typical in times of exceptionally high rainfall runoff.

4.2 Other Observations

The entrance to Salty Creek was open and appeared to be tidally influenced on 15 March 2022 (**Plate 4.1**). Few birds were observed incidentally during the site inspection. The species observed were Pacific Black Duck, Pied Cormorant, and Common Rail. 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 15 March 2022

Plate 4.2 Water flowing over the erosion control structure.

Plate 4.3 The position of the headcut on 15 March 2022 showing no significant movement

Plate 4.4 The position of the headcut on 12 January 2022 before the floods

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 did not comply with the guiding values, mostly nitrate concentrations and pH and conductivity measurements.

3. Chlorophyll-a concentrations were below detection limits at all sites.

4. Blue-green algae were detected for the ninth consecutive reporting period, but at very low levels. The *Microcystis* bloom observed at S4 in October 2021 has dispersed.

5. Although rainfall has greatly exceeded average conditions and a large hydraulic head persisted for much of this reporting period, the erosive headcut has not advanced since the measurements on 12 September 2021, indicating that the repairs to the erosion control structure are functioning well so far.

6. The risk rating for the Salty Lagoon Response Protocol is low.

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