Subject: No.1 Drain Wetpond Hydrological Data Review

Attention: Christchurch City Council

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1 Introduction

Christchurch City Council (CCC) have constructed a stormwater retention pond within No.1 Drain, which discharges to Horseshoe Lake. Compared to the concrete lined drain prior, the wetpond consists of naturalised channels, a floating wetland system with an orifice outlet weir and naturalised plantings. The system is located within the Christchurch Golf Club in Shirley, so may also receive localised runoff from the golf course also.

CCC are interested in understanding the wet ponds performance with respect to dissolved oxygen, temperature flux and water levels due to the shallow nature of the pond system and ecological aspirations to provide for aquatic values.

This memo summarises the performance of the No.1 Wetpond at Christchurch Golf Club for 2021. A site overview and data collected are detailed in Section 2. Water levels, temperature, and dissolved oxygen (DO) results are shown in Section 4 and summarised in Section 4.

As part of the project a trial use of custom loggers was utilised to explore if a new cost effective solution could be deployed successfully (Figure 1).

Figure 1. Custom logger system deployed in the pond location.

2 Site overview and data

Data are derived from three custom water level, dissolved oxygen and temperature loggers (**Upstream**, **Pond**, and **Downstream**) which have been developed as an alternative option for cost effective monitoring and were being trailed as part of this project. CCC also installed two water quality Sondes (**Pond** and **Downstream**) operated by CCC over the summer months prior (Table 1). Text colour corresponds to **Figure 2** and the plots included in this memo. Rainfall data are from the NIWA Bromley Ews station[1].

Table 1 No.1 Wetpond sensors

Sensor	Period	Measurements Analysed
Sonde – Pond and Downstream	6/01/2021 – 10/05/2021	Dissolved Oxygen (DO), Temperature.
Water level loggers – Upstream, Pond, Downstream	11/03/2021 – 26/02/2022	Relative Level (RL), Dissolved Oxygen (DO), Temperature.

Figure 2. No.1 Wetpond and sensor locations

[1] https://cliflo.niwa.co.nz/ Agent number 43967.

3 Findings

3.1 Water levels

Figure 3 shows the daily average water levels in metres relative levels (mRLs) for the Upstream and Downstream loggers[2]. The Pond logger is not shown, as fouling and technical issues prevented consistent data recording. Figure 3 suggests that No.1 Wetpond is hydrologically performant:

- Observed water levels do not exceed the weir spillway crest of 11.2 mRL,
- Water level peaks Downstream are generally smaller than at Upstream, indicating storage within the lake following rainfall.
- Baseflow (during periods of low rainfall) are stable, indicating consistent inflows and stable lake levels between rainfall events.

Figure 3 also shows the gradual increase in water levels through the year which was established to be due to aquatic vegetation growth in the outlet channel which was observed to raise water levels through the entire system (likely by reducing conveyance of outflows). Manual vegetation removal and a subsequent drop in levels can be seen in early November 2021 at both sites.

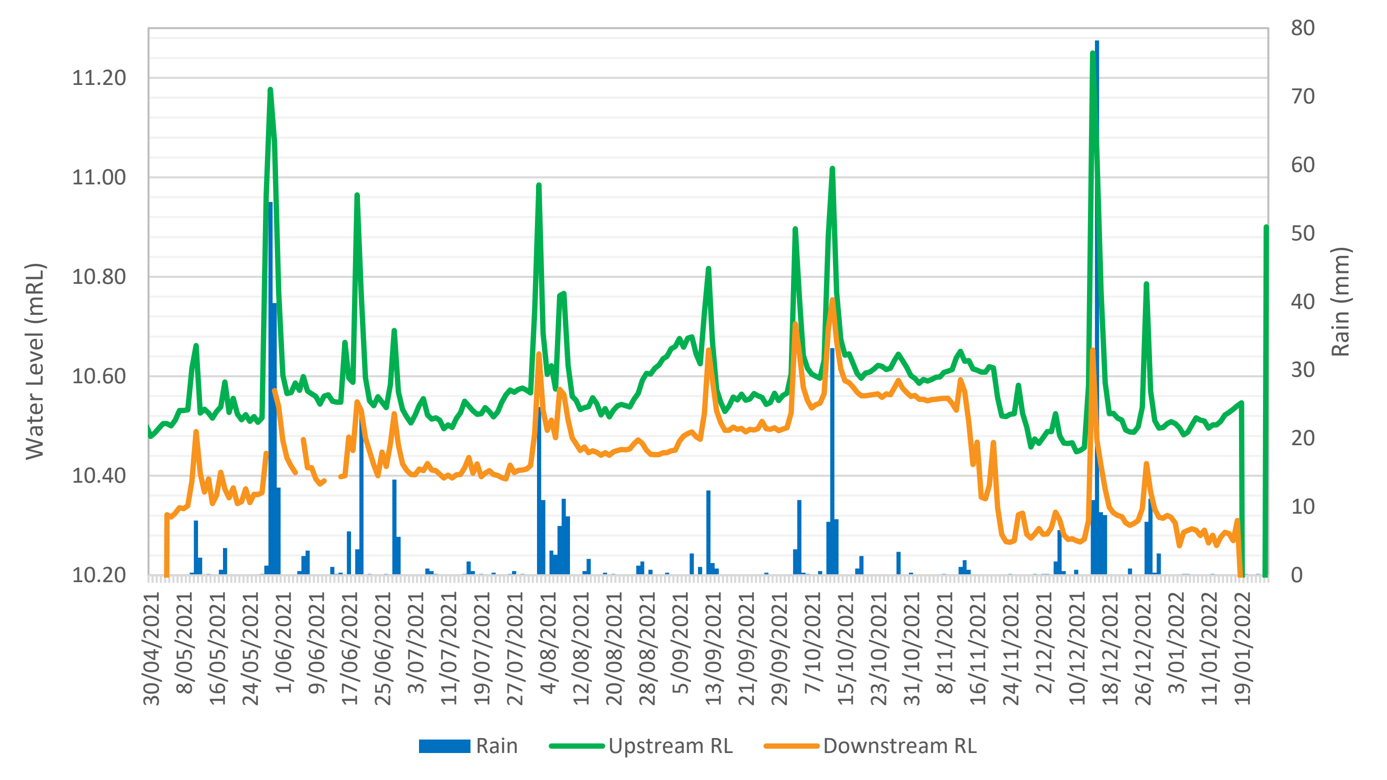

Figure 3. Daily average water level (mRL) for full data period

Figure 4 shows the water level at the Upstream site during the May/June 2021 Canterbury Floods event. The event was the largest 24-hour event on record for Environment Canterbury foothills rain gauges (e.g. Ashburton, Opuha, Mt Somers, Rangitata, Ashley, Selwyn and Waimakariri)[3]. The extreme event flooded the Downstream logger, and the extended overcast conditions depleted the

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[2] Levels are provided by CCC surveyors and are in terms of Christchurch Drainage Datum – Epoch July 2019. BM164 and collected using a dumpy level.

[3] https://www.ecan.govt.nz/your-region/your-environment/river-and-drain-management/canterbury-flood-recovery/flooding-events/

Pond logger battery[4]. The Upstream logger water levels indicate that the wetpond system maintained performance during the event, with levels increasing in response to rainfall peaking at ~11.3 mRL when levels topped the spillway downstream, before receding to baseflow conditions over the following 24 hours.

Figure 5 plots the water levels for all sites for 5–7 December 2021 during a series of summer rain showers. In response to the initial rainfall and increased inflows from 8 pm 5 December 2021, pond levels (Pond logger) increased by almost 100 mm from 10.4 to 10.5 RL. Subsequent rainfall further filled the pond, with levels reaching that of the Upstream during the recession phase, indicating backwater effects in the channel between the Upstream and Pond loggers.

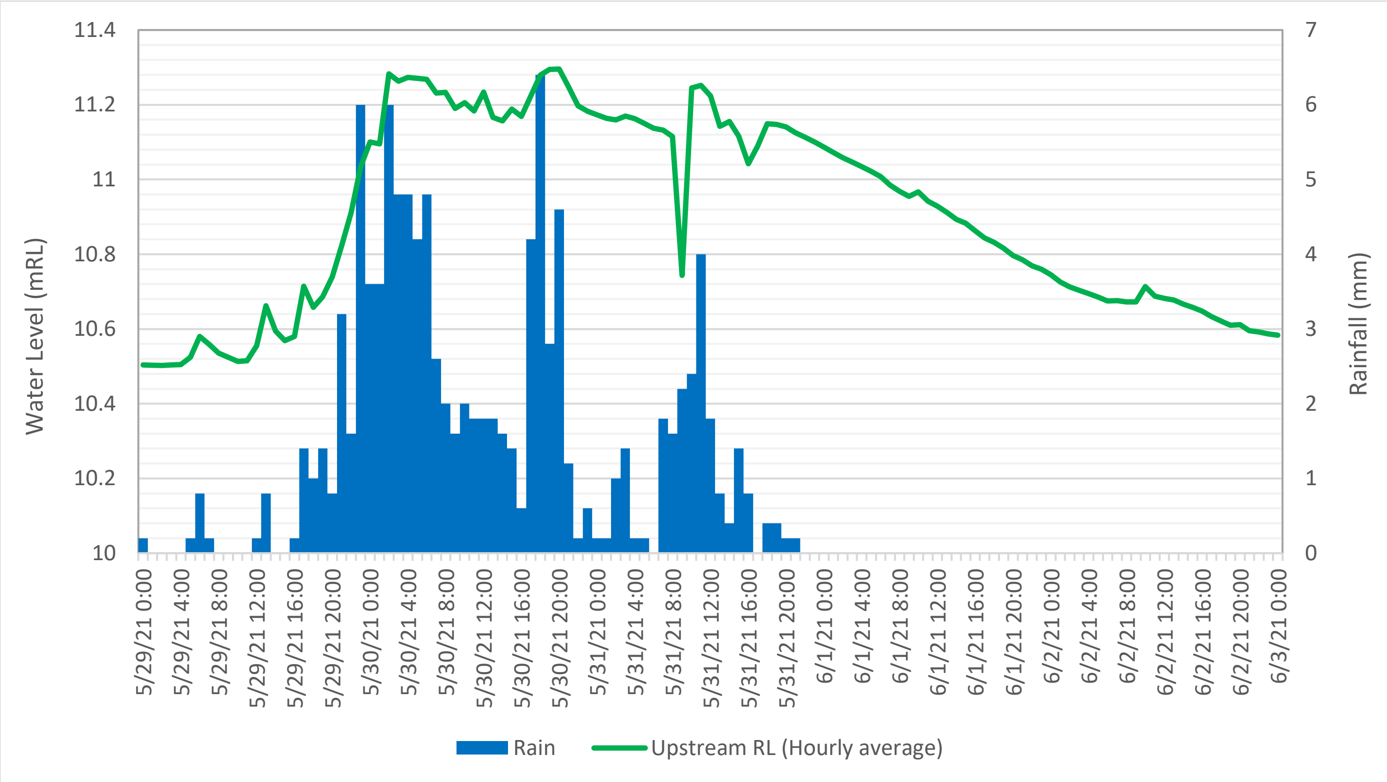

Figure 4. Upstream water levels (mRL) during May/June 2021 Canterbury Floods event

[4] Batteries were replaced and solar panels upsized at this site; however, solar gain was low during winter due to location requirements set.

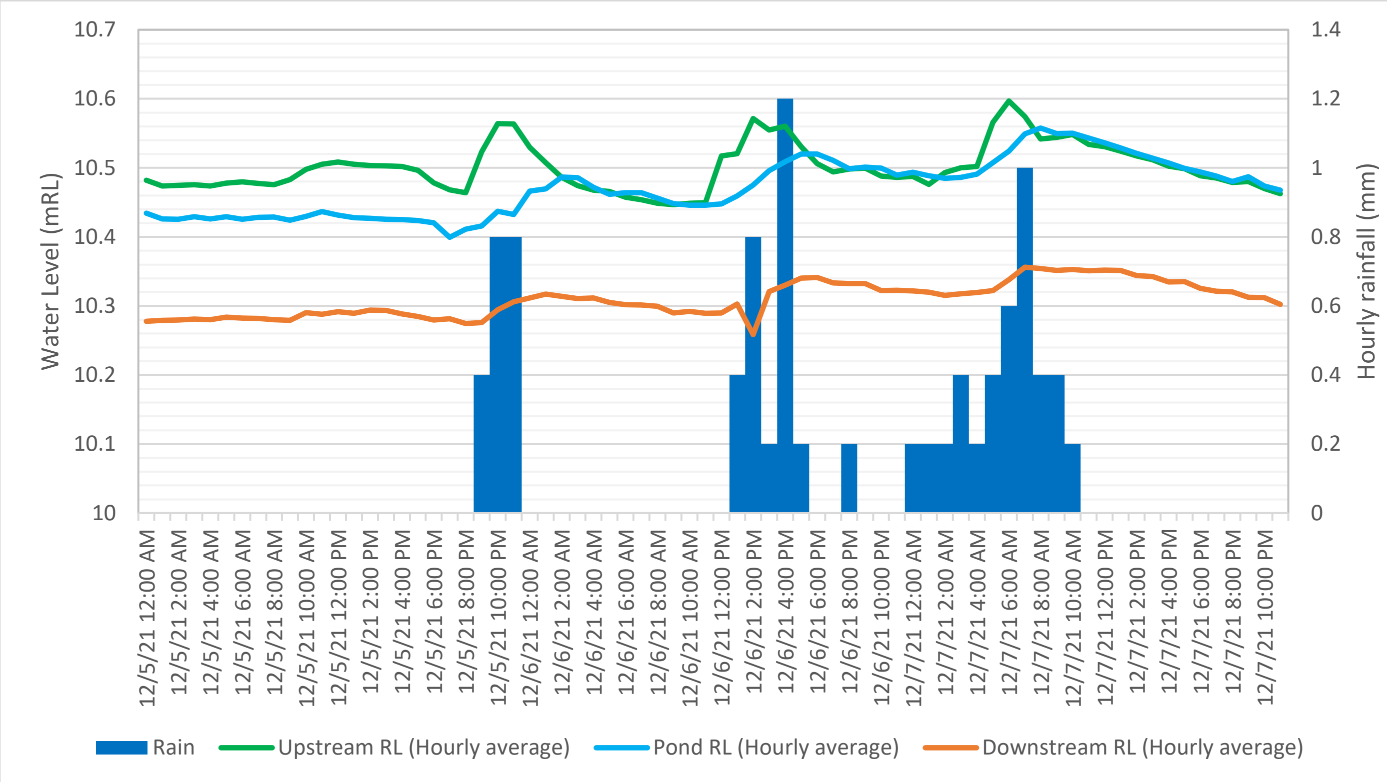

Figure 5. Water levels (mRL) for 5–7th December 2021

3.2 Temperature and Dissolved Oxygen

Figure 6 shows the temperature recorded at the three loggers for March 2021 to January 2022. Pond and Downstream temperatures are relatively similar and show a more pronounced seasonal trend than the Upstream inflow, typical of a shallow lake system. Inflows during rain events temporarily decrease temperatures at all sites. Water stored within the Pond maintains a lower temperature than the upstream inflows during parts of autumn and winter, but is warmer than inflows during spring and summer. This is likely due to the upstream baseflows being derived from some spring discharges connected to the underlying aquifer, which will maintain a more consistent temperature than a surface water body subjected to direct climate variations. A spring was observed near the upstream logger supporting this possibility.

Figure 7 shows the water quality sonde daily average temperature and DO for the Pond and Downstream. Temperatures show a seasonal decreasing trend from a maximum of above 22°C in late January to below 12°C in early May. The Downstream temperature is slightly raised compared to the Pond due to warming within the wetpond between the sensors; the last measurements in early May indicate this trend may reverse over winter where solar radiation on the wetpond is reduced. DO readings show a variable, less seasonal trend than temperature, controlled by incoming flows. The increased DO readings at the Downstream location are indicative of photosynthesising aquatic vegetation within the wetpond and some oxygen additions due to greater velocity and turbulence within the channel.

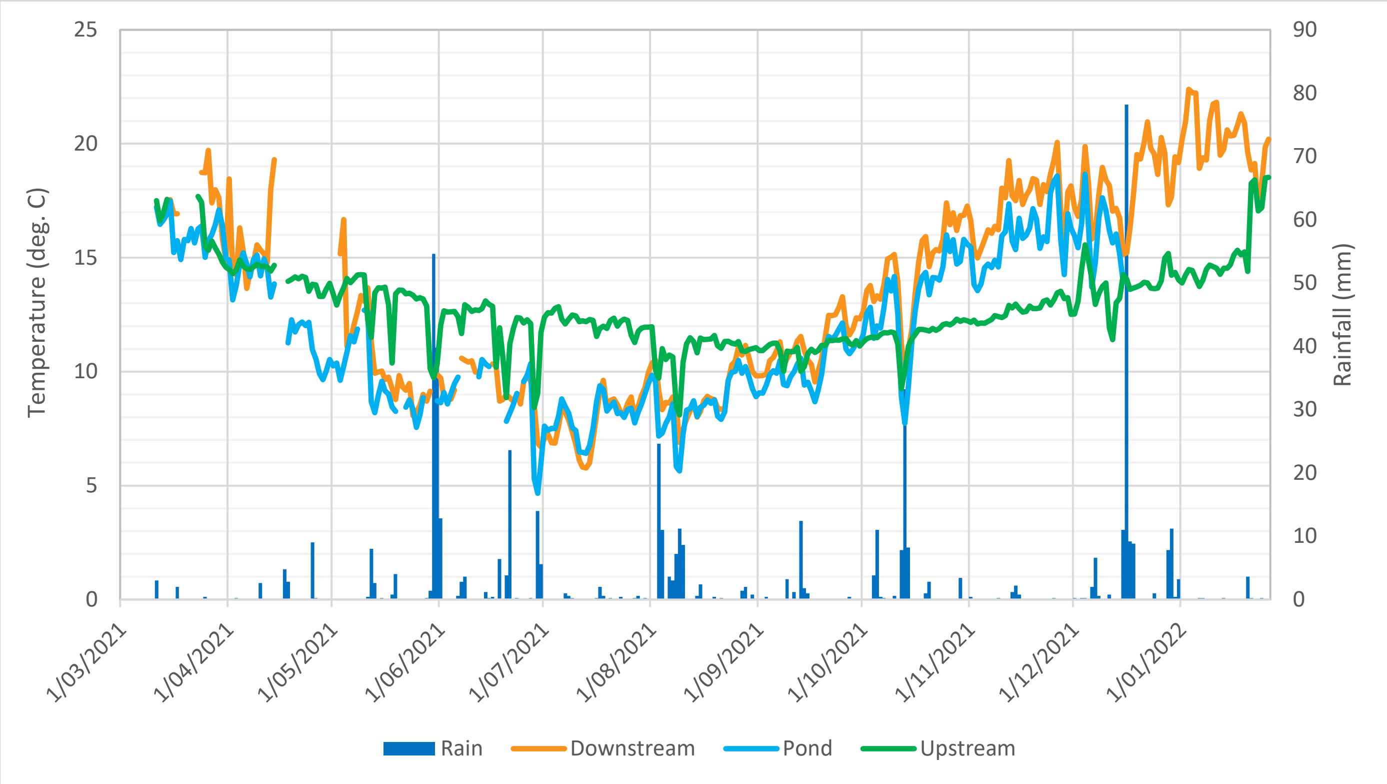

Figure 6. Daily average logger temperatures

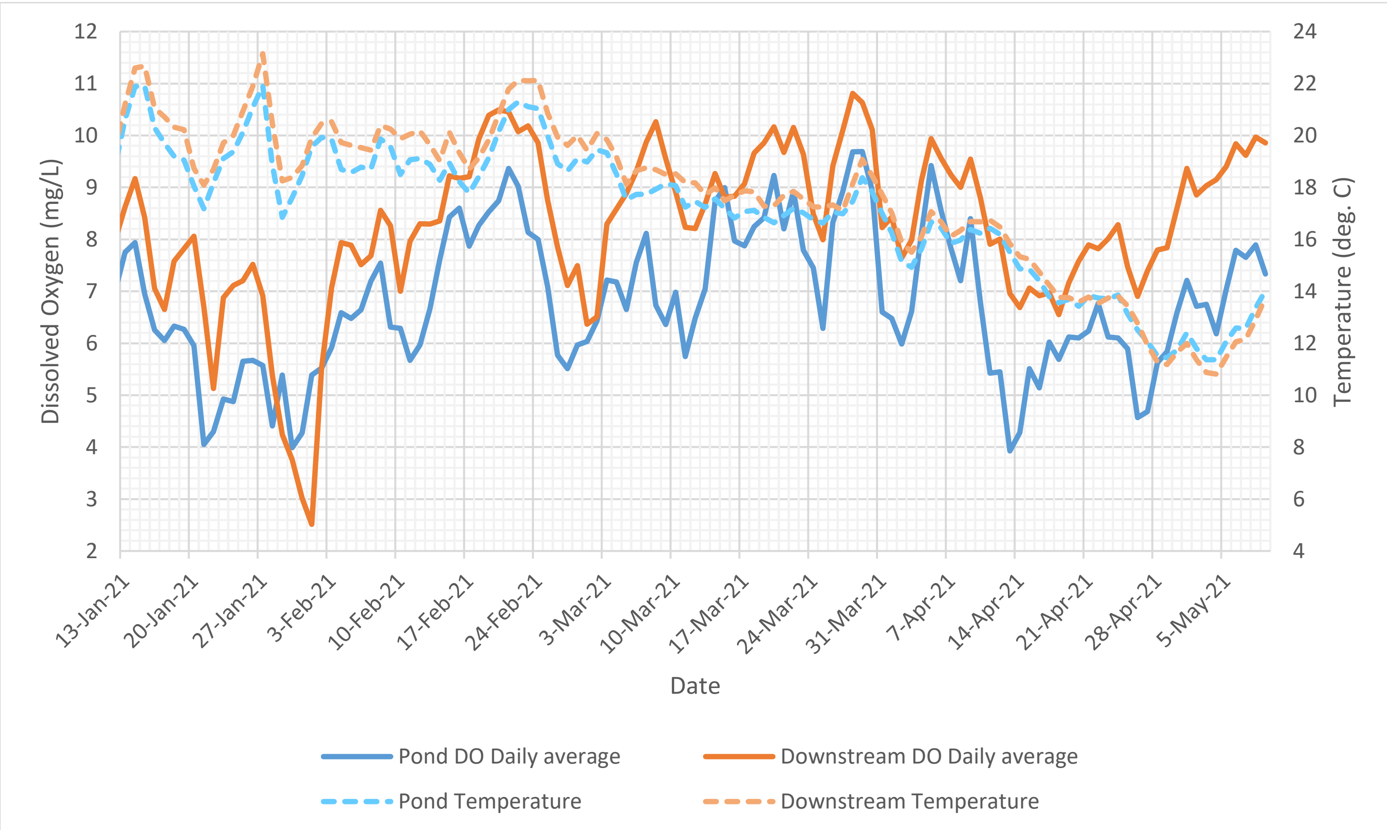

Figure 7. Daily average temperature and dissolved oxygen

Figure 8 shows the diurnal fluctuations in DO driven by photosynthesis and respiration of aquatic vegetation during a selected period in February 2021. Following 11.6 mm of rain over 12 hrs from 9pm on the 9th of February, DO levels at the Pond and Downstream lowered and the following day's peak was dampened before gradually increasing over the following days. A similar pattern of DO reduction following rainfall can be seen in the 7-day average DO levels in Figure 10. As significant seepage and spring inflows have been observed adjacent to the Upstream site, it is suspected that low-oxygen groundwater inputs are contributing to the lower DO levels.

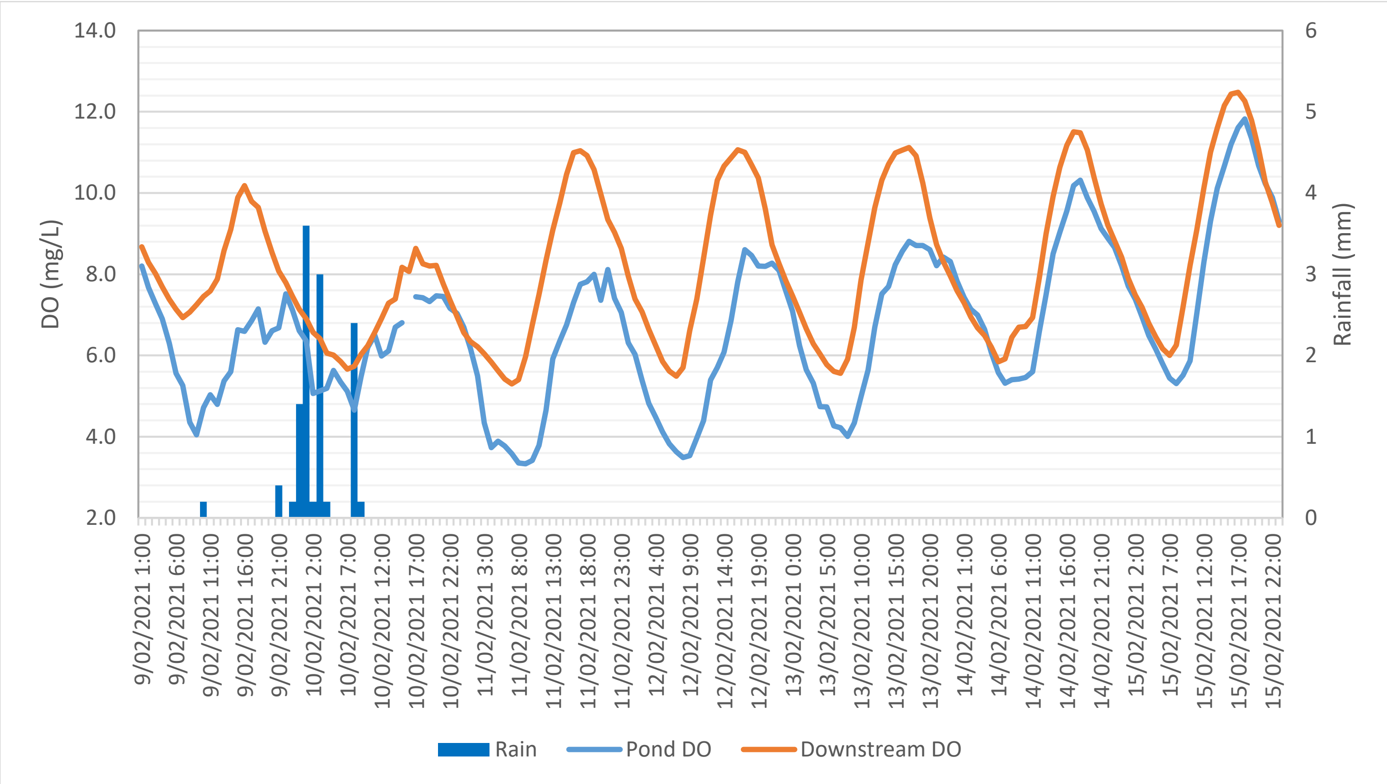

Figure 8. Hourly average DO February 2021

3.2.1 Land and Water Regional Plan (LWRP) Freshwater Outcomes

The LWRP dissolved oxygen ecological health indicator for 'Spring-fed – plains – urban' streams is ≥70 %[5]; to be compared to median levels from one calendar year of monitoring. For the four months of available sonde data, the median DO level was 70.6% at the Pond, and 85.2% at the Downstream site, indicating satisfactory DO levels. Further monitoring over winter and spring is necessary to determine if the guideline will be met across the full calendar year. The LWRP Freshwater Outcomes and daily average DO levels are plotted in Figure 9.

[5] Environment Canterbury (2018). Canterbury Land and Water Regional Plan - Volume 1 (May 2018). Environment Canterbury, Christchurch.

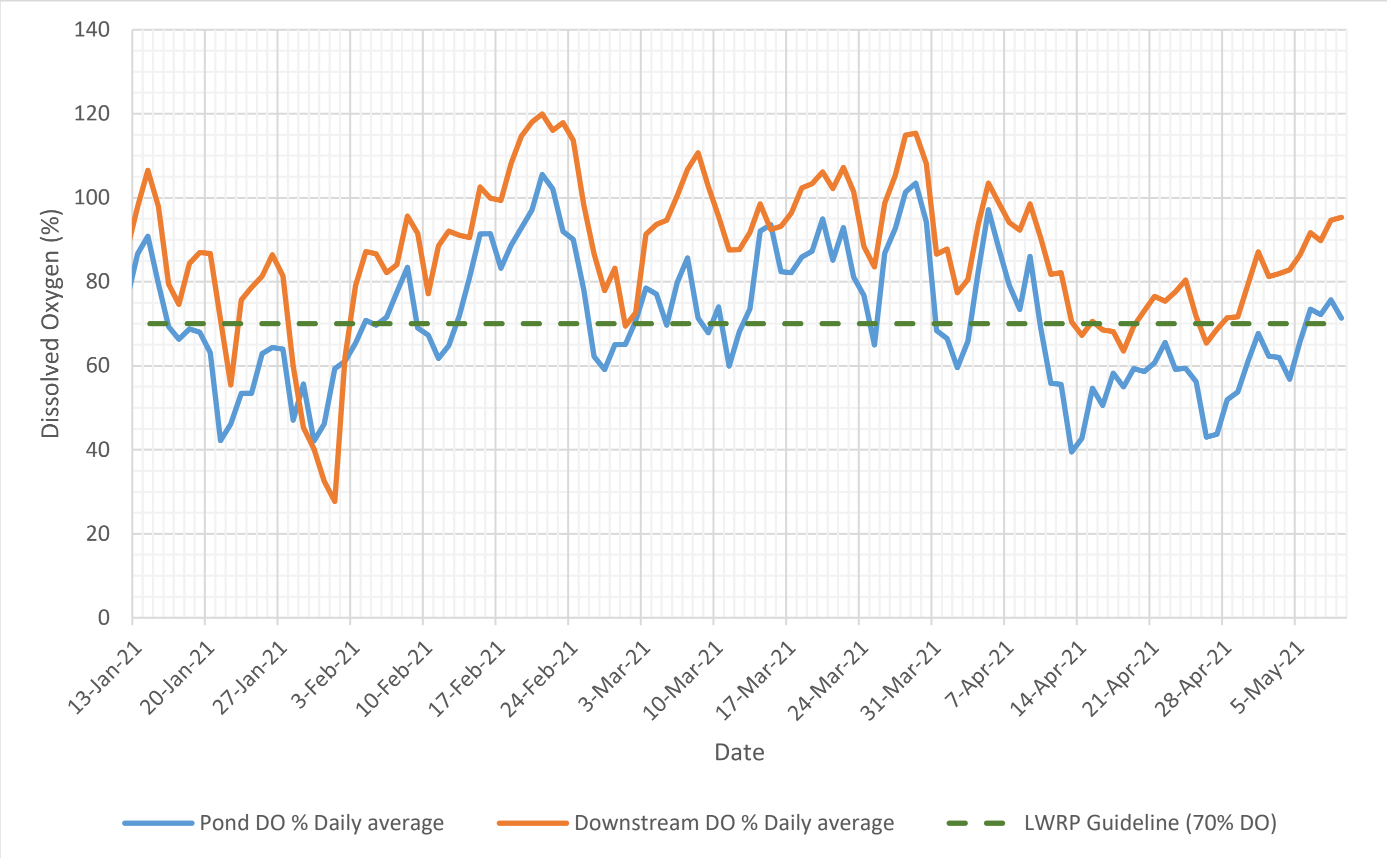

Figure 9 Daily average DO % saturation and LWRP Freshwater Outcomes

3.2.2 Dissolved oxygen guidelines for fish

DO levels at the Pond and Downstream are generally poor when assessed against the NIWA DO guidelines for fish[6]. Table 2 shows that the 7-day average minimum DO (lowest 7-day average in the observation record), and 1-day average minimum were below the Early Life stages Imperative guideline level for the Pond and Downstream. The 1-day mean minimum at the outlet of 2.51 mg/L is below the Adult Imperative guideline; it occurred on 3rd February and was the only recorded instance when the Downstream DO level was lower than the Pond.

Figure 10 and Figure 11 show the 7-day mean and 30-day mean DO levels compared to the NIWA guidelines. Other than the minimum observed during early February, DO levels were generally higher than the Adult and Early Life Stages imperative values.

[6] https://niwa.co.nz/freshwater-and-estuaries/research-projects/dissolved-oxygen-criteria-for-fish

Table 2. DO minimum guidelines

Dissolved Oxygen guidelines		Early life stages	Adults	Observed values	
				Pond	Downstream
7-day average minimum (mg/L)	Guideline	6.0	5.0	4.9	4.5
	Imperative	5.0	4.0		
1-day minimum (mg/L)	Guideline	6.0	4.0	3.9	2.5
	Imperative	4.0	3.0		
30-day mean (mg/L)	Guideline	9.0	8.0	Figure 10	
	Imperative	6.5	6.0		
7-day mean (mg/L)	Guideline	7.5	6.5	Figure 11	
	Imperative	5.5	5.0		

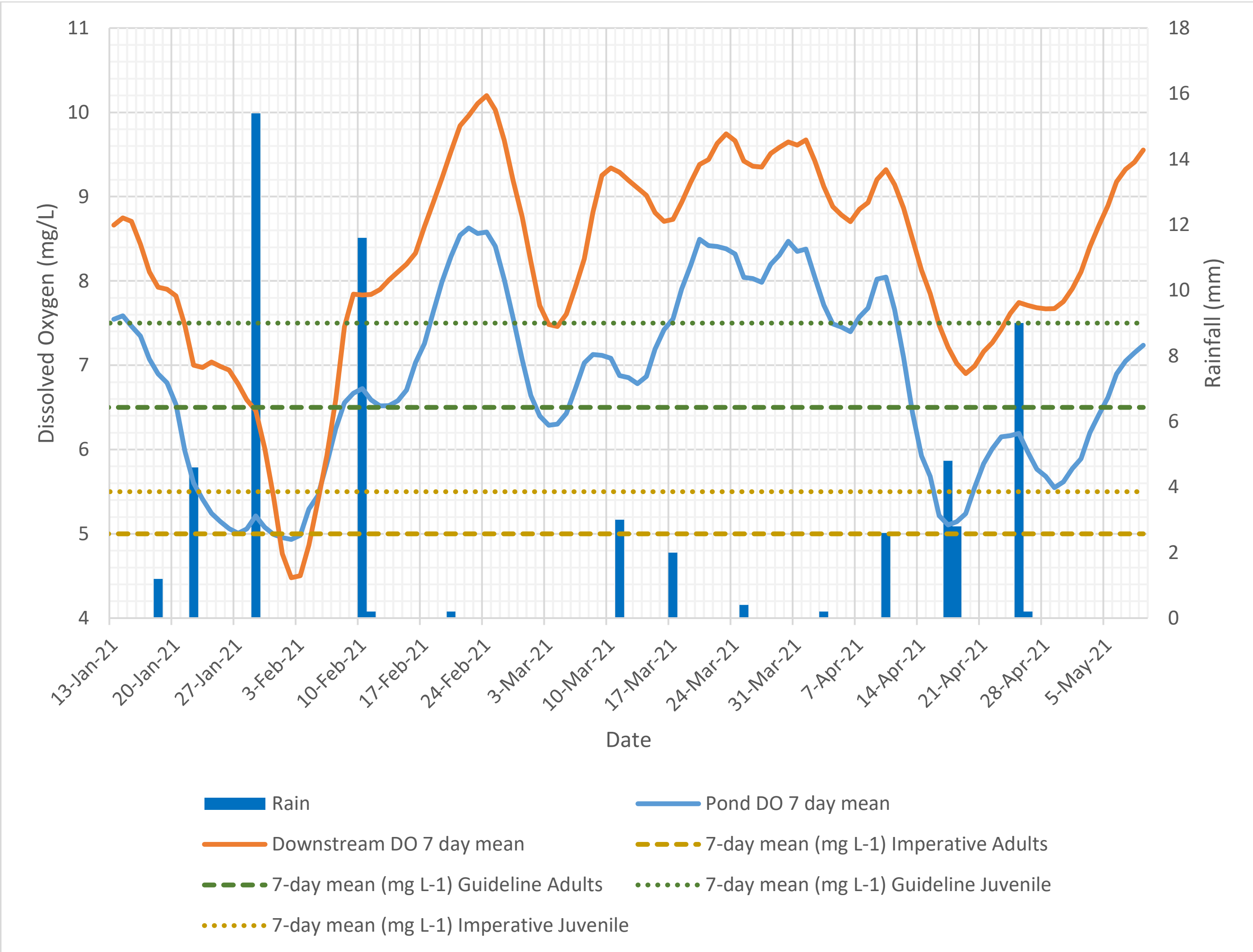

Figure 10. 7-day average DO in the Pond and Downstream

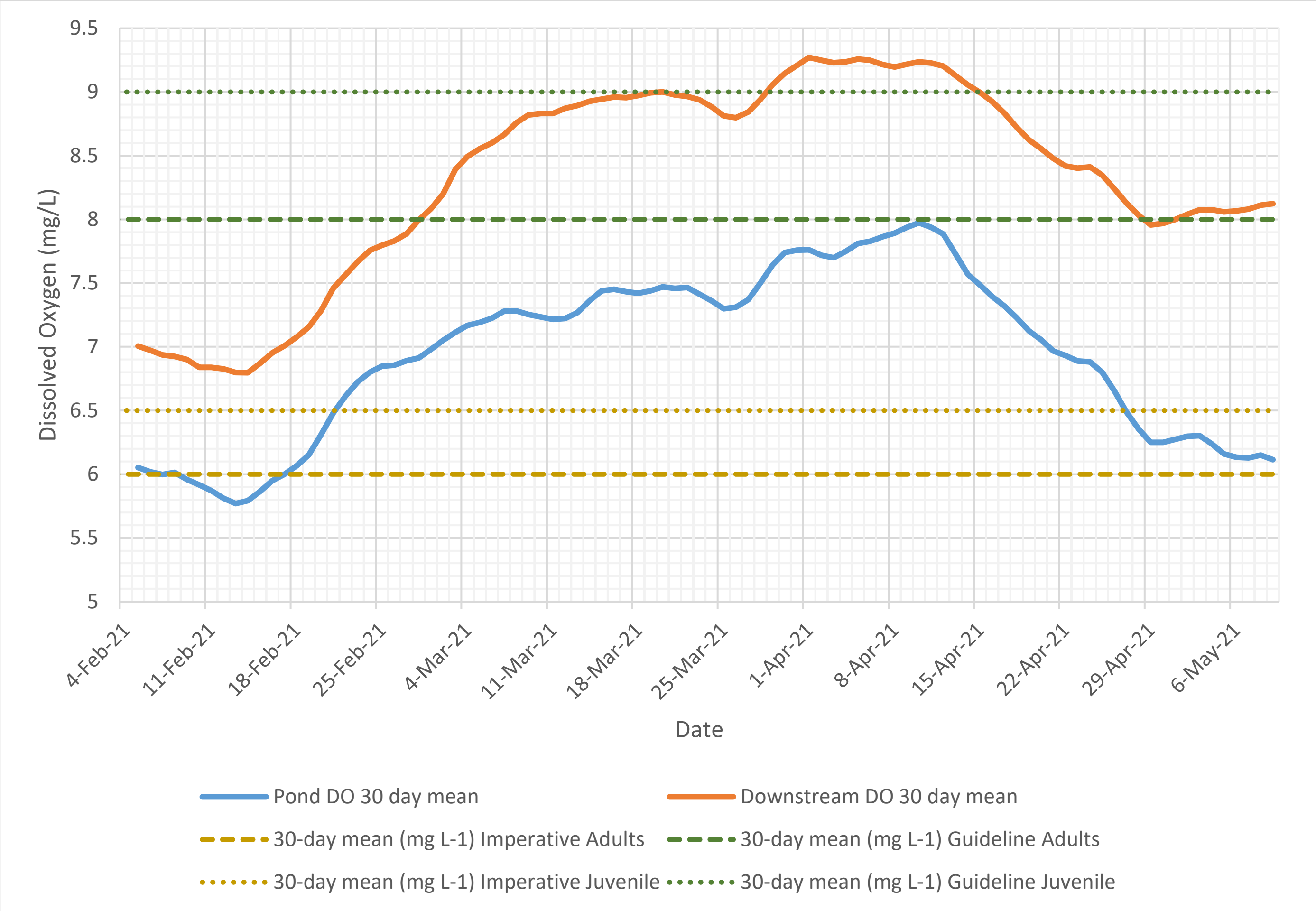

Figure 11. 30-day average DO in the Pond and Downstream

4 Options for water quality improvement

Table 3 provides a high-level summary of some potential options available to increase DO levels and regulate temperature in No.1 Wetpond. As well as receiving piped stormwater and groundflow inputs which have low DO levels, a unique site challenge is the pond's location within the Christchurch Golf Club, a designated 'Links' course with minimal vegetation. The aesthetics of any works is likely to be an important consideration and may need to be accepted by the golf club.

Table 3 No.1 Wetpond mitigations matrix

Mitigation		DO (level of increase)	Temperature (level of decrease)	Cost	Challenges
Mechanical aeration	Systems include aerating fountains, submersed diffuse aerators	High	Low	High	Power source, maintenance, noise
Increase pond depth	Earthworks to re-shape pond with aim to reduce summer heating	Low	Medium	High	Major works, potentially increase groundwater inputs to system

Constructed riffles	Low site gradient and water velocity may marginalise effectiveness	Low	Low	Medium	Change in gradient is low so may not be possible to achieve
Increase floating wetland coverage	Provides increased shading and minor (day-time) DO augmentation	Medium	Medium	Medium	Maintenance, aesthetics
Aquatic planting	Native species preferred	Low	Low	Medium	Species selection, establishment & maintenance, aesthetics
Riparian planting	Low riparian planting to increase shading of pond edge and channels	Low/Medium	Medium	Low	Species selection, establishment & maintenance, vision across golf course could be an issue as is known to be a 'links' course.
Golf course management plan	Reduce inputs of fertiliser and organic matter (grass clippings) from Golf course	Low	Low	Low	Buy-in from Golf club

5 Summary

- Based on the logger levels Wetpond No. 1 is holding water up to 11.2 mRL before spilling down the spillway. Whilst the sensor on the pond was fouled in large wet weather events making data continuity difficult, observations identified water level was maintained through the year.
- Temperatures are seasonally variable. Pond and Downstream temperatures are higher in summer and lower in winter than the Upstream inflows. This is due to direct connection of the standing water body to climatic influences, while the upstream channel maintains a steadier temperature year round due to groundwater spring discharges from an underlying aquifer.
- DO levels are generally low and fail to meet all fish health criteria. However, DO levels for the four (summer) months of sonde data do meet the LWRP guideline, and DO is higher Downstream than at the Pond over the summer months, likely due to photosynthesising aquatic vegetation and increased turbulence within the channel. There is no evidence of anoxic conditions or eutrophication based on the current data set.
- Groundwater inputs are likely to be contributing to low DO levels, but this could also be due to wider catchment inflows. Further investigation into the groundwater and catchment inflows may be required to understand if improvements in DO are achievable by further works.

- Further recording of DO over winter and spring and at the Upstream site may be required to better understand the risk to fish health and wet pond dynamics as catchment changes occur.
- Options exist to increase DO; however, there may be limitations to success of such options due to the desired aesthetics of the golf course. For example riparian shading would help to reduce temperature fluctuations; however, a links style course is known to be clear this type of vegetation and therefore may not be possible to implement and therefore less visible options may be required such as mechanical aeration or increase floating wetland cover.