The following document includes extracts from a full report from Golder Associates (NZ) Ltd, commissioned by Todd Property late last year.

GOLDER

REPORT

Cyanobacteria Blooms in Pegasus Lake

Assessment of potential management options

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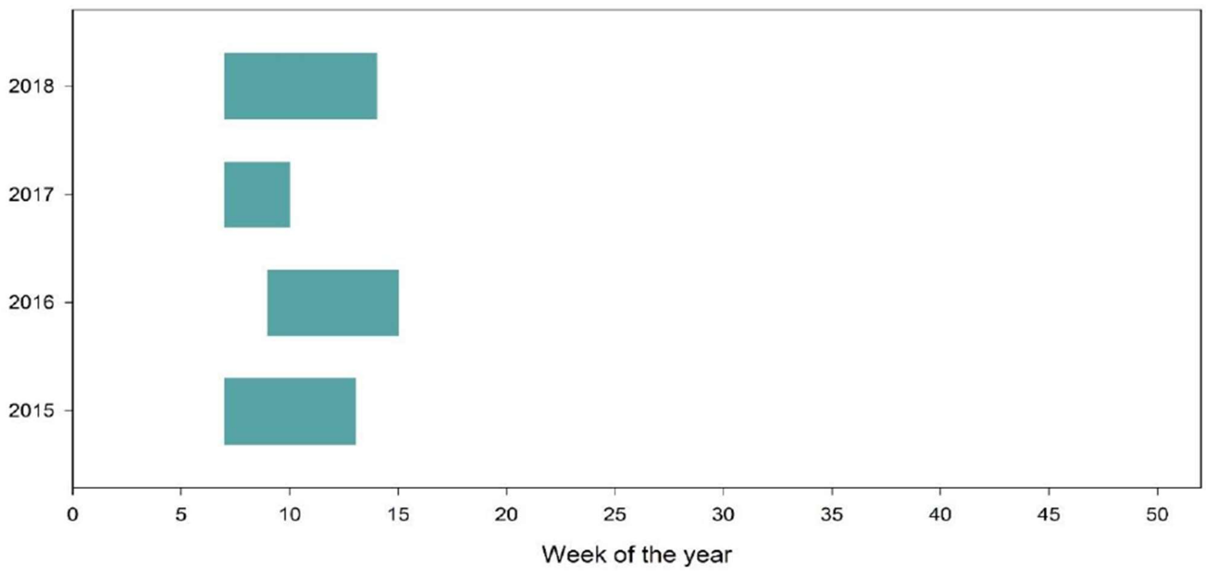
5.5 Adaptive Management Regime

Under the adaptive management approach, monitoring for cyanobacterial bloom development, and the management of lake closures, would still be undertaken in accordance with the Ministry for the Environment Guidelines (2009). For Pegasus Lake, this presently involves monitoring for the presence of cyanobacteria during the summer months, placement of warning placards around the lake during the bloom event and management of the timing of events involving the use of the lake to ensure that they occur outside of the potential bloom periods.

Since the start of blooms in Pegasus Lake in the summer of 2015, bloom onset has occurred at similar times each summer, with three of the four blooms starting in the 7th week of the calendar year (Figure 10). If the predictability of bloom onset continues, both monitoring and management response can be targeted around the early February period.

In addition to the current monitoring and lake-closure management, additional measures could be implemented under the adaptive management option to help lessen the length of time the lake is in bloom. These measures are discussed below.



5.5.1 Weir management

Water leaving the lake is channelised through corrugated iron culverts (three for the northern outlet and one for the southern outlet), underneath the road bridges, towards the weir. Immediately downstream of the road bridges, the area in front of the weir widens, which acts to slow the water down, particularly at the margins. Cyanobacterial biomass accumulates at the margins, preventing it from being flushed from the lake. In addition to this, the open area provides habitat for macrophytes to grow, which, when they reach the surface, act as a filter that retains cyanobacteria biomass upstream of the weir (Figure 11). This accumulated biomass acts as a re-inoculum source that is blown back into the lake under easterly winds. Modification of the weir to prevent biomass accumulating at the margins and prevention of surface reaching weed stands would help to flush the bloom from the lake and prevent re-inoculum.

Figure 11: Looking downstream at the Southern Outlet, showing surface reaching macrophytes retaining cyanobacteria scum upstream of the weir structure.

5.5.2 Beach management

Benthic algae occur along the shallow margins of the lake and periodically lift off from the lake floor, either as a result of trapped gas in the mat or from wave action and is washed ashore (Figure 12). Cyanobacteria trapped along the shoreline presents a potential hazard to children and dogs playing in the area, as well as providing a re-inoculum source for the lake during rain or storm events. Periodic removal of the shoreline accumulated algae helps to reduce both risk and re-inoculum.

5.5.3 Weed and grass management

The dominant macrophyte in Pegasus Lake is the introduced curly pondweed, *Potamogeton crispus*. In Pegasus Lake, *P. crispus* is currently managed with the regular application of the aquatic herbicide, Diquat. However, due to its low susceptibility to diquat (Wells & Sutherland 2002), biomass cover is only temporarily reduced in the lake and regrowth occurs rapidly (author's own observations). *P. crispus* is vulnerable to high water temperatures, with die-off occurring when water temperatures reach 25 °C (Sutherland 2005). Surface water temperature regularly exceeds 25 °C during mid to late January in Pegasus Lake, resulting in *P. crispus* die-off. The decaying biomass either washes up on shore, trapping cyanobacteria or acts as a nutrient pulse to stimulate algal and cyanobacterial growth in the lake (Figure 13).

Mechanical harvesting, such as raking or dragging of chains, would better manage the *P. crispus* biomass in Pegasus Lake than current chemical control. Mechanical harvesting would remove biomass from the lake, minimise shoreline accumulation (and associated trapping of cyanobacteria) and reduce nutrient recycling.

Grass that is mown around the perimeter of the lake provides an additional nutrient input as clippings are blown into the lake. A cut and collect mowing technique for the grass on the lake side of the perimeter pathway minimises this source of nutrient. Catching all of the grass clipping and removal offsite would eliminate this source of nutrients into the lake.

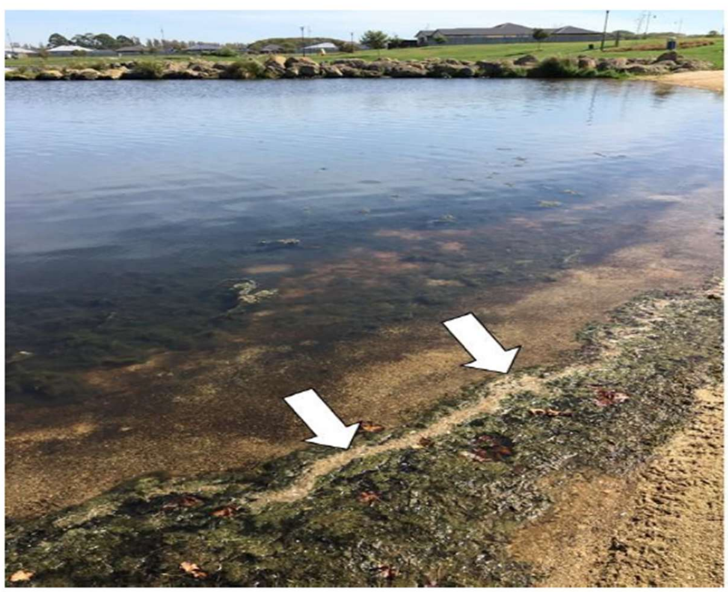


Figure 12: Benthic algae washed onto the beach, trapping cyanobacteria biomass on the surface (as indicated by white arrows).

Figure 13: Decaying *Potamogeton crispus* washed up on shore at Pegasus Lake.

An indication of the pros and cons for adaptive management of Pegasus Lake is listed below:

Pros:

- Achieves the objectives of the Lake Management Plan
- Proven protocols and procedures for notifying and managing cyanobacterial bloom durations
- Low capital and operational costs

Cons:

- No reduction in cyanobacterial bloom duration
- No ability to improve water quality