Managing for Ecosystem Health in the Waikato River: Interactions between phytoplankton, nutrient availability, flow and temperature

TLG Summary for CSG#10

25 February 2015

National Policy Context

1. The National Policy Statement for Freshwater Management (2014) identifies two compulsory values (Ecosystem Health and Secondary Contact Recreation) that need to apply to all Freshwater Management Units.

2. In the process of setting regional plan objectives, regional councils must include these compulsory values and identify attributes that can be used to measure their 'State'.

3. Among other attributes, the NPS-FM (2014) identifies Phytoplankton biomass (algae; measured as mg Chlorophyll a per cubic metre), Total Nitrogen (TN, mg/m^3) and Total Phosphorus (TP; mg/m^3) as appropriate Attributes to measure Ecosystem Health in lakes. National guidance on numeric states (A-D bands) for these Attributes has been provided.

Attributes for Ecosystem Health along the Waikato River main stem

4. In recognition of the lake-fed nature of the Waikato River and the potential influence of hydro lakes along the river system, the TLG has previously recommended that the CSG adopt Phytoplankton, TN and TP as attributes relating to Ecosystem Health along the entire main stem of the Waikato River (excluding Waipa River). There is a session planned on these attributes for CSG#10.

State and trends in phytoplankton biomass, TN and TP

5. The TLG has previously summarised the current state of the Waikato River in relation to Phytoplankton biomass, TN and TP levels (see presentation at CSG#8).

6. In general, phytoplankton biomass and levels of nutrients increase down the Waikato River. Phytoplankton biomass and TN increase from an 'A' state in the Upper River to a 'C' state at Karapiro. TP reaches a 'D' state below Ngaruawahia.

7. Phytoplankton biomass is generally low in winter and increases in September and can be high in October to March. There is seasonal and month-to-month variability. Despite this short-term variability, there are also long-term trends apparent in phytoplankton biomass, TN and TP (WRC data analysed in Vant 2013).

8. The long-term (10 and 25 year periods) water quality monitoring data from the Waikato River shows there is a significant trend of decreasing chlorophyll-a concentration at all sites downstream of Lake Ohakuri. Overall, long term trends for the Waikato River also demonstrate

increasing total nitrogen concentration and no or decreasing trends in total phosphorus concentration.

9. The decreasing trend in chlorophyll-a concentration despite an increasing trend in nitrogen indicates that controls of phytoplankton biomass are more complex than being simply linked to nitrogen concentration.

Factors controlling phytoplankton biomass

10. Light, temperature, hydrodynamics (e.g. flow, water level and mixing regimes), grazing pressure and nutrient availability all influence the growth and biomass of phytoplankton in lakes and lake-fed rivers. In determining appropriate freshwater objectives for the Waikato River, including the hydro lakes, it is important to understand these drivers of phytoplankton biomass, their interactions, and the extent to which they can be managed.

11. Two separate studies have recently been completed to better understand nutrient limitation and drivers of phytoplankton biomass in the hydro lakes and main stem of the River and these add to the body of previous research and monitoring.
    a. WRC commissioned NIWA to undertake monthly nutrient bioassay and zooplankton grazing experiments at four river monitoring locations (Ohakuri, Karapiro, Ngaruawahia and Rangiriri) from November 2013 to April 2014 (Gibbs et al. 2014).
    b. DairyNZ commissioned NIWA to measure primary production rates under four different flow regimes in Lake Karapiro between December 2013 and March 2014, and to understand stratification and mixing processes, dissolved oxygen dynamics, and in-lake nutrient limitation on one sampling occasion (Gibbs et al. 2015).

    The studies were conducted separately and shared between DairyNZ and WRC only after completion of the reports in January 2015. Both parties agreed to make the reports available to the TLG (and their reviewers) on a confidential basis prior to any wider release.

12. Gibbs et al. (2014) found indications that phytoplankton growth at the four sampling sites along the river was enhanced with the addition of N and P, and to a lesser extent, P alone (see Figure 1 below). There were no apparent increases to N addition on its own. However, based on a single, short-term assay in late summer along the length of Lake Karapiro, Gibbs et al (2015) found that phytoplankton growth responded to addition of N and P, P, and N alone.

13. Gibbs et al. (2015) found that surface chlorophyll-a concentration increased with distance from Lake Arapuni during periods of thermal stratification[1]. Stratification coincided with increased water residence times associated with low to medium flow rates though the Karapiro dam. (See Figure 2 below).

[1] The thermal stratification of lakes refers to a change in the temperature at different depths in the lake, and is due to the change in water's density with temperature. Essentially the lake separates into different layers based on temperature/density differences.

14. This finding confirms earlier studies that water quality in the Waikato River is affected by processes occurring in the hydro lakes, in particular by providing residence time for algae to grow with flow-on effects downstream of Lake Karapiro.

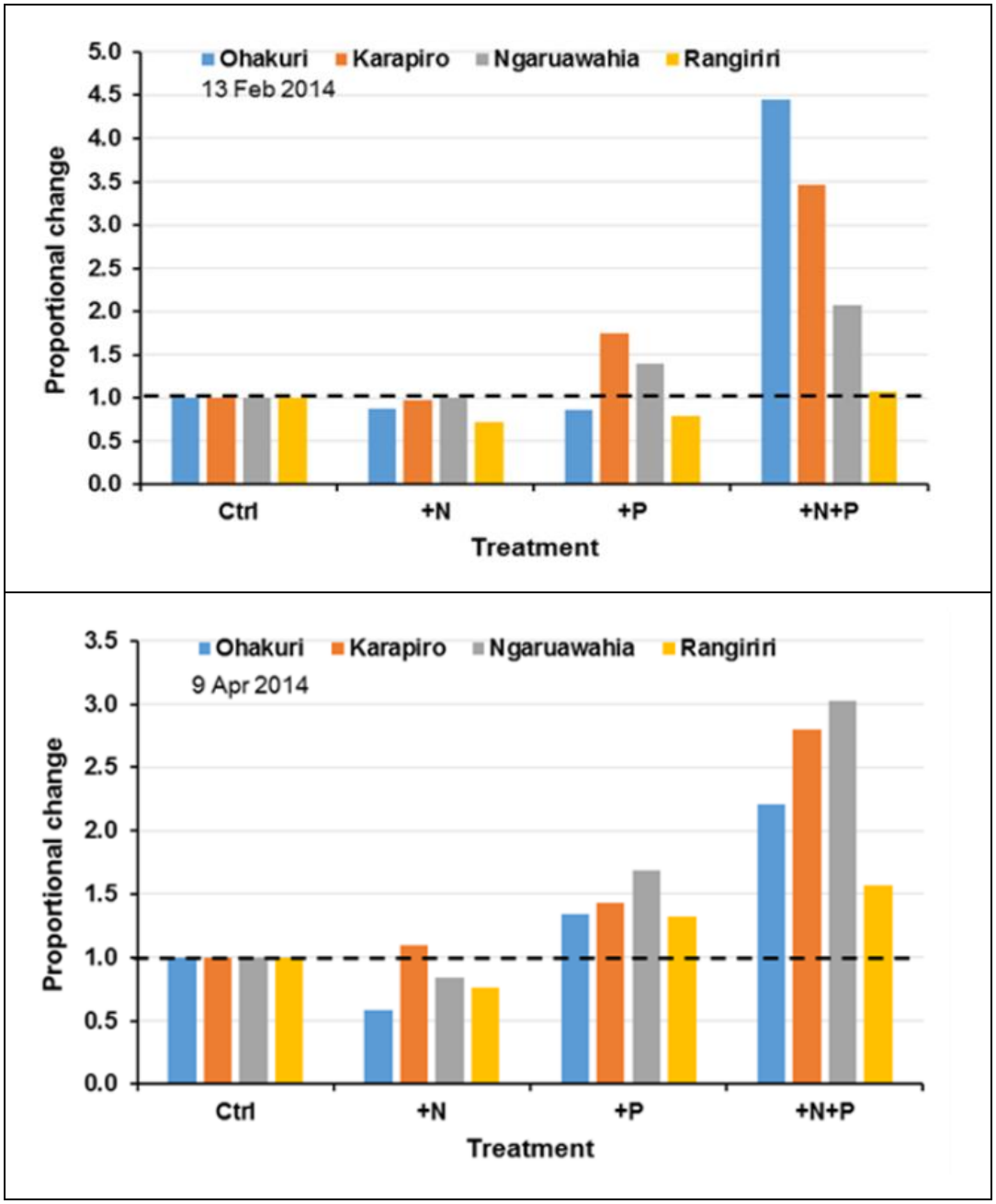

Figure 1. *Examples of observed changes in algal biomass resulting from experimental additions of N, or P, or N&P on two of the six occasions studied. Changes are relative to Control (Ctrl).*

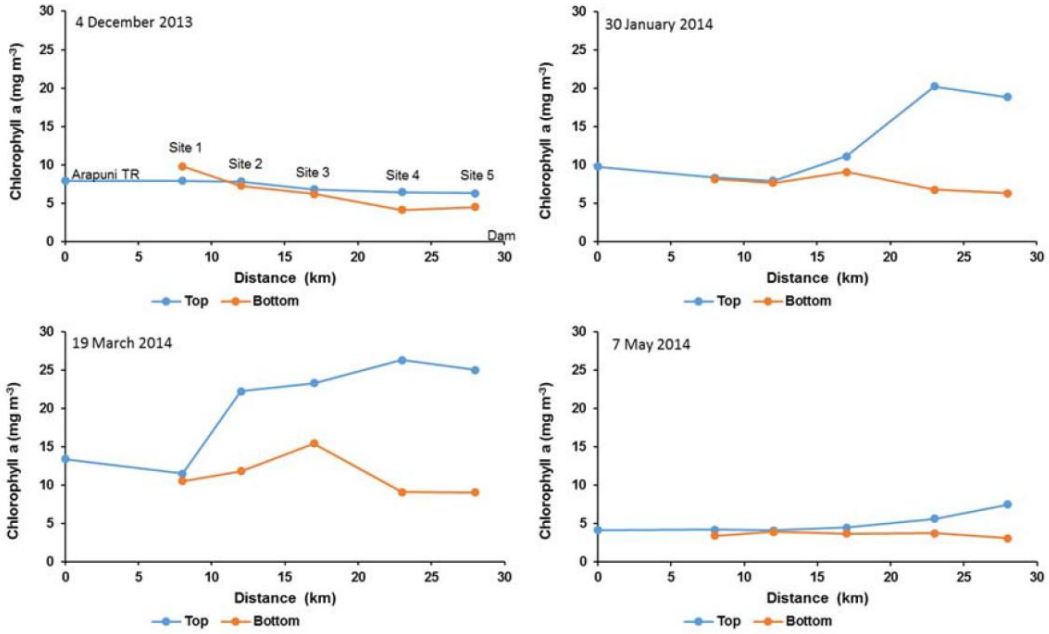

Figure 2. Phytoplankton biomass (Chlorophyll a; mg/m3) along Lake Karapiro on four occasions. Figures show phytoplankton growth in the surface waters in January and March, but not in December and May.

Peer review

15. The TLG has sought peer review from three nationally-recognised lake scientists - David Hamilton, Ian Hawes and Marc Schallenberg.

16. These reviews have been received and a caucusing of the authors, the reviewers, and technical expertise from the commissioning organisations (WRC and DNZ) took place on 26th February 2015. This was facilitated by TLG member John Quinn, with Bryce Cooper (TLG Chair) in attendance for parts of the meeting.

17. The reviewers were asked to focus on 23 draft key messages that had been prepared by the authors and technical experts in the commissioning organisations. The caucusing resulted in a consensus view being reached on 22 of 23 points, with the last point still to be resolved (either as an agreed point or, if consensus cannot be reached, an explanation of the different viewpoints).

18. In preparing this document, the TLG have taken note of the caucusing but we still await the final wording and sign-off by the parties on a final agreed key messages statement.

References

Gibbs, M., Albert, A., Croker, G., Duggan, I., Ovenden, R. 2014. Waikato River bioassay study 2013-14. NIWA Client Report HAM2014-072. 43 p.

Gibbs, M., Safi, K., Albert, A., Duggan, I. Bowman, E., Burger, D. 2015. Factors influencing chlorophyll a concentrations in the Waikato River. NIWA Client Report HAM2014-059. 58 p.

Vant, W. 2013.Trends in river water quality in the Waikato region, 1993-2012. Waikato Regional Council Technical Report 2013/20. 40 p.