A method for managing the alum dosing of Lake Rotorua

Prepared for Bay of Plenty Regional Council

2012 Draft

1 Introduction

Alum dosing of the Utuhina Stream and the Puarenga Stream has become an important method for remediation of Lake Rotorua. In 2012, Lake Rotorua has reached its objective quality set as a Trophic Level Index (TLI) of 4.2 in the Bay of Plenty Regional Council's Water & Land Plan. Alum dosing of the Rotorua streams is likely to be the most effective method that has enabled this achievement.

Comment [DO1]: No evidence provided yet. I would probably omit this sentence!

The occurrence of blue-green algal blooms in Lake Rotorua, the Ohau Channel, the Okere Arm of Lake Rotoiti and the Kaituna River are related to the nutrient status of Lakes Rotorua and Rotoiti. The potential adverse health effects, of blue-green algal blooms in these waters are to some extent manageable by alum dosing of Lake Rotorua and by the effectiveness of the Ohau diversion wall. The proposal to cap the sediments of Lake Rotorua with an alum dose to the hypolimnion was partly based on the objective of lessening blue-green algal blooms in the Okere Arm of Rotoiti and the Kaituna River. This action ~~is~~ appears now unnecessary due to the Utuhina and Puarenga Streams alum dosing, achieving the same objective. Because of the apparent effectiveness of the stream dosing, ~~A~~ a management system for alum dosing is proposed in this report so that the quality of the lake can be maintained at a level where adverse health effects do not re-occur.

Comment [DO2]: Maybe you want to tame this down a little. It reads very conclusive, but in fact is an unsupported claim.

In the first instance it is assumed that if Lake Rotorua meets or betters the Water & Land Plan objective TLI of 4.2, blue-green algal blooms are unlikely to occur. The parameters from which the TLI is derived were proposed by Rutherford *et al* (1989). An average in-lake total phosphorus concentration of 0.020 g/m^3 was proposed (Rutherford *et al* 1989) in conjunction with an average total nitrogen concentration of 0.300 g/m^3, an average chlorophyll *a* concentration of 10 mg/m^3 and an average ~~secchi~~ Secchi disc depth of 2.5 – 3 m. The annual TLI calculation does not provide a ~~precise~~ sensitive enough mechanism to act as a trigger to control the stream alum dose rate and maintain phosphorus levels in Lake Rotorua on a month to month basis. A mechanism derived around the monthly lake phosphorus concentration could provide a suitable mechanism with the annual TLI acting as a longer term control.

Comment [DO3]: Probably worth noting that samples will have to be analysed much quicker then.

2 Monthly phosphorus concentration

Water quality monitoring in ~~Two sites~~ in Lake Rotorua is carried out at two sites ~~are monitored~~ on a monthly basis. In Figures 1 and 2 the total phosphorus concentration for the surface water from these two sites are plotted with the raw data, and with a 2 term, a 6 term and a 12 term moving average. The 2 term average is the monthly data for each site averaged, the 6 term data point is a three monthly average and the 12 term data point is a 6 monthly average. The 2 term average has highlighted apparent errors in the data set (Appendix I) and is useful for that purpose but as an alum dosing trigger it would be too ~~reactive~~sensitive.

Alum dosing started at the Utuhina Stream site in 2006 and at the Puarenga site in April 2010 and this at least doubled the alum dose to Rotorua inflows and to the lake. Figure 2 shows that the response in reduction of the phosphorus load in Lake Rotorua was within an annual period of the Puarenga Stream dosing plant starting. The three-monthly average phosphorus concentration could be a sensitive trigger to use for adjusting the alum dose and the six-month average could provide an added control.

Comment [DO4]: It would be useful at this point to include a summary table of the dose rates per year for each stream.

For every 0.001 g/m^3 increase in total phosphorus in Lake Rotorua, the load of total phosphorus in the lake increases by 800 kg. To remove 800 kg of phosphorus, a minimum of 2400 kg of Al^{3+} (55944 kg 47% liquid alum or 4.8 L/hr for a year) would

Comment [DO5]: It would be very useful to outline your mass balance approach here so people can reconstruct your calculations.

be required based on an optimistic Al^{3+}:P reaction ratio of 3:1 (Cooke *et al*, 2005). ~~A~~ The proposed management strategy ~~could~~ to be implemented could be where the alum dose was increased by 5 L/hr from the current steady state for each 0.001 g/m^3 increase of the three-monthly average total phosphorus concentration in Lake Rotorua, above 0.020 g/m^3. —The dose would not be increased unless the six-monthly average total phosphorus for Lake Rotorua was higher than 0.020 g/m^3. If this happened, the alum dose would be increased by 10 L/hr for each 0.001 g/m^3 that the six-month average total phosphorus concentration exceeded 0.020 g/m^3. Once the six-month average in-lake phosphorus concentration was reduced below 0.020 g/m^3 then the alum dose rate should be reduced by 5 L/hr for each 0.001 g/m^3 but maintained above the original steady state dose rate.

Comment [AB6]: John your calculated ratio is 5:1 so unless we have a reason to be at 3:1 then why not change to 4,000kg Al3+ per 0.001ppm P.

Comment [DO7]: What is the current steady state?

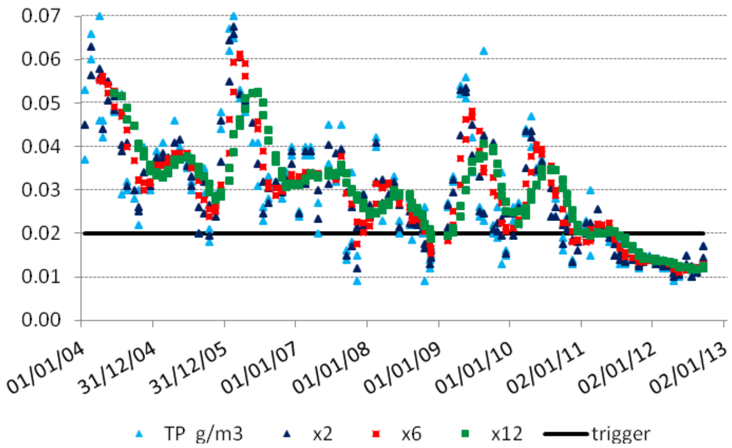


Figure 1 *The total phosphorus concentration in Lake Rotorua from 2 sites, with the monthly average (x2), the three monthly average (x6) and the six monthly average (x12) from January 2004.*

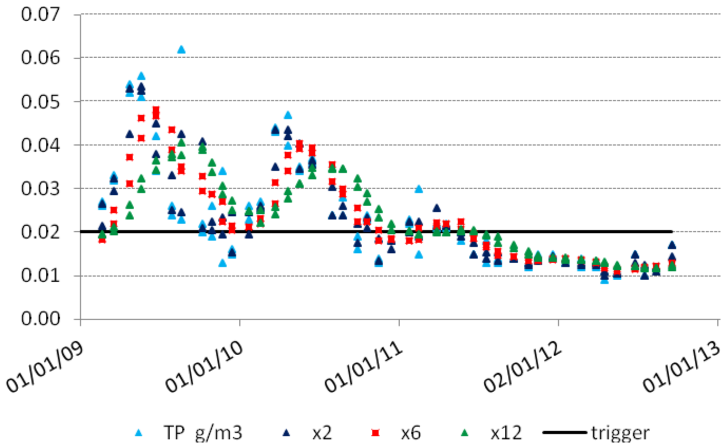


Figure 2 *The total phosphorus concentration in Lake Rotorua from 2 sites, with the monthly average (x2), the three monthly average (x6) and the six monthly average (x12) from January 2009.*

3 Discussion

The phosphorus concentration of Lake Rotorua will fluctuate with changes in the annual climate and changes in external/internal nutrient loading. Thus, ~~Adjustment~~ adjustment of the alum dose may be required continually. Frequent small adjustments may provide better management than allowing the lake concentration to fluctuate wildly.

The annual average total phosphorus concentration of 0.020 g/m^3 is the phosphorus component of the objective TLI of 4.2 for Lake Rotorua (Rutherford *et al* 1989, and BoPRC,). The TLI is an index of four components (total phosphorus and nitrogen, chlorophyll *a* and Secchi depth) and a TLI of 4.2 may or may not be met while maintaining the total phosphorus concentration at 0.020 g/m^3. While the total phosphorus concentration has varied between 0.010 and 0.020 g/m^3 the TLI has been below 4.2. If the TLI is found to exceed 4.2 while the total phosphorus concentration is 0.020 g/m^3, a lower total phosphorus concentration may provide a better objective.

The Bay of Plenty Regional Council has the ability to control the adverse effects of blue-green algal blooms which ~~effect~~ affect Rotorua, Rotoiti and the Kaituna River by alum dosing of the Utuhina Stream and Puarenga Stream. The funding for alum dosing will cease in the future unless the Regional Council and their Lakes Strategy partners renew their commitment. In the meantime, a science task exists to fine tune the alum dosing strategy so that an accurate cost can be made for alum dosing which can be balanced against other nutrient reduction methods. A dosing strategy is proposed in this report based on maintaining the total phosphorus concentration of Lake Rotorua waters at or below 0.020 g/m^3.

An initial steady state dose rate is required, which could be based on the action plan proposal to reduce the annual Lake Rotorua phosphorus input by 10 tonnes. Using a Al^{3+}:P ratio of 3:1 (Cooke *et al*, 2005), an annual dose rate of 30 tonnes Al^{3+} (699 tonne 47% liquid alum/year, 60 L alum/hr) would be required. As the in-lake phosphorus concentration is now below 0.020 g/m^3 a more conservative approach would be to set the steady state dose rate to 50 L/hr, allow the lake to equilibrate and apply the suggested alum dosing management method.

4 Conclusion

To be completed after a discussion as directed by the last TAG meeting

5 References

Cooke G D, Welch E H, Peterson S A, Nicholas S A (2005). Restoration of Lakes and Reservoirs. Third Edition

Rutherford ...

To be completed …

Comment [DO8]: Year?

Formatted: Font: Italic

Comment [DO9]: So, are you proposing a new lower TP concentration limit?

Comment [DO10]: I think you need to tame this down a little bit. This reads like alum is the "only" solution to completely control algae blooms.

Comment [DO11]: Do we know when?

Comment [AB12]: My concerns are these: is the 3:1 ratio high enough in view of what you reported to us last year about our success of alum locking?
Any average is based on the recent history of the lake P concn. I am concerned that we could allow an algal bloom if we are not responsive enough. A bloom can presumably occur if we get a nice period of stratification and a heavy P release. By the time we monitor that in the water it will all be too late for us to control and the bloom will be in full force. My suggestion is that we generally follow your strategy but adjust in times that we would be expecting a P release to occur. So for example we adjust alum dose rate to the lake over the months of March April May regardless of P concn at least in the first 2 years. Could base the dose on say total P expected if we get a good release event or two?

Secondly we must also incorporate a calculation to ensure compliance with both resource consents. I expect we can easily meet that but need to confirm with any adjustments and it might be a good plan to set up a table that shows compliance dose rates at the two plants over the range of dose rates expected. Please do this as Al3+ as well as alum chemical as that is what the operators know.

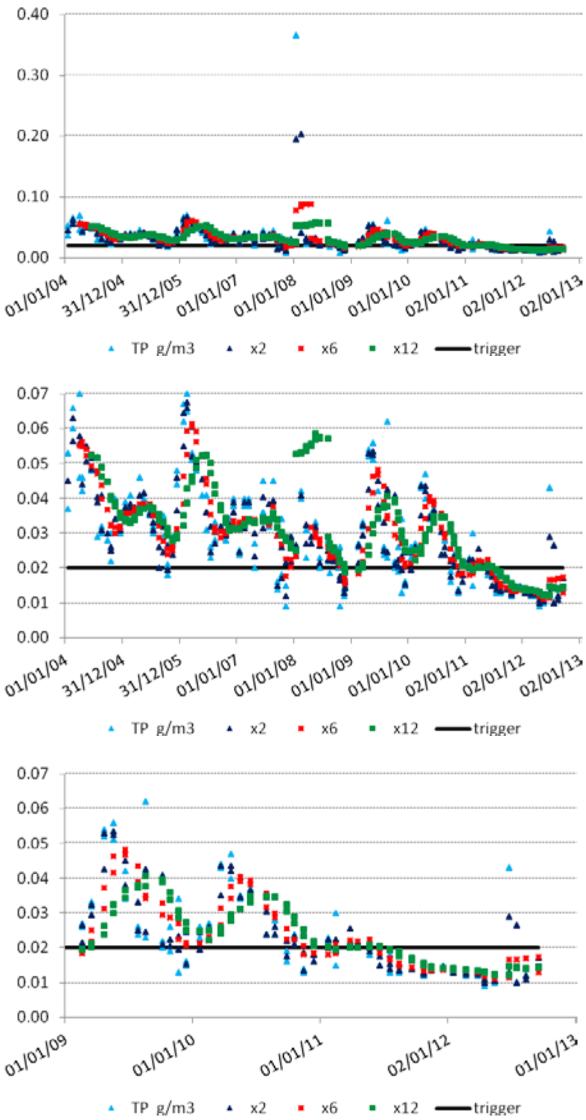
I think it would be useful to prepare a total dose rate table based on the expected Al:P ratio, or could do both. This could be a total dose to both streams including both alum and al3+ as well as a split table as to how to adjust each plant.

In view of what you have presented here I should make sure we are adjusted to dose say 20ppmP X 2400(3:1) X 100/4.2 = 1,142,857 kg annually? Or if (5:1) 20 X 4000 X 100/4.2 = 1,904,761kg. What one do you think we should go with? Now of course the dosing is based on the lake needs not the stream needs as initially planned. I think I need to check how much alum we have dosed this year to help make that decision but we have been overdosing by accident as the control systems at RDC were not properly calibrated and cocked the actual dose rate up. That is why I want to tell them alum dose rather than al3+ dose as it just adds another level of error at the control switch. ...

Appendix 1 Errors in the lake monitoring dataset.

This will be left out of the final document. It is just to highlight that I changed the data set as downloaded from the database.

Comment [DO13]: I would leave this section in the document as an appendix.



In my opinion there are errors:

TP, 26/6/12, site 2, 123317 (123318 was not in this data set but was also high).
TP. 16/1/08, site 5, 080350