IN THE MATTER OF	The Resource Management Act 1991
AND	
IN THE MATTER OF	Lake Rotorua Nutrient Management – **PROPOSED PLAN CHANGE 10** to the Bay of Plenty Regional Water and Land Plan

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SUMMARY OF EVIDENCE IN CHIEF OF ANDREW CHARLES BRUERE ON BEHALF OF THE BAY OF PLENTY REGIONAL COUNCIL

Evidence topic: Overview of Science and Restoration Initiatives.

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1. The management of Lake Rotorua is a part of the Rotorua Te Arawa Lakes Programme (the programme). I am involved in three aspects of the programme #4:
    a. Delivery of the science through our various science providers,
    b. Development of Action Plans for each lake, and
    c. Implementation of in-lake restoration initiatives.

2. My evidence is an overview of how the science programme works and feeds into the development of Action Plans, Planning documents and interventions #9, and is designed to be read as an introduction to the technical reports of Dr Rutherford and Professor Hamilton that detail their modelling outputs and conclusions. I use a # reference to the relevant paragraph in my evidence in chief for cross-referencing purposes.

3. My main point is that there is a robust background of a programme of scientific consideration that supports the planning decisions made in PPC 10 that has been developed over a long time. Recent work continues to support those decisions and proposals rather than other options.

4. I provide summary evidence on:
    a. The use of computer environmental models to predict the effect of land use changes on lake water quality #39 and #49, and explained at paragraph 17 and 18 below.
    b. How and when N reaches the lake (Dr Rutherford's ROTAN modelling),
    c. The relationship between N and P, and water quality (Professor Hamilton's DYRESM-CAEDYM modelling work),
    d. How these nutrients can be manipulated to affect water quality (Hamilton #27).

5. The programme is supported by a substantial science team, comprising: #16 #17
    a. The Water Quality Technical Advisory Group, which has been in existence since the 1970s,
    b. The Chair in Lake Restoration at the University of Waikato,
    c. A range of Crown Research Institutes,

d. Specialist BOPRC scientists, and
e. The Land Technical Advisory Group. #18

6. The quality of water in Lake Rotorua can be measured using a number of key parameters. The Regional Water and Land Plan (RWLP) sets specific water quality targets using a metric called the trophic level index (TLI). #20. The TLI is a statistical indicator relying on four water quality parameters measured monthly in the lake to achieve a single indicator result #22. The TLI is calculated using data about the lake total N, total P, chlorophyll-a and secchi disc water clarity.

7. The actual TLI calculated in this way can be compared with the Regional Water and Land Plan TLI target to assess compliance with the standard set for a particular lake #21.

8. For Lake Rotorua the TLI standard set is 4.2 units. A higher TLI represents poor water quality while a low TLI represents improved water quality #23. The TLI for Lake Rotorua is presented in Figure 4 below:

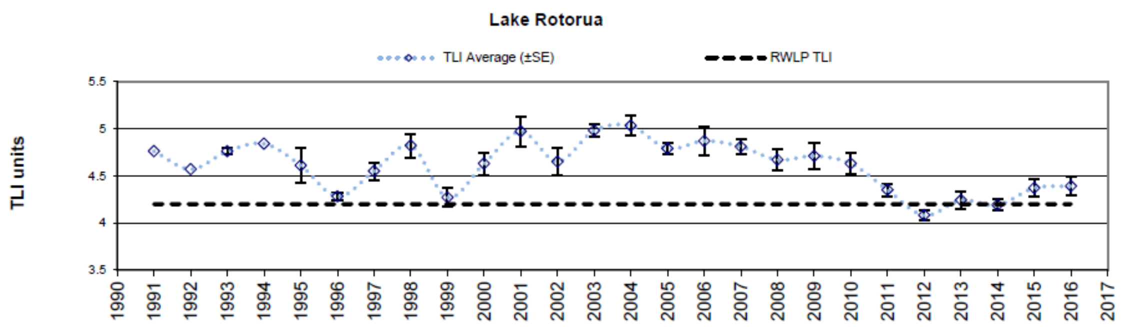

Figure 4, Historic Lake Rotorua TLI.

9. Figure 4 shows that water quality measured by the TLI can fluctuate and that since about 2006 there has been a clear trend of improved water quality #28. There has been recent compliance with the target TLI #28. This is largely due to the alum dosing programme #85 #86.

10. To achieve the TLI of 4.2 units the science advice is that catchment inputs of both N and P need to reduce to 435 t/y and 37 t/y of N and P respectively #24. These targets require a substantial reduction from the current catchment input loads for N and P, and were first set in 1986 #26.

11. In setting these targets the science advisors had regard to the communities perception of: when did the lake have acceptable water quality? The TLI target of 4.2 relates to a perceived water quality in the 1960s. The catchment nutrient targets were set to achieve the prescribed TLI target #26.

12. In managing water quality in the natural environment it is important to have regard to the level of nutrients available for algal growth. Typically either N or P (or both) are

limiting factor in algal growth. In other words the addition of either N or P will stimulate more algal growth #27 #30. So taking away one or both nutrients will reduce algal growth. This is the basis of most lake management programmes.

13. Nutrients reaching the lake come from all types of land use #30. Some are more polluting than others. N tends to exist in the environment in a soluble state where as P tends to be readily absorbed onto soil particles and is generally not in a soluble form #30. This means the method of transport for the two nutrients differs. N will more readily travel through ground water whereas P will travel more readily along the land surface on its way down the catchment to streams and the lake #37, although in this catchment natural sources of dissolved reactive phosphorus forms dominate #30, #32.

14. The science advice to the programme is that in addressing the problem of poor water quality in Lake Rotorua the control of both N and P is necessary #31. Addressing only N could cause the lake to become dominated by blue green algae, many of which can fix their own N from the atmosphere. The control of phosphorus alone would need to be to the extent that it made P the limiting nutrient.

15. The prospect of limiting P to the extent that the lake can be made Phosphorous limiting would be highly challenging as research has shown there is a highly elevated contribution of P to the lake from natural sources #31. The old age ground water of the catchment (average age of 60 years) leaches geological P from the underlying geology #32. Generally without an intervention such as alum dosing this geological source cannot be managed, and therefore only a fraction of the P reaching the lake is from manageable anthropogenic sources.

16. Of that anthropogenic sourced P, recent research indicates that somewhere between 43 – 64% already will need to be reduced as well as reaching the N load of 435 t, to achieve the TLI target #33. Obviously to target P in the absence of reducing N would be vastly more difficult still, and the science opinion is that it would not be possible to get enough P out of the system for this to be feasible #31.

17. The focus of PPC10 rules is on the reduction of N. Some P reduction will occur in association with this. However the sources are not necessarily the same and due to the increased time of travel for N (through ground water) it is practical to start the control of N in advance of the P reductions from the catchment as changes to P reductions will not have the same time delays, and will also involve urban sources. Currently alum dosing is controlling in-lake P levels, however due to environmental risks, uncertainties and cost, alum dosing is not identified as a long term solution #34.

18. Further work is identified to evaluate in more detail the sources of P and estimate the P reductions associated with actions aimed at removing N #38. This will occur as part of the wider NPS-FW programme for the Rotorua Lakes #57.

19. The assessment of the sources of N contributing to the lake and the pathways is complex. Environmental computer models are used for this purpose #39. The

OVERSEER model is used to assess the level of N and P leaving the farm, below the plant root zone or runoff. NIWA has developed the ROTAN model used to assess how N losses travel from the farm root zone to the receiving waters of the lake. The outputs of the ROTAN model along with other P estimates of runoff are used to inform the Lake Model. The Lake Model is used to predict water quality according to differing land use scenarios. ROTAN takes account of varying ground water age in the catchment.

20. The outcomes of three modelling studies using ROTAN 2011, The lake Model and ROTAN 2016 support that the sustainable catchment N target of 435 t/yr #40.The Lake Model indicates the impact of meeting the 435 t/y N RPS requirement along with an associated P reduction will bring the lake close to the 4.2 TLI target. It also recommends action to get sediment releases of P under control, which are currently being controlled by alum dosing #42.

21. ROTAN 2011 predicts that if N loads remain constant at 2010 level the steady state load would reach 755 t/y N in the next 70 years #45.

22. Future updates of the OVERSEER model will result in different nutrient output predictions. ROTAN will need to be recalibrated to the new OVERSEER outputs when and if it changes. This would enable ROTAN to continue to be used to make predictions of N loss to the lake from changing land use scenarios #49.

23. As water travels through the environment it can gain or lose contaminants such as N and P #58. The loss of N or P through the environment is referred to as *attenuation*. Dr Rutherford is the expert on this issue. In summary, for N attenuation can be complex and measurement of losses is not simple. The main driver of N loss in the environment is de-nitrification where a carbon source (normally organic matter) and a lack of oxygen is necessary to drive this biochemical reaction. Assessing attenuation is further complicated by the varying ages of ground water reaching the lake (time of travel). The water reaching the lake today has started its journey through the land anywhere between: less than one year ago up to 140 years ago, depending on the particular pathway it followed.

24. The only practical way of assessing the potential loss of N through this journey is the use of a model that can have regard to the varying ground water ages reaching the lake. This is a key component of the ROTAN model # 59-64.

25. The most recent estimate of attenuation by ROTAN is in the range 32 to 50%. This compares favourably with other published estimates of catchment scale attenuation #66.

26. Land use change through the application of PPC10 rules is not the only method applied to improving lake water quality #67. The RWLP brought in Rule 11 in 2005 to control nutrient loss from 5 lakes including Lake Rotorua. It was implemented to address the risk of increased nutrients from intensifying land use, by benchmarking them and holding them constant. The development of action plans for was also required by RWLP and 10 lakes are subject to these non-statutory plans.

27. A $40 M incentives fund and a XX$M fund for gorse removal are available to encourage voluntary land use change #70. The total in-lake N target for these two funds is 130 t N.

28. A number of interventions have already commenced and are having an impact on improving water quality. Some of these are seen as permanent changes to protect water quality such as sewage reticulation, while others are seen as temporary changes to address nutrient issues while more permanent land use change options are implemented #68 -72.

29. Two key interventions for the Rotorua/Rotoiti Lakes complex are:
    a. The alum dosing programme, and
    b. The Ohau Diversion wall.

30. The alum dosing programme has effectively controlled in-lake P since about 2006 when dosing first commenced. The Ohau Wall has been in place since 2008 with the aim of protecting Lake Rotoiti from the ravages of poor Lake Rotorua water #73 -80. These interventions have been promoted as *“short-term”* to improve water quality while the community waits for the improvements from sustainable land use to take effect. (The Wall does not alter the Lake Rotorua quality but manages its effects).

31. Alum dosing requires obtaining resource consents and community support both for the funding and cultural aspects. There is a risk alum dosing may need to stop due to lack of support or possible environmental impact. In the case that dosing ceases, the level of phosphorus will increase and algal blooms may resume after a few years to plague the lake #87. The Ohau wall is designed to last 50+ years in anticipation that it will take an extended time for the impacts of land use change to reach Lake Rotorua and flow through to Rotoiti.

32. In addition the reticulation of sewage and an improved treatment process for Rotorua City sewage in 1990 made an immediate reduction in N and P of 150 t/yr and 30 t/yr respectively #84.

Conclusion

33. ROTAN annual has predicted that the N load reaching the lake under current use will most likely reach 750 t/y. This aligns with the 725 t/y initially modelled by ROTAN 2011 #53.

34. A significant reduction in N is required to reach the 435 t/y target #54.

35. The ROTAN annual model has predicted the N load reaching the lake as a result of simulated land use change. The predicted N load after the prescribed land use change is 450 t /y. The difference between this and the 435 t/y target is not statistically significant #55.

36. The conclusion from the ROTAN annual modelling is that the reductions from PPC10 and associated non regulatory reductions may slightly undershoot the reduction target by 2032.

37. The key long term solution for many of our lakes is to ensure that the inputs of nitrogen and phosphorus are managed to a level that meets the sustainable nutrient load associated with meeting the lakes target TLI as specified in the Regional Water and Land Plan[1]. For Lake Rotorua these are 435 t nitrogen (through the Regional Policy Statement) and an associated 33.7 to 38.7 t phosphorus. If these targets for nutrient input are not achieved then any short term intervention such as alum dosing or other options will need to be implemented on an ongoing basis. This is not viewed as a sustainable long term option #89.

38. Long term land use changes as required by PPC 10 rules, the RLP Incentives programme and Gorse control programme will take time to implement and for the effects of these changes in nutrient status to flow through to the lake. The short term interventions being used within the programme are designed to hasten lake recovery by complementing the land use change as well as providing some support for addressing legacy impacts, for example alum is having an impact on reducing the legacy impact of phosphorus releases from the lake sediments during summer stratification events. However, land use change is the most vital part of the sustainable long term recovery for Lake Rotorua, and this is supported by the science programme. Without land use change to meet the sustainable nutrient targets either the TLI will not be sustainably achieved or ongoing interventions such as alum dosing will need to continue in perpetuity to achieve the lake TLI target #90.

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Date: 06 March 2017.

[1] Refer evidence of David Hamilton.