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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REBUTTAL EVIDENCE OF ANDREW CHARLES BRUERE
ON BEHALF OF THE BAY OF PLENTY REGIONAL COUNCIL

Dated 6 March 2017

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1. I confirm my name, qualifications and compliance with the Code of Conduct – Expert Witnesses, as per my evidence on chief. Since filing my evidence I have read the evidence of the following submitters and now make comments in rebuttal and explanation:

    1. Dr Thomas Stephens for Dairy NZ Limited,
    2. Carla Muller for Dairy NZ Limited,
    3. Rotorua District Residents and Ratepayers
    4. Lindsay Hugh Moore.

1.1 Rebuttal of evidence Dr Thomas Stephens:

1. Dr Stephens states at 3.4: "*Given uncertainty in how Lake Rotorua will respond to future nutrient management and evidence that P-limitation is effective at attaining a TLI ≤4.2, I support a science review and implementation of adaptive management as set out in Method LR M2 and M3.*"

    Response: I do not agree with the first part of that statement. It is not uncertain about how Lake Rotorua will respond to the future nutrient management. Considerable science research and modelling has been undertaken from the 1980s to the current time. The advice from this research has been consistent since the 1980s and is supported by recent reports including the 2012 and 2015 lake modelling undertaken by Hamilton et al.

    The data show that Lake Rotorua has recently reached the TLI for a limited period, but not consistently or sustainably, and largely as a result of the alum dosing programme. Evidence from Hamilton et al (2015) does not conclude the lake is solely

P limited and does detail the mechanisms by which alum has assisted in the temporary achievement of the TLI limit of 4.2. Specific references to studies testing whether the lake is N or P limited are reported and it is stated that: *"In these studies nitrogen + phosphorus additions have consistently been found to have the greatest growth-stimulation effect on phytoplankton".* It is therefore my opinion that, although I support the current programme of ongoing science reviews, this is not a requirement of uncertainty or P-limitation, but of ongoing best science and evaluation practices, upon which the Lake Programme is built. Adaptive management is an integral part of that process, and always has been.

2. Dr Stephens states at 4.1: *"Lake Rotorua attained the community water quality target in 2012 with limited variation since (±0.2 TLI units) but here, I demonstrate this was not predicted by in-lake modelling, nor considered in the approach underpinning derivation of the sustainable nitrogen load (435 tonne TN/yr)."*

   Response: I do not agree with this statement. Lake Rotorua reached the TLI during 2012 – 2014 but in 2015 and 2016 it failed to meet the TLI target. Hamilton et al (2015) predicted alum dosing along with a nitrogen load of 645 t annually would achieve around the TLI observations described above.

3. Dr Stephens states at 5.6 (c): "*However even this, the most exhaustive review to date, failed to consider that: … (c) A lack of knowledge about the efficacy of P-mitigation is not evidence that P-mitigation would be ineffective."* (referring to Smith et al 2016).

   Response: I do not agree with Dr Stephens' statement; it is a fundamental misunderstanding of the work. The advice regarding a co-limited (N and P) approach to achieving the TLI target is not based on the efficacy of P-mitigation but on inability to deal with high natural P inputs to the lake. This is supported by Tempero et al (2015), where under the co-limited scenario; 43 – 64% of the anthropogenic P reaching the catchment would need to be removed. To achieve P-limitation would require a greater amount of P to be removed from the catchment P load, and it is not at all clear if this is possible. It is possible that to achieve P-limitation a load greater than the entire anthropogenic contribution may need to be removed. This aligns with the conclusions of White et al. (1988) where they state: *"Application of these figures to the procedures developed in this paper suggest that a 75% reduction of in-lake total phosphorus would be required to achieve a 42% reduction in chlorophyll-a to an* *average concentration of 10 mg/m^3. "* Note 10mg/m^3 for chlorophyll-a concentration is equivalent to the 4.2 TLI target. Although White et al. (1988) refer to in-lake P concentrations as opposed to catchment loads, a 75% reduction of in-lake P to achieve P-limitation is clearly challenging. It is interesting to note that science advice on the difficulty of achieving P-limitation by reducing P has been consistent since 1988.

4. Dr Stephens states at 6.1: *"Here, I demonstrate a lack of evidence about P-management has guided the decision by Council to prioritise N-management in PC 10. That without robust science on P-management strategies specific to Lake Rotorua, a science-based decision on whether to prioritise N and/or P-management cannot be made…"*

   Response: This has been covered in point 3 above, where I rebut the assertion of a lack of evidence, and explain what the evidence means.

5. Dr Stephens states at 6.2 states: *"Mr. Bruere identifies that the focus of PC 10 is upon reducing N (paragraphs 34 & 38) due to the "challenging" nature of controlling for anthropogenic P-loss (i.e., that a 43-64% or 10-15 tonne TP/yr reduction in anthropogenic loads is required for a TLI ≤4.2). In his evidence, Prof. Hamilton (paragraph 15[l]) also identifies that high background (natural) inputs of TP "limit" the Council's ability to manage P in Lake Rotorua without alum dosing, acknowledging the 43-64% reduction in anthropogenic P-losses otherwise required."*

   Response: I refute Dr Stephens' comments here. I have not identified the reason for a focus on N reduction in either of the paragraphs referenced as being due to the challenging nature of controlling for anthropogenic P-loss.

6. Dr Stephens states at 6.3: *"Mr. Bruere (paragraphs 34 & 38) identifies P-mitigation strategies have been poorly researched, with limited effort to date investigating the opportunity to mitigate external loads, their costliness nor their cumulative effect towards achieving the sustainable P-load."*

   Response: I strongly disagree with this statement, which misrepresents my evidence, or misunderstands it. I did not make any comment about the <u>quality</u> of P-mitigation research as stated by Dr Stephens ("*poorly researched*"), or 'identify' such a matter by implication. In Para 34 of my evidence in chief I was specifically referring to the

amount of P which may be removed in association with N reduction techniques and commented that: *"the level of phosphorus reduced in this way is as yet uncertain."*
In para 38 I was referring to Council undertaking further study to establish more certainty around this question of P reductions associated with land use N reduction techniques.

I had no expectation that the N reduction techniques would achieve the necessary P reduction target for the catchment. I explain in my evidence that this is due to the different methods of transport of each nutrient from the catchment to the lake.

7. Dr Stephens states at 6.6*: "Understanding how to reduce lake TP loads to ~37 tonnes TP/yr is fundamental to managing Lake Rotorua to a co-limited or P-limited TLI target. It remains uncertain however, if mitigation of anthropogenic P-loads can generate equivalent or greater reductions than alum has in achieving a TLI ≤4.2."*

   Response: The level of uncertainty is not as stated by Dr Stephens. My understanding is that it is highly unlikely that mitigation of anthropogenic P-loads can generate equivalent or greater reductions than alum has in achieving a TLI < 4.2. This is explained in more detail in Rebuttal point 3 above. The approach of Plan Change 10 is to achieve a nutrient co-limited state where both N and P loads are reduced.

   It is also of value to consider the historic inputs of N and P to understand the changes over a longer time period. Rutherford et al. (1989) provide some estimates of nutrient inputs over the 1960s to the 1980s. During the period 1984-85 the N and P inputs to the lake from sewage discharge were estimated to be 33.8 and 150 t/year for P and N, respectively. Current sewage loads to the lake are now around 1.5 and 30 t/y P and N, respectively. These reductions relate to a 45% and 26% reduction in P and N, respectively. This indicates that previous reductions from improved sewage treatment to address nutrient loads to Lake Rotorua have actually been more focussed on the total P load. (See parag 84 in my evidence in chief).

8. Dr Stephens states at 7.3: *"However, the scientific evidence underpinning P-management is uncertain regarding, whether:*
   a. *Anthropogenic P-loads can be mitigated sufficiently to achieve P- or co-limitation of TLI ≤4.2 (i.e., the potential for and effect of P-strategies in the catchment relative to those of alum);*

b. *Prioritising P-management would carry with it lesser cost or risk to the community in achieving a TLI ≤4.2 than the focus on N-management in PC 10."*

Response: This matter is not uncertain as stated by Dr Stephens. Evidence in paragraph. 3 above demonstrates the difficulty in achieving P-limitation. Co-limitation is a far more likely and attainable scenario and results in requirements of significantly less challenging reductions in phosphorus, c.f. a P-limited situation.

Prioritising P-management is likely to present a greater risk than the co-limiting approach BOPRC has adopted. The reasons for this are partly outlined in paragraph. 3 above. Under the alum dosing regime, where in-lake P levels have been significantly reduced, phytoplankton are not solely P-limited. Hamilton et al. (2015) state that alum has not only had an impact on in-lake P concentrations but likely also on in-lake nitrogen concentrations. A P-limiting approach without alum would most likely not be able to be to achieve what alum dosing has done in terms of reductions in nitrogen and TLI.

9. In Dr Stephens' Parag. 7.4 and 7.5, the evidence emphasises the need for an adaptive management approach and robust evidence-based scientific input at 5 yearly intervals.

Response: As noted above, I support Dr Stephens comments in this regard and highlight the research work dating back to the 1980s, the Rotorua Lakes Water Quality TAG which is responsible to the Rotorua Te Arawa Lakes Strategy Group, the engagement of the Bay of Plenty Regional Council Chair in Lake Restoration and other key research contributions. These have resulted in ongoing review of the science which supports the co-limited approach to the restoration of Lake Rotorua. This research has provided the underpinning regular science evidence and is most recently demonstrated in the contributions from recent reports such as:

- Hamilton et al. (2012), Predicting the effects of nutrient loads, management regimes and climate change on water quality of Lake Rotorua,
- Hamilton et al. (2015), Assessing the effects of alum dosing of two inflows to Lake Rotorua against external nutrient load reductions: Model simulations for 2001-2012
- Rutherford et al. (2011), ROTAN catchment modelling,
- Rutherford (2016), ROTAN annual catchment modelling,

- Tempero et al. (2015), reviewing the anthropogenic P loads reaching Lake Rotorua,
- Tempero (2015), Ecotoxicological Review of Alum Applications to the Rotorua Lakes.
- There are numerous other works published in refereed journals associated with the Rotorua Lakes Programme.

The research and implementation programme are ongoing and at no point has there been an identified need to change the requirement to address both N and P in the restoration of Lake Rotorua water quality.

10. Dr Stephens states at 7.6: *"Currently, there is simply no robust evidence of the potential for or benefit of prioritising a P-management approach to achieve a TLI ≤4.2, meaning there is equally, no firm evidence for an N-management approach being more cost-effective or risk-averse."*

    Response: This statement is fundamentally misconceived. BOPRC is not promoting the former approach, so of course would not have any evidence that such an approach would be beneficial. BOPRC, through Plan Change 10, wishes to ensure a co-limitation of phytoplankton growth in Lake Rotorua, in line with the Regional Policy Statement direction, and for reasons already detailed in paragraph 3 above. The science evidence since Rutherford et al. (1989) advises against a single P reduction approach because of the difficulty of achieving P-limitation. This is supported by Hamilton et al. (2015) and studies into phytoplankton limitation have found additions of both N and P have consistently been found to have the greatest growth-stimulation effect on phytoplankton.

1.2 <u>Rebuttal of evidence Carla Muller</u>:

1. At 1.2 Ms Muller refers to Dr Stephens conjecture that we may not be undertaking the most cost effective solution in achieving the desired water quality objectives.

   Response: We first have to develop a way that is supported by science evidence before looking at economic advantages. I have presented rebuttal evidence at point 3 in response to Dr Stephens suggestion that a P-limiting approach may be more cost effective. In effect I do not believe it is possible without on-going high levels of alum dosing.

2. Ms Muller states at 1.2: *"However, there is no requirement to reduce phosphorus losses."*

   Response: Significant P reductions from sewage occurred in 1990, which have been referenced in rebuttal of Dr Stephens evidence. The Plan Change 10 makes reference to reducing P loads from land use. BOPRC is required under the NPS-FM to bring in regulations around meeting water quality standards including standards for phosphorus. This will be an opportunity to review the necessary P regulations for the Lake Rotorua catchment. In addition, BOPRC has an ongoing commitment to researching land-based P sources and mitigation options. For example, I convened a phosphorus science workshop in November 2016 to specifically consider the efficacy of a range of P mitigations. This workshop was attended by members of BOPRC's Land Technical Advisory Group, other invited experts and staff. One issue highlighted at the workshop was clarification of P loss rates from forestry which we are currently following up with Dr Rich McDowell.

3. Ms Muller states at 1.2: *"…recent changes in the understanding of how nitrogen and phosphorus interact in Lake Rotorua,"*

   Response: The general response to deteriorating water quality in Lake Rotorua has not changed since 1989 when Rutherford et al say:

   "Removal of phosphorus alone may produce no measureable improvement in the lake conditions unless it can be made the limiting nutrient. Even then, this may take a number of years, because of recycling of phosphorus already in the lake system. Removal of nitrogen alone may reduce phytoplankton growth in the short term (say 5-10 yr) but is not recommended because the algal community may become dominated by heterocyctous blue-green algae, which can meet their nitrogen requirements by fixing dissolve molecular nitrogen and form unsightly assemblages. Thus, removal of both nitrogen and phosphorus is recommended."

   The Water Quality TAG 2014 statement (attached to my evidence in chief) reinforces the dual nutrient approach, and the recent lake modelling work continue to support the dual nutrient approach. There is no recent change in science research that contradicts this key approach to lake recovery.

4. Ms Muller states at 1.3: *"Mitigating nitrogen leaching does not mitigate phosphorus losses proportionally. Nitrogen and phosphorus losses originate in fundamentally different processes, and the Bay of Plenty Regional Council (the Council) has prioritised nitrogen management at to a far greater extent than phosphorus management. The decision about which nutrient to prioritise markedly alters the choice of mitigation. It is most cost-effective to select mitigations based on which nutrient is prioritised."*

   Response: I agree with this statement. Unfortunately the proportions of N and P loss in the various different types of farming systems also varies. What this in effect means is that to achieve the best reductions in both nutrients there is likely to need to be a focus on getting N and then a focus on achieving P. More research is necessary to refine the target land activities and mitigation options for P in the catchment and it would be premature to impose a prescriptive approach to P management in Plan Change 10. BOPRC is not ignoring the issue and has an active land-based research work stream (e.g. November 2016 P workshop; P detention bunds field trials). Further, the P mitigation requirements for Nutrient Management Plans (NMPs) emphasise landowner adoption of good management practices, including those related to Critical Source Areas where (typically) the most cost-effective P reductions can be gained (McDowell, 2014).

5. At 1.4 Ms Muller refers to the possibility of "over-regulating" and overshooting the nutrient targets and TLI.

   Response: In Rutherford 2016, the ROTAN annual modelling predicts: *"The "most likely" steady state load assuming nitrogen reductions and again excluding rainfall on the lake was estimated to be 420t y^{-1}…"* This exceeds the 405 t y^{-1} (excluding rainfall) target. Therefore predicting any *"overshooting"* the target is unlikely. Rutherford then says: *"Nevertheless, while the nitrogen loss reductions specified by BoPRC are predicted to significantly reduce lake loads, they may not quite reach the target load."*

6. At 1.5 Ms Muller refers to phosphorus limitation. She provides no evidence of this P limitation and the reasons for the lake reaching its TLI for a limited period over 2012 to 2014 are explained in more detail in Professor Hamilton's evidence.

7. Ms Muller states at 4.4: *"My understanding of PC10 is that there is no farm level target for managing phosphorus loss from rural land uses. Reducing nitrogen and*

phosphorus losses from dairy farms will require different mitigation strategies as these nutrient losses have very different pathways."

Response: Plan Change 10 has policy LRP2 providing the policy for the management of phosphorus, and this is supported by methods LRM2(c) and LRM5 (d) and (e). I also support the suggested amendment to LRM5(e) to highlight the ongoing development of good management practices to deal with both nitrogen and phosphorus losses. This will recognise the generally different loss pathways and mitigations for each nutrient, as noted by Ms Muller. This is consistent with Plan Change 10's requirements for the contents of Nutrient Management Plans, where nitrogen and phosphorus mitigation need to be addressed (Schedule LR Six 5(a) and 5(b) respectively).

8. Ms Muller states at 6.1: *"The evidence of Dr. Stephens has shown that managing phosphorus is important in meeting the water quality objectives of Lake Rotorua of a TLI of 4.2."*

   Response: This is covered in rebuttal of evidence from Dr Stephens.

9. At 7 and 8 Ms Muller comments on the relationship between nitrogen and phosphorus and the difficulty in achieving both N and P reductions from single farm intervention approaches. She goes on to conclude that interventions focussed on reducing N will not necessarily achieve a similar reduction in P. She recommends that understanding the cost effectiveness of alternative types of P mitigations will help minimise the cost to the community if phosphorus loss (reduction) is required following a science review.

   Response: We understand the relationship between N and P in terms of how they travel in the environment and how that can affect potential mitigation strategies. Current science is advising that we need to achieve a sustainable N and P load to the lake. Phosphorus reduction from the catchment is a necessary part of that, but it will not necessarily target the same areas that are being targeted for N reductions, to the same extent.

1.3 Rebuttal of evidence Rotorua Residents and Ratepayers (RRR):

1. RRR states: Plan Change 10 has *"…an exclusive focus on nitrogen management…".* They suggest: "*Emergent science points to the practicality of integrating and co-managing N and P reductions by catchment."*

   Response: Plan Change 10 does not have an exclusive focus on nitrogen management as RRR claim. Plan Change 10 has policy LRP2 providing the policy for the management of phosphorus, and this is supported by method LRM5 (d) and (c).

2. RRR states: *"Isolating N and P management from each other and other independent systems runs counter to the systematic growth of multi-disciplinary practical knowledge on farms that can be appropriately governed by the consenting process to achieve nutrient targets."*

   Response: The BOPRC and Plan Change 10 do not deliberately isolate N and P management, however the ways in which each of these two nutrients are transported from the catchment to the lake differ, as detailed in my evidence in chief at Parag. 30. Although some management techniques will have an impact on reducing the levels of both nutrients, many interventions favour the reduction of one or the other.

3. RRR states that they are unconvinced that alum dosing is not part of a long term solution, and that detention dams have significantly reduced P discharges from storm water. They are now sceptical that an approach based solely on N mitigation will achieve the TLI target, and regard the 435 t N target as simplistic.

   Response: As already pointed out the approach is not solely based on N mitigation. The approach is to achieve reductions of both N and P. Although Plan Change 10 does have provision for P management further P management may be necessary through the implementation of the NPS-FM for the Rotorua lakes. It is acknowledged that the alum dosing programme has contributed positively to the improvement in water quality of Lake Rotorua, but it is not envisaged as a long term solution for the reasons outlined by Tempero (2015). Detention dams are one of the methods in BOPRC tool kit to assist farmers in reducing P inputs. Their level of contribution to P reduction for the catchment is as yet not clear, but a current industry research project supported by the SFF is designed to establish their P-removal performance.

1.4 Rebuttal of evidence Lyndsay Hugh Moore on behalf of Lyndsay and Alison Moore:

1. Mr Moore provided a detailed submission that gives interesting historical context to many issues with the quality of water in Lake Rotorua. Much of what he says aligns generally with my understanding of the catchment, but not all of it. There are some specific points of question that are raised by Mr Moore and I would like to clarify where appropriate.

2. Mr Moore states at page 8, that he was told in the 1970s the water from the springs near the Utuhina Stream last saw the light of day in the Mamaku's over 20,000 years ago.

   Response: Geological and Nuclear Sciences (GNS) has undertaken groundwater aging in the catchment of Lake Rotorua. In a recent paper (Morgenstern et al 2015) it is reported the average age of groundwater in the Utuhina stream is 60 years, and the oldest age of groundwater in the Rotorua catchment is the Hamurana Stream at 145 years.

3. This takes me to page 10 where the Mr Moore says: *"A realistic approach to time is essential. If water falling on a property takes hundreds or even thousands of years to enter Lake Rotorua what is the utility and justification for now limiting nutrient input to that property? Our submission was that a line should be drawn at 200 years."*

   Response: Even for the oldest age ground water within the catchment, the average age is about 145 years.

4. Mr Moore then concludes by pointing out that any analysis is only as sound as its underlying assumptions. He then claims regional council has made five assumptions that are not reasonable and the adoption of change based on them is unreasonable. I will make a response to three of the alleged assumptions. The assumptions I refer to are numbered 1, 2 and 3 on pages 10 and 11.

   Response: Mr Moore is incorrect in saying these are assumptions. The subject of the statements he is challenging have been properly researched by qualified and experienced scientists and reported on in a number of science reports.

   He claims: *"Here the regional council's assumptions appear to be:*

   1) *All water falling on the asserted catchment either evaporates, is transpired, or drains into Lake Rotorua,*

2) *Nutrients applied to or generated on any land within the asserted catchment contribute to the nutrient input into Lake Rotorua.*
3) *The water and nutrients referred to in 1 and 2 enter the lake within a time frame relevant to the present exercise."*

Response 1: The catchment area for Lake Rotorua has most recently been researched and reported on by GNS Science for BOPRC in 2015 (see White et al. 2014). This research is required to implement a regime of nutrient management for Lake Rotorua and the Council needs to fully understand the extent of the contributing catchment. Establishing the surface water catchment is relatively simple using modern remote sensing techniques and the surface catchment is reported on by White et al 2014. It is the ground water catchment that is more complex to establish. In the report (White et al. 2014) the "best estimate" ground water boundary has also been established by using multiple data sets; taking account of catchment water balances, surface topography, the underlying geology and information about rainfall and surface water flows. Estimates of the accuracy of this "best estimate" are contained in the report in line with accepted scientific practice.

Response 2: Nutrients applied to land within the catchment may reach Lake Rotorua in time. It is not concluded by Plan Change 10 or the Regional Council in developing Plan Change 10 that all nutrients discharged to land in the catchment will contribute to input to Lake Rotorua. There are many reasons for this. Nitrogen can be transformed as it travels with water in the catchment towards Lake Rotorua. The most likely transformation is denitrification of soluble nitrate to nitrogen gas. Other transformations are possible, such as plant uptake and organic material binding that may endure for a long time, such as timber, and also be taken from the catchment. In the application of Plan Change 10 this is accounted for as firstly the rules require the application of a model that accounts for nitrogen lost beyond the plant root zone. Then catchment modelling using the ROTAN model provides an estimate of "attenuation" which includes the process of denitrification, described above.

For phosphorus, transformations to a gaseous state are not possible, but P can be retained very strongly by absorption processes in soil and in the underlying geology. Whether it is released or not is dependent on the particular chemistry of the environment. This is the reason why natural sources of P in the catchment are high. Long residence times for groundwater in parts of the catchment dissolve P from the underlying geology as it travels towards the lake (Tempero et al , 2015). Phosphorus can also be bound up in organic matter, remaining unavailable to the environment or exported out of the catchment in various forms.

These transformations have been accounted for in the way Plan Change 10 is applied.

Response 3: I have responded to this concern at point 3 above. The average age of ground water in the catchment is less than 200 years based on research.

Name: Andrew Bruere

Date: 06 March 2017

<u>References</u>:

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