BEFORE A SPECIAL TRIBUNAL UNDER SECTION 203 OF THE RESOURCE MANAGEMENT ACT 1991

IN THE MATTER OF AN APPLICATION FOR A WATER CONSERVATION ORDER AT TE WAIKOROPUPŪ SPRINGS AND ASSOCIATED WATER BODIES

BY: NGĀTI TAMA KI TE WAIPOUNAMU TRUST AND ANDREW YUILL

EVIDENCE OF DR. JOHN L. B. GAMLEN

17th June 2018

1. My name is John Laurence Blagdon Gamlen.

2. I hold a Bachelor of Science degree, majoring in Mathematics and Physics, from NZU. I hold a Masters degree in Mathematics, from NZU.
I hold a Doctorate (Ph.D. Math) from Monash University, Australia.

3. I have held Academic positions in several Universities, including a senior position in the Mathematics Department of Yale University, New Haven, USA.
I have been a consultant to groups of researchers in many areas of Science, including Physics, Physical Geography, and Aquaculture.
I have a subsequent career as an Interdisciplinary Consultant Scientist.
My core expertise is:

Methodology of Science,
Mathematics & Physics,
Mathematical Modelling.

4. I have read the Code of Conduct for Expert Witnesses in the Environment Court's 2014 Practice Note and agree to comply with it. I confirm that the opinions I have expressed represent my true and complete professional opinions. The matters addressed by my evidence are within my field of professional expertise. I have not omitted to consider material facts known to me that might alter or detract from the opinions expressed.

5. My previous submission was written under time pressure, because the hearing began soon after the distribution of evidence. Because I did not expect to testify orally, I omitted paragraph 4 above from the previous submission. In the present document I have included some of the points of the previous submission, this time as expert evidence. I have also explained the same science in a more accessible way.

6. This evidence bears mainly on what I believe to be major flaws in the evidence of Mr. Andrew Fenemor. My comments are in no way personal, but are simply part of the peer review and robust debate that are essential steps of Scientific Methodology. I address mainly Mr. Fenemor's predictions of Nitrate-Nitrogen concentrations at the Springs, and the lack of public domain data to support those predictions.

7. SUMMARY OF LOGIC & CONCLUSION

(details follow in later paragraphs.)

7.1 In order to predict Nitrate-Nitrogen at the Springs with 20% accuracy, at least the following data and calculations would need to be achieved with overall accuracies better than 20%:

a) Nitrate precursor inputs such as fertilizer, feed, fixation by clover, etc.
b) Calculation of estimated Nitrate inputs to the Valley Water System, which means Aquifers and the Takaka River.
c) Calculation of Nitrate flow through the huge Karst Aquifers, especially the delay due to long residence in the Karst.

7.2 Regarding 7.1a, fertilizer use is not known due to perceived commercial sensitivities (Refer appendix 2). Not only is this a problem for current Nitrate

precursor inputs, but there is no historic time-series. As a result it is impossible to historically verify overall model accuracy by comparing time-series of inputs with the time-series of Nitrate-Nitrogen at the Springs. Such verification would only have been possible had there been very good 30 to 40 year time-series of data re both 7.1a AND Nitrate-Nitrogen at the Springs. (The delay of about a decade is what mandates such historic knowledge.)

7.3 Regarding 7.1b, Overseer is used by Mr. Fenemor who uses its outputs as inputs to his modelling for 7.1c. The creators and the promoters of Overseer estimate its accuracy as only about 30%. Senior Mathematician/Modellers have been unsuccessfully requesting Overseer's internal details for decades, and Overseer's mathematical competence is very uncertain. Accuracy might be much worse than 30%, but until top mathematicians are permitted to perform peer review, we cannot know. The Community of Mathematician/Modellers does not accept the scientific validity of Overseer's predictions. (It may still be a useful tool for farmers, but not for Science, therefore not for Public Policy.) Refer paragraph 8 below for a more detailed discussion.

7.4 The programme of 7.1 (above) fails completely at stage b), so there is little point in moving on to c), given that the available input data for c) is insufficient in quantity and quality to imply anything useful. Mr. Fenemor's recommendations depend on the accuracy of his Eigenmodel outputs, yet it is mathematically impossible, in the circumstances, that his model outputs are much more accurate than the input data accuracy! Even without consideration of Mr. Fenemor's modelling, his predictions are therefore proved to be unreliable. I now examine his modelling to consider whether it would predict usefully given better input data.

7.5 Mr. Fenemor's modelling assumptions include complete mixing within the Aquifer System. This is very unrealistic, given that the water progresses through the Aquifer very slowly on a wide front, over many years. Even if his model is used solely to predict equilibrium Nitrate at the Springs, I question why equilibrium is relevant, given that we face changing inputs, with a decade of waiting to measure output consequences. Furthermore, if such equilibrium predictions were relevant, a good scientist could calculate them from inputs on the back of an envelope.

7.6 Mr. Fenemor's Eigenmodel has been calibrated using short-term variations in flow rate at the springs ("pulse data"). (Refer Appendix 1.) This means that the model can only validly predict the response to short-term pulses in input flow rate. These pulses register at the springs after about a day, and subside in about a week, but no molecules from the pulse flow though to the springs, because that takes about 8 years, which is 3000 times the pulse response time. (Refer Paul Williams' paragraphs 18, 26, 27, 28, 29, 54, 55). But then the model's Nitrate calculations fail to take into account the 8 year delay. However, in his paragraph 71 Mr. Fenemor falsely compares his model's Nitrate predictions with measured Nitrate at the Springs. This is fundamentally flawed modelling, because pulse data does not imply any information about flow through of Nitrate molecules. Refer paragraph 9 below for a more detailed discussion of 7.4, 7.5, 7.6, and other modelling issues.

7.7 CONCLUSION

Considering 7.1 to 7.6, I conclude there is not enough good data to support numeric prediction of the consequences for the Takaka Valley of changed land use. The most significant numeric knowledge is the average age of water at the Springs (7.9 years). That data, together with Paul Williams' evidence on Karst aquifers, is sufficient to justify his conclusion (his paragraph 75) that contaminants entering the Aquifer System will take many years to reach the Springs, and take even longer to flush out.

8. OVERSEER PROBLEMS.

8.1 The Overseer model has been calibrated using data in regions of low rainfall (up to 1200 mm/year). In contrast, the Takaka Valley catchment receives net rainfall averaging roughly 2000 mm/year. This greatly adds to the uncertainty surrounding use of Overseer in the Takaka Valley.

8.2 Soils on Karst have very distinctive properties, and yet Overseer has no corresponding soil type. This means Overseer's predictions in the Takaka Valley are not founded on measurements made here. Klaus Thoma's evidence is that Overseer may underestimate Nitrate leaching in the Takaka Valley. (Refer Appendix 2.)

8.3 Mathematical Modelling is a very very expert area of science, requiring deep knowledge of mathematics, and substantial experience with interdisciplinary projects. To be a competent Mathematician/Modeller, one should know mathematics at a professional level, especially Probability Theory, and Dynamical Systems Theory. Without this knowledge it would be impossible to build a Stochastic Model capable of tracking errors through the modelling stages, as probability distributions. Such a modeller typically works with a colleague who is expert in his field (eg. Soil Science, Water). The Soil Scientist would normally leave Model Design to the Mathematician, who would reciprocate by respecting the Soil Scientist's expertise. I do not see any signs of such teamwork in Overseer's history, nor in its current leader's public defense of Overseer. (Refer Appendix 3)

8.4 Science Methodology is often neglected in Science Curricula, in favour of the "Facts" of science. As a result, too many professional scientists fail to address the methodology by which science learns: - sifting knowledge according to the reliability of the foundations for the knowledge. For example, with Fenemor's modelling, the main issue is how much information can be deduced from a small patchy data set. Good science requires care regarding what makes scientific knowledge credible. In USA the Daubert standard for credible science in the courts is roughly the following:

a) whether a method can or has been tested;
b) the known or potential rate of error;
c) whether the methods have been subjected to peer review;
d) whether there are standards controlling the technique's operation;
e) the general acceptance of the method within the scientific community.

Neither Overseer nor Mr.Fenemor's use of Eigenmodels meet these standards.

9 EIGENMODEL PROBLEMS.

9.1 The kind of Eigenmodel Mr. Fenemor uses is explained in a paper he attaches, authored by Bidwell & Burbery. In section 3.4 of that paper, an assumption is made that flow rates are proportional to pressure applied. But Paul Williams (his paragraph 18) writes that this assumption is "inappropriate in Karstic Aquifers".

9.2 Mr. Fenemor and his Aqualinc colleagues have developed Eigenmodels for Canterbury Plains aquifers, and it appears that Mr. Fenemor has applied those models to the Takaka Valley without much modification. For example, some of his modelling assumptions fit Canterbury Plains aquifers, but not Karstic aquifers. After carefully considering paragraphs 7.5, 7.6, and 9.1 above, I conclude that Mr. Fenemors's modelling completely fails to take account of the distinctive qualities of Karstic aquifer systems, particularly the long water residence time. These Karst aspects are clearly the determining factors for water flow and Nitrate prediction. As a result, even if more accurate input data were to be found, his models would still have no predictive value for Nitrate-Nitrogen at the Springs.

9.3 Mr. Fenemor has not revealed his model's internal details sufficiently to allow proper peer review, although he has recently supplied helpful background information. As a result, some of my peer review opinions necessarily have a speculative element. However, I have certainty in concluding that the standards for credible science that I outlined in paragraph 8.4 (above) have not been demonstrated by Mr. Fenemor's analysis.

Signed: John L.B. Gamlen Sunday 17th June 2018

Appendix 1: Attached File: Modelled & Measured flows - Fenemor.pdf
Appendix 1: Attached File: Klaus Thoma - Conclusions.pdf
Appendix 3: Email from Professor Graeme Wake to Caroline Read.pdf