BEFORE CANTERBURY REGIONAL COUNCIL
AT CHRISTCHURCH

In the matter of	the Resource Management Act 1991
And	
In the matter of	Proposed Variation 2 to the Proposed Canterbury Land and Water Plan
And	
In the matter of	a submission by Te Rūnanga o Ngāi Tahu

EVIDENCE OF BRUCE DAVID DUDLEY
ON BEHALF OF TE RŪNANGA O NGĀI TAHU
DATED 15 May 2015

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INTRODUCTION

Qualifications and experience

1. My full name is Bruce David Dudley.

2. I am a scientist in the Hydrological Processes Group at the National Institute of Water and Atmospheric Research (NIWA) where I have worked since 2014. From 2010-2014, I worked as a postdoctoral fellow in terrestrial and aquatic biogeochemistry for the Research Corporation of the University of Hawaii, hosted by the U.S.D.A. Forest Service in Hilo, Hawaii. In 2011, I was accepted to an adjunct faculty position at the University of Hawaii at Hilo. From 2007-2010 I worked as an environmental scientist with consulting firm URS New Zealand. From 2003-2007 I conducted Ph.D. research on stable isotope methods for tracing nitrogen movement from land to aquatic ecosystems.

3. I was awarded a B.Sc. in biological sciences in 1998 and a M.Sc. in biological sciences in 2000 by Auckland University. I was awarded a Ph.D. by Victoria University of Wellington in 2008.

4. I have had eight years' experience in professional scientific research, teaching and consulting. My area of expertise is biogeochemistry - the movement of elements (such as nitrogen and phosphorus) through physical and biological systems. I have published ten papers on biogeochemistry and aquatic ecology in international peer reviewed journals. I am a referee for the journals *American Journal of Botany, Aquatic Botany, Ecology, Ecological Applications, Estuaries and Coasts, Journal of Toxicology and Environmental Health Part A, Plant Ecology, Pacific Science*, and *Phycological Research* as well as one book. I have written more than 20 consultancy reports and given over 15 conference presentations. I have been researching nutrient cycling and aquatic ecology for over 14 years.

5. I have read the 'Hinds Plains Water Quality Modelling for the Limit Setting Process – Environment Canterbury Technical Report R13/93', the technical compendium reports relating to that document, and 'Ecological assessment of scenarios and mitigations for Hinds Catchment streams and waterways – Environment Canterbury Technical Report R14/72'. However, I have not been able to examine the spreadsheet files used in Scott (2013).

Scope of evidence

6. My evidence will cover:

   (a) A recalculation of nitrogen in the form of NO_3^- (nitrate) loads for alternative land use scenarios using the methodology of Scott (2013) and data from Scott (2014).

   (b) The suitability of the methodology of Scott (2013) and Scott (2014) for management of nitrate loads to ground and surface waters.

   (c) The suitability of nitrate-N as a proxy for nutrient loading effects on aquatic ecosystems.

7. My evidence is structured as follows:

   (a) A description of the methodology and input data used

   (b) A description of the scenarios used

   (c) Results

   (d) Interpretation of results

   (e) The suitability of nitrate-N as a proxy for nutrient loading effects on aquatic ecosystems.

Expert Witness Code of Conduct

8. I have been provided with a copy of the Code of Conduct for Expert Witnesses in the Environment Court Practice Note 2014. I have read and agree to comply with that Code. This evidence is within my area of expertise, except where I state that I am relying upon the specified evidence of another person. I have not omitted to consider material facts known to me that might alter or detract from the opinions that I express.

Terms and Definitions

9. Throughout my text I will use the term 'nitrate-N' to refer to the mass of nitrogen (N) in the form of nitrate ions. All loading rates (in kg/ha/yr) and concentrations (in mg/L) refer to the mass of the nitrogen atom only, rather than the molecular mass of nitrate. These are the same formats used in Scott (2013).

METHODOLOGY

General methods

10. Input data was taken from Scott (2014), which provides final versions of the nitrate-N load calculations that informed the Ashburton ZIP Addendum March 2014.

11. I first calculated the proportion of present day nitrate-N loading to groundwater contributed by irrigated arable land, irrigated dairy and irrigated dairy support land classes according to Scott 2014, using ‘Good Management Practice’ (GMP) values for irrigated dairy support.

12. I then calculated catchment Nitrate-N loading and groundwater N concentrations under four scenarios:

    (a) Under current land use (Table 7 of Scott (2014)) if all irrigated dairy and dairy support Nitrate-N loads were capped at 27kg/ha/yr.

    (b) Under the ‘development’ land use scenario (Table 8 of Scott (2014)) with Nitrate-N loads for all existing and proposed irrigated dairy and dairy support capped at 27kg/ha/yr.

    (c) Under the ‘development’ land use scenario (Table 8) with Nitrate-N loads for all existing and proposed irrigated dairy and dairy support capped at 27kg/ha/yr except in soils where GMP loading rates do not exceed this number, in which case the GMP value was used.

    (d) Under the ‘development’ land use scenario with caps as for scenario 3, with an increase to 15 kg/ha/yr nitrate-N loads for all land uses where current estimates of N-loading are below that value.

13. For scenario 1, I multiplied land use areas in Table 7 by leaching rates in tables 9 of Scott (2014), capping dairy and dairy support at 27 kg/ha/yr to give estimates of nitrate-N loading for each land use category.

14. For scenarios 2, 3, and 4 I multiplied land use areas in Table 8 by leaching rates in Table 11 of Scott (2014). I modified the values from table 11 of Scott (2014) first by capping dairy and dairy support at 27 kg/ha/yr for all soil types (Scenario 2), then using whichever values was smaller, 27 kg/ha/yr or the solutions package nitrate-N leaching rate for that soil type (Scenarios 3 and 4), to give estimates of nitrate-N loading for each land use category. Finally,

for Scenario 4 I also increased the minimum nitrate-N leaching loads for all land uses in the catchment to 15 kg/ha/yr.

15. For Scenarios 1, 2, 3 and 4 I calculated nitrate-N concentration in shallow groundwater according to the methods of Scott (2014) by dividing nitrate-N loads for each land use category by soil drainage estimates from Tables 10 (Scenario 1) and 12 (Scenarios 2, 3 and 4).

RESULTS

16. Irrigated arable land, Irrigated dairy and Irrigated dairy support contribute 82.6% of the current nitrate-N load according to the data provided in Tables 7 and 9 of Scott (2014).

Table 1: Nitrogen loads and nitrate concentrations using methods from the Hinds Plains water quality model.

			GMP (Scott (2014))	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Recharge	**Land surface recharge volume (million m^3/yr)**		364	364	349	349	349
	Average soil drainage (mm/yr)		287	287	275	275	275
Nitrate-N loads	**Leaching losses by land use class (tN/yr)**	Arable – irrigated	419	418	502	502	509
		Arable – dryland	9	9	1	1	3
		Dairy	2202	1064	1553	1433	1481
		Dairy support	1086	585	854	825	825
		Sheep, beef and deer	736	740	141	141	149
		Other	30	31	34	34	38
		Forest	3	3	3	3	42
	Catchment total nitrogen load (tN/yr)		4484	2850	3087	2938	3047
	Average nitrogen leaching rate (kgN/ha/yr)		35	22.5	24.3	23.1	24.0
Nitrate-N concentrations	**Average in shallow groundwater and springs (mg/L)**		12.3	7.8	8.8	8.4	8.7

INTERPRETATION OF RESULTS

17. There are small differences in some calculated values in Table 1 to those in Scott (2014) that are likely due to rounding; Scenarios 1, 2, 3 and 4 were calculated using rounded values from the tables in Scott (2014) because the data spreadsheets used to write that report were not available. This rounding changes GMP catchment load values by less than 0.5% and does not alter my conclusions.

18. These results, calculated using the methods of Scott (2013) are subject to the same assumptions and limitations stated in that report. Scott (2013) states 'Because of uncertainties in the input data and assumptions, the modelling cannot give accurate quantitative predictions of water quality. It is intended to give estimates of the direction of trends and relative scale of changes in nitrate concentrations that might occur under different land management.'

19. Measured or modelled figures for losses of nitrate from agriculture are beset by uncertainties, so that N-loss estimates are normally presented as ranges in scientific literature (e.g. Smil 1999).

20. Input data for the calculations of Scott (2013), Scott (2014) and this evidence are single values, reliant on the nitrate-N loads calculated by Everest et al. (2014) using the software package *Overseer*. With regards to this input data Everest et al. state 'Because of the uncertainty of some sub-models and the variability of results produced between versions of Overseer, the results from this analysis should be used with extreme caution'. Nitrate-N lost from land use scenarios may therefore differ substantially from those presented here, in Scott (2013) or Scott (2014).

21. Another limitation of the method of Scott (2013) as a quantitative tool is that it does not take into account differences in nutrient loading to groundwater in time or in space throughout the watershed and assumes perfect mixing of all leached water.

22. Mixing of leached nitrate within shallow groundwater and streams is likely to be less than complete, so that shallow groundwater nitrate concentrations at different parts of the catchment will vary substantially above and below the catchment mean. This can be seen from differences in nitrate concentrations measured at monitoring sites within the Hinds watershed (Meredith 2013).

23. I agree with Scott (2013) that this method is useful as a management tool for communities to assess the directions of trends of nitrate concentrations under different land management. Because of the uncertainty of the nitrate-N load data calculated using *Overseer* I think this is particularly the case for comparisons between land uses for which the likely nitrate-N loads are well separated (e.g. irrigated dairy and dryland farming). I suggest that output values from the methods of Scott (2013) are not appropriate for comparison with water quality guideline values.

24. The results above suggest that imposing nitrate-N loading limits of 27 kg/ha/yr to all land within the catchment would reduce catchment nitrate-N loading below current levels, with or without the addition of irrigated land proposed under Variation 2.

25. Scenarios 3 and 4 yielded similar nitrate-N loading rates; under Scenario 3, land with nitrate-N losses under 15 kg/ha/yr would form a small proportion of the catchment land area.

THE SUITABILITY OF NITRATE-N AS A PROXY FOR NUTRIENT LOADING EFFECTS ON AQUATIC ECOSYSTEMS

26. Although my primary brief related to nitrate-N loads to the Hinds watershed, it is important to remember that in streams such as the Hinds it is very likely that availability of phosphorus (P) limits in-stream algal growth for at least some of the year (Larned et al. 2011). Evidence that the regional-scale pattern of P-limitation shown in Larned et al. (2011) applies to the Hinds catchment is in Table 4-3 of Meredith and Lessard (2014) which shows moderate maximum values but very low minimum values of soluble reactive phosphorus (SRP) in the Lower Hinds and Tributaries, Valetta-Lowland Waterways and Mayfield-Lowland Waterways. This indicates that algae and aquatic plants periodically take up nearly all the SRP available in streamwater. Hence, small increases in SRP availability could result in large corresponding increases in algal growth.

27. Nitrate-N and SRP differ in their mobility from soils to water bodies. For example, phosphate ions show adsorption-desorption behaviour on soils that may restrict P mobility to groundwater in dissolved form, but also increases the importance of managing surface runoff to control P movement from land to streams and lakes (Sharpley et al. 2015).

28. Because proportional increases in N and P availability in surface water will not often have the same effects on growth of aquatic plants and algae, and these nutrients show differing patterns of movement from soils to water, in my opinion it is not sufficient to treat controls on nitrate-N loss to water as a proxy for preservation of water quality in rivers and streams in the Hinds catchment.

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