in the matter of: the Resource Management Act 1991

and

in the matter of: a number of applications to take and use water from the Upper Waitaki catchment

Addendum to brief of evidence of **Matt Ryan** (on cumulative water quality effects)

Dated: 30 November 2009

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ADDENDUM TO BRIEF OF EVIDENCE OF MATTHEW RYAN (ON CUMULATIVE WATER QUALITY EFFECTS)

INTRODUCTION

1 My full name is Matthew Ryan.

2 My qualifications and experience are set out in the brief of evidence dated the 16 September 2009.

3 I have been engaged by Meridian Energy Limited (Meridian) to provide an addendum to my evidence dated the 16 September 2009 on soil nutrient leaching (WQS) in response to caucusing that has occurred with experts engaged by Mackenzie Water Research Limited (MWRL) and Environment Canterbury (ECan) and in response to the supplementary evidence presented by MWRL.

4 I confirm that I have read the Environment Court's Code of Conduct for expert witnesses and this evidence has been prepared in accordance with that code. I agree to comply with the code's terms. In that regard, I confirm that the statements made in this evidence are within my area of expertise (unless I state otherwise) and I also confirm that I have not omitted to consider material facts which might alter the opinions stated in this evidence.

5 In preparing this evidence I have reviewed the following:

5.1 Notes from the caucusing meeting (12/10/09) between MWRL and Meridian technical experts and **Dr Clothier**.

5.2 The supplementary evidence of **Dr Snow** for MWRL;

5.3 The supplementary evidence of **Dr Robson** for MWRL;

5.4 The supplementary evidence of **Dr Monaghan** for MWRL; and

5.5 Additional data worksheets used in the WQS provided by **Mr Mzila** (GHD) and **Mr Chapman** (UWAG).

SCOPE OF ADDENDUM

6 In this addendum I:

6.1 Update Paragraphs 43 to 48 and Paragraphs 54 to 58 from my evidence in chief based on new information provided by **Dr Robson** and GHD;

6.2 Make reference to the caucusing notes from the caucusing session on the 12th October 2009; and

6.3 Provide additional comment and analysis on the required level of on-farm mitigation, nutrient discharge allowances (NDA) and assimilative capacity of sub-catchment nodes.

AMENDMENT TO PARAGRAPHS 42 TO 48 OF EVIDENCE IN CHIEF

7 In paragraphs 42 to 48 of my evidence in chief I took Table 1 from the WQS Summary Report (Table 5 in my evidence) and corrected the assimilative capacity for both *developed* and *highly developed* scenarios for each sub-catchment node to take into account what I considered to be the underestimation of soil nitrogen leaching losses.

8 Both the use of the "developed" and the "highly developed" scenario, and what I consider to be the underestimation of N leaching from sheep, were discussed at caucusing. It was agreed that the "developed" scenario should be the default. The reasoning for this decision being that the highly developed setting essentially doesn't have any scientific justification (see Paragraph 61 from my evidence in chief) and is only useful to give an indication of extreme upper bound nitrogen leaching values. Although the figure (12 kg N/ha/yr) I consider more appropriate to use for nitrogen leaching losses was agreed by **Dr Clothier**, it was not supported by **Dr Snow**, while **Dr Monaghan** did not consider the difference significant.

9 I also stated that a sensitivity analysis be undertaken using OVERSEER to ascertain the effect of key high impact input variables (i.e. nitrogen fertiliser in particular) on nitrogen leaching to obtain meaningful upper bound leaching estimates. A sensitivity analysis[1] of the OVERSEER model estimating nitrogen leaching from three farming systems in the Taupo catchment, showed that the model was particularly sensitive to a number of key input variables such as amount of nitrogen fertiliser applied, stocking rate etc.

Apart from providing potential upper bound nitrogen leaching estimates, the results from this exercise could have been used to provide guidance to Commissioners with respect to formulating resource consent conditions such as placing limits on nitrogen fertiliser loadings to irrigated land. This would provide an additional degree of assurance that nitrogen leaching loads from these areas will be minimised.

10 I have however revised Table 5 in my evidence in chief to show just the developed scenario with the revised N leaching losses that have been agreed with **Dr Clothier**. I have focused on the Ahuriri sub-catchment as I'm confident of the land use areas under irrigation and it is also a good example of a sub-catchment where the available assimilative capacity is limited. Taking into account that the nitrogen leaching loads from irrigated sheep farms have been underestimated by at least 2 kg N/ha/yr for the developed scenario, I have adjusted MWRL's figures in Table 1 of the WQS Summary Report accordingly. You should note that only the non-dairy component (6,182 ha) of the total proposed (7,282 ha) irrigation area draining to the sub-catchment node has been amended. With these corrections, the required

[1] A simple sensitivity analysis of nitrogen leaching for three Taupo farming systems, estimated using the OVERSEER nutrient budget model. Client report prepared for Environment Waikato. AgResearch (March 2006).

nitrogen leaching reductions for the developed scenario should be at least -12 kg nitrogen per hectare of new or renewed irrigation.

11 An underestimation of nitrogen leaching of 2 kg/ha/yr does seem small, but it is an additional 20% on top of the MWRL estimate of 9 kg N/ha/yr. On a catchment scale, this would equate to around an additional 40,000 kg N being leached into the receiving environment, based on the information provided by Dr Robson[2] that dairy farming will account for around 8,000 ha of new or renewed irrigation, with the remaining irrigation areas (20,000 ha) being used for sheep and beef.

12 To summarise:

12.1 MWRL have stated that the total nitrogen leaching change to meet the Environment Threshold (154,185 kg N/yr)[3] for the Ahuriri sub-catchment node under the developed (Scenario 2) will be -10.7 kg nitrogen per hectare of new or renewed irrigation.

12.2 taking into account that the nitrogen leaching loads from irrigated sheep farms that I consider to have been underestimated by at least 2 kg N/ha/yr for the developed scenario I have adjusted MWRL's figures accordingly. Of note, only the non-dairy component (6,182 ha) of the total proposed (7,282 ha) irrigation area draining to the sub-catchment node has been amended by the approximate 2 kg N/ha/yr. With these corrections, the required nitrogen leaching reductions for the developed scenario should be at least -12 kg nitrogen per hectare of new or renewed irrigation.

13 It is also worth acknowledging that based on the proposed Environmental Threshold and the total current nitrogen load (136,645 kg N/yr)[4] draining to the sub-catchment node, the actual assimilative capacity currently available is only 17,540 kg N/yr. I assume this low assimilative capacity is due to current forage cropping contributing a high relative nitrogen load (i.e. 43 kg N/ha/yr) per area.

14 Although it is not transparent in the WQS, I assume that in order to enable irrigation; forage cropping has had to be eliminated from the proposed farming systems altogether. However, this could only apply to farms that are proposing new or renewed irrigation.

15 Dr Snow states in Paragraph 53 of her rebuttal evidence:

"where dryland farms are using this winter forage crops these blocks can lose substantial amounts of nitrogen... and add-on mitigations such as nitrification inhibitors ... can be used to reduce nutrient losses"

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[2] Paragraph 10, Dr Robson's rebuttal evidence

[3] WQS Summary Report, Table 1

[4] WQS Summary Report, Appendix BB

I agree with this statement, but it is only relevant to farms with irrigation that are required to mitigate. Farmers not irrigating or not involved in these consent hearings cannot be forced to mitigate or remove forage cropping.

Table 5: Permitted changes in nutrient loads to maintain the Ahuriri Arm of Lake Benmore in an Oligotrophic state

Nitrogen Leaching for Irrigated Land	Leached N (kg/ha/yr)
MWRL	9
EIA Farm + 150 N Fert	11

Developed (Scenario 2)

Sub-catchment Node	Irrigation (ha)	Current N Load (kg N /yr)	Additional N Load from Irrigation (kg N/yr)	Total Proposed N Load (kg N /yr)	Environmental Threshold (kg N/yr)	Assimilative Capacity (kg N/yr)	Total N Change to Achieve Environmental Threshold (kg N/ha/yr)	Total N Change to Achieve Environmental Threshold (kg N/ha Irr/yr)	
								MWRL	**Corrected**
Ahuriri Arm	7,282[a]	136,645[b]	95,124[c]	231,769[b]	154,185[a]	17,540[d]	-77,584[a]	-10.7[a]	-12.4

[a]Sourced from Table 1 in WQS Summary Report

[b]Appendix BB of WQS Summary Report

[c]95,124 kg N/yr = 231,769 kg N/yr – 136,645 kg N/yr

[d]17, 540 kg N/yr = 154,185 kg N/yr – 136,645 kg N/yr

Amendments to Paragraphs 54 to 58 of evidence in chief

16 In paragraphs 54 to 58 of my evidence in chief I discussed the practicality of achieving significant reductions in nitrogen leaching losses in order for development to proceed.

17 I stated that the level of nitrogen leaching reductions required to meet the required Environmental Thresholds in some receiving environments, such as the Ahuriri Arm example (**Table 5**) will be unachievable with the two mitigation options outlined in my evidence in chief available in OVERSEER. The level of nitrogen leaching reduction from intensively grazed pastures achieved via the nitrification inhibitor mitigation measure is expected to be around 30% as modelled by OVERSEER. This appears to be regardless of whether the pasture is grazed by cattle or sheep, as shown in **Table** 1.

Table 1: OVERSEER Modelling of Nitrogen Leaching from Four Farming Systems in the Upper Waitaki Catchment Showing the Effect of the Nitrification Inhibitor Mitigation Option on Reducing Nitrogen Leaching.

System	**Nitrogen Leached (kg N/ha/yr)**		**% Reduction**
	without DCD	**with DCD**	
Dairy (Killermont –grazed)	41	28	-32%
Dairy (Killermont – cut & carry)	16	16	0%
Sheep (16 SU, 150 N Fert)	11	8	-27%
Beef (16 SU, 150 N Fert)	15	11	-27%

Additional comment on the feasibility of achieving mitigation targets to comply with farm NDAs

General

18 In my evidence in chief I have tried to ascertain whether the nitrogen leaching loads from the proposed farming systems used in the WQS are realistic and whether there has also been an under-estimation of the nitrogen leaching loads from grazed irrigated land and thus an over-estimation of the remaining assimilative capacities of the relevant receiving environments and an underestimation of the degree of farm mitigation required.

19 It remains my opinion that the remaining assimilative capacities have been over-estimated and that the required farm mitigation has therefore been underestimated.

20 In my evidence in chief I also commented on whether the mitigation measures available to farmers would be sufficient to achieve the required nitrogen leaching reduction level in some receiving environments. I have outlined that of the only two on-farm mitigation measures available, it was likely that these would only provide around a 30% reduction in nitrogen leaching from farms. It is likely that this will not be enough to meet the required level of mitigation at some sub-catchment nodes such as the Ahuriri Arm where available assimilative capacity is already constrained.

21 I re-iterate my comment (Paragraph 49) in my evidence in chief that the 40 possible mitigation practices outlined in the WQS and Dr Robson's evidence in chief that could be available to farmers, are not viable mitigation measures but best management practices (BMPs) that are already assumed in OVERSEER in its default settings (i.e. no N fertiliser applications over the winter period or P fert applications within 3 weeks of border-dyke irrigation). I also emphasise the fact that most of the BMPs presented in the WQS are not quantifiable in OVERSEER. Nor have there been any reduction factors presented in the WQS that would be used if any of these BMPs were actually employed in Farm Management Plans (FMPs) to specifically reduce farm nutrient nitrogen leaching loads.

22 I am also unchanged in my original opinion that at some sub-catchment nodes the available mitigation will not be sufficient to mitigate the effects of irrigation.

RESPONSE TO MWRL EVIDENCE PROVIDED

Scenario used in WQS

23 I would like to clarify my position on a number of earlier comments made by some of MWRL's technical experts (**Dr Snow** and **Dr Monaghan**) with regard to how the proposed leaching loads in the WQS have been derived. Specifically, this relates to the statement that the WQS is sufficiently conservative as the assessment was based on projected nitrogen leaching loads from highly developed soils, or Scenario 4 in the WQS.

24 Just to clarify, the WQS has been based on the projected nitrogen leaching loads from **developed** soils only, or **Scenario 2**. The proposed leaching loads from highly developed soils under Scenario 4 have been presented in the WQS Reports and been used solely to provide a potential upper bound nutrient concentrations in some receiving environments when the soils eventually reach a point of a highly developed state. I believe that **Dr Snow** has also corrected her previous statements on this issue and confirmed this fact in her supplementary evidence (12 November 2009).

25 In my evidence in chief I also stated that I consider that the nitrogen leaching estimates for Scenario 2 have been underestimated and that no sensitivity analysis has been undertaken to derive upper bound nitrogen estimates. I further stated that the WQS and calculated NDAs in particular should be based on the nitrogen leaching estimates provided in the WQS for **highly developed** soils (Scenario 4). However, I now consider that Scenario 2 is appropriate to use provided an appropriate sensitivity analysis is undertaken. To give an example of

the upper bound nitrogen estimates (from developed soils) likely to have been provided by a sensitivity analysis, I have prepared a simple sensitivity analysis shown in **Figure 1** below which shows the effect of varying nitrogen fertiliser inputs on nitrogen leaching from irrigated blocks from three grazed farming systems under **developed** soils.

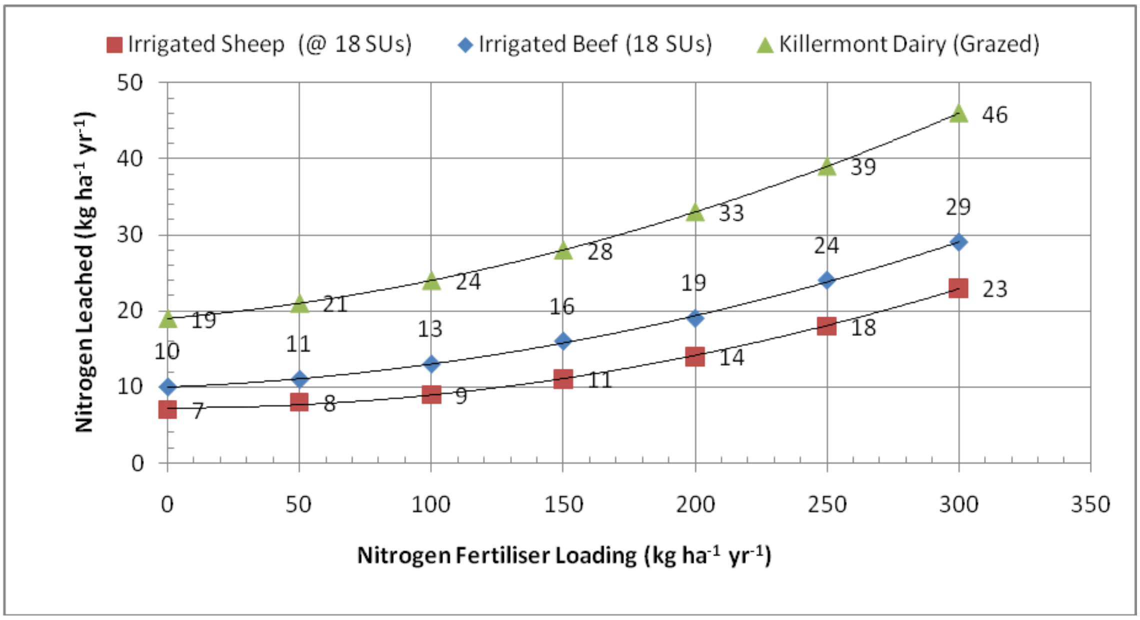

Figure 1: Sensitivity Analysis of Varying Nitrogen Fertiliser Inputs on Nitrogen Leaching from an Irrigated Sheep, Beef and Dairy Farm on Developed Soils

26 The figure shows that for an irrigated sheep farm, the upper bound leaching estimate would be around 22 kg N/ha/yr, which is in agreement with that reported from research studies (27) in New Zealand that showed nitrogen leaching losses from sheep farms in New Zealand to range from 6 - 66 kg N/ha/yr[5]. Note that for irrigated land grazed solely by beef cattle, the leaching estimate is approaching 30 kg N/ha/yr under high nitrogen fertiliser loadings, which is comparable to the nitrogen leaching estimate (31 kg N/ha/yr) from highly developed soils under Sheep & Beef in the WQS.

27 The main conclusion to draw from this exercise is that the nitrogen leaching estimates generated by the OVERSEER model are particularly sensitive to nitrogen fertiliser inputs[1]. Given this, and the fact that no sensitivity analysis has been undertaken in the WQS, and that both **Dr Monaghan** and **Dr Snow** believe that the OVERSEER nitrogen leaching estimates for the light soils in the catchment could be underestimated by up to 20%, I would suggest that a conservative approach is required.

[5] Land Use Impacts on Nitrogen and Phosphorus Losses and Management Options for Intervention. Report prepared by Environment Bay of Plenty by AgResearch Limited (June 2004).

28 To counter any suggestion that a sheep and beef farmer would never apply large amounts of nitrogen fertiliser to their irrigated blocks as I have assumed in sensitivity analysis, I would make the following two points:

28.1 Regardless of whether a farmer is grazing sheep, beef or dairy cattle, a farmer will inherently try and maximise pasture dry matter production from their irrigated land in order to maximise the capital returns from the large investment in irrigation infrastructure.

28.2 I would also re-iterate Paragraph 22 of my evidence in chief that irrigated pasture dry matter production values for the six station used in the baseline study that were modelled using the assumptions of **Dr Snow** (and not based on any actual farm survey data) have generally been over-estimated in the modelling given the nitrogen fertiliser inputs. This can simply be cross-checked by a simple nitrogen balance of pasture uptake of nitrogen balanced with nitrogen inputs.

28.3 For example, **Table 2** below shows that a pasture growing 12 tonnes dry matter per hectare per year with a mean dry matter nitrogen concentration of 3% will take up around 360 kg N/ha/yr. In a soil in steady state (which all soils will eventually reach over time) where net nitrogen mineralisation is roughly equally net nitrogen immobilisation, the only source for this nitrogen uptake by the pasture is either from clover nitrogen or mineral fertilisers. Thus, a pasture yielding 12 t/ha/yr with high nitrogen fixing (i.e. 150 - 200 kg N/ha/yr) clovers will require at least 200 kg N/ha/yr of nitrogen fertiliser to meet pasture requirements. Likewise, a pasture yielding 14 t/ha/yr in the same situation will require nitrogen fertiliser inputs of at least 270 kg N/ha/yr.

Table 2: Simple Mass Nitrogen Balance of Pasture Nitrogen Uptake and Soil Nitrogen Inputs

Pasture DM Yield (kg/ha/yr)	**12,000**	**14,000**
%N in DM	3%	3%
Plant N Uptake (kg N/ha/yr)	**360**	**420**
Clover N Input (kg N/ha/yr)	150	150
N Fert Input (kg N/ha/yr)	210	270
Total N Inputs (kg N/ha/yr)	**360**	**420**

28.4 Therefore, based on this simple mass balance, it is not unreasonable to assume that higher nitrogen fertiliser loadings will be required to achieve higher pasture dry matter production targets. This is in contrast to **Dr Snow's** modelling, however this is in agreement with two studies undertaken by two highly experienced farm consulting companies (MacFarlane Rural Business Limited and The Agribusiness Group) which have a wealth of experience of working in the Upper Waitaki and therefore should have a good feel for farm management practices and the level of the pasture production able to be achieved in the area. Both of these firms in respective reports[6] [7] estimated that irrigated pasture production in the Upper Waitaki typically averages around 12 t DM/ha/yr requiring nitrogen fertiliser inputs of up to 200 kg N/ha/yr, which is in general agreement with the mass balance presented in **Table 2** above.

Mitigation, NDA methodology and Sub-catchment Assimilation Capacity

29 In their joint evidence **Drs Bright** and **Robson** provided two examples (Paragraphs 10.27 to 10.31) of how two dairy farms would be able to comply with the calculated NDA of a particularly sensitive sub-catchment node.

30 **Dr Robson i**n Paragraph 24 of her rebuttal evidence states: *"the purpose of these examples was to illustrate that the required mitigation was possible even with the most intensive systems and largest developments in the areas where most mitigation is required".*

31 However, the problem with **Dr Robson's** examples is that the cut & carry mitigation option the two proposed dairy farms would employ, although effective, is not actually an option available for less intensive sheep and beef systems, which would likely make up about two thirds of the proposed new and renewed irrigation area.

32 For the Killermont dairy farm located in the Ahuriri sub-catchment, used as an example by **Drs Bright** and **Robson** it is stated that the NDA for the farm is approximately 26 kg N/ha/yr, which the farm will easily be able to comply with as OVERSEER modelling indicates that the farm will only leach 16 kg N/ha/yr[8]. However, I question the validity of this NDA and its use as a benchmark for environmental compliance based on reviewing how MWRL have apparently determined the assimilative capacity for the Ahuriri sub-catchment, as I have outlined in the following paragraphs.[9]

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[6] MacKenzie Water Research Limited. Farm Irrigation Analysis II. Partially Irrigated Farm Model. Prepared by MacFarlane Rural Business Limited (2009).

[7] Meridian Energy Limited. Water Quality Impacts from Irrigation Development, Upper Waitaki. Prepared by Glasson Potts Fowler Limited (2005).

[8] Based on OVERSEER source file (SHL KMT Final) used to model the Killermont cut and carry system provided by MWRL

[9] The assimilative capacity is defined as being the difference between the proposed nutrient load and Environmental Threshold, so any under or over-estimation of the proposed load will obviously affect the assimilative capacity of a sub-catchment.

33 The Ahuriri sub-catchment has a total area of 49,192 hectares[10], of which 7,282 hectares is proposed for new and renewed irrigation[11], of which 1,100 hectares is for the Killermont dairy farm and the other 6,182 hectares being used for sheep and beef farming[12].

34 The Environmental Threshold for the Ahuriri sub-catchment node is estimated to be 154,185 kg N/yr[3], with the existing nitrogen discharges to the node estimated to be 136,645 kg/yr[4]. Note, this includes nitrogen leached from areas under forage cropping, which would give a remaining assimilative capacity for the sub-catchment of only 17,540 kg N/yr (**Table 3.1**). As mentioned earlier (see Paragraph 14), it is my understanding that for the proposed land use scenario, forage crops may be eliminated in order that the remaining assimilative capacity of the sub-catchment nodes can be increased to allow more irrigation.

Table 3.1: Ahuriri Sub-catchment - Existing N Load

Land use	Area (ha)	N Leached (kg/ha/yr)	Total N leached (kg/yr)
Irrigated Sheep & Beef	?	9[a]	?
Forage	?	43.3[a]	?
Dryland Pasture	?	2.6[a]	?
Total	**49,192**		**136,645**
Environmental Threshold (kg N/yr)			**154,185**
Available Assimilative Capacity (kg N/yr)			**17,540**

[a]Source: Upper Waitaki Farm Systems and Nutrient Assessment. Stage 3: Base case nutrient assessments. AgResearch (2008).

35 For example, eliminating the forage crop land use option from the Ahuriri sub-catchment, I have made a simple broad-brush assumption to demonstrate the point, that all of the land (49,192 ha) will be under dryland farming with a nitrogen loss estimate of 2.6 kg N/ha/yr. This is the mean nitrogen dryland pasture loss modelled from the six stations used in the baseline assessment[13]. Using this figure, the proposed existing N leaching load without forage cropping is estimated to be 127,899 kg/yr, which would give a remaining assimilative capacity of 26,286 kg N/yr (**Table 3.2**). This would be enough assimilative capacity to accommodate approximately 4,100 ha of irrigation, assuming that a hectare of irrigation under sheep & beef will only leach 9 kg N/yr and not 12 kg N/ha/yr which I consider more realistic.

[10] Sourced from GHD worksheets provided by Doug Mzila

[11] WQS Summary Report, Table 1

[12] Rebuttal evidence of Dr Melissa Robson, Paragraph 13.

[13] Upper Waitaki Farm Systems and Nutrient Assessment. Stage 3: Base case nutrient assessments. AgResearch (August 2009).

Table 3.2: Ahuriri Sub-catchment - Existing N Load (without forage crops)

Land use	Area (ha)	N Leached (kg/ha/yr)	Total N leached (kg/yr)
Irrigated Sheep & Beef	-	9	-
Forage	-	43.3	-
Dryland Pasture (remaining)	49,192	2.6	127,899
Total	**49,192**		**127,899**
Environmental Threshold (kg N/yr)			**154,185**
Available Assimilative Capacity (kg N/yr)			**26,286**

36 Using the nitrogen leaching load (9 kg N/ha/yr) from sheep and beef farms used in the WQS, and the modelled nitrogen leaching load (14.7 kg N/ha/yr) from the proposed Killermont cut & carry dairy farm, we can see from **Table 3.3** that the Ahuriri sub-catchment would actually have negative assimilative capacity (-26,589 kg N/yr) based on the irrigation area (7,282 ha) proposed.

Table 3.3: Ahuriri Sub-catchment - Proposed N Load (without forage crops)

Land use	Area (ha)	N Leached (kg/ha/yr)	Total N leached (kg/yr)
Irrigated Sheep & Beef	6,182	9	55,638
Irrigated Dairy	1,100	14.7[a]	16,170
Dryland Pasture (remaining)	41,910	2.6	108,966
Total	**49,192**		**180,774**
Environmental Threshold (kg N/yr)			**154,185**
Available Assimilative Capacity (kg N/yr)			**- 26,589**

[a]Sourced from joint evidence (Paragraph 10.29) of Dr Bight and Dr Robson

37 As nitrification inhibitors are really only effective on grazed pastures (**Table 1**), this mitigation measure is therefore only a viable option for irrigated blocks on grazed dairy and sheep & beef farms in the sub-catchment. In effect, cut and carry dairy farms have no mitigation options available, apart from reduced nitrogen fertiliser and effluent inputs which in turn will lower farm production.

38 In my evidence I demonstrated that with nitrification inhibitors a 30% reduction in nitrogen leaching could be expected from grazed pastures. Therefore for an irrigated sheep and beef block leaching 9 kg N/ha/yr, could be expected to leach around 6 kg N/ha/yr after nitrification inhibitors are applied. **Table 3.4** below shows the effect of applying the nitrification inhibitor mitigation option to the proposed irrigated blocks of sheep and beef farms, which shows that this action would have limited success and still not be able to provide enough mitigation for the proposed load (162,228 kg N/yr) under the proposed irrigation area (7,282 ha) to comply with the environmental threshold.

Table 3.4: Ahuriri Sub-catchment - Proposed N Load (without forage crops) - with mitigation

Land use	Area (ha)	N Leached (kg/ha/yr)	Total N leached (kg/yr)
Irrigated Sheep & Beef	6,182	6	37,092
Irrigated Dairy	1,100	14.7	16,170
Dryland Pasture (remaining)	41,910	2.6	108,966
Total	**49,192**		**162,228**
Environmental Threshold (kg N/yr)			**154,185**
Available Assimilative Capacity (kg N/yr)			- **8,043**

39 By presenting this simple cross-check for the Ahuriri sub-catchment, I believe that the proposed method to allocate available assimilative capacity to irrigating farms via NDAs is not going to work in every sub-catchment and I consider this is further exacerbated by the fact that the proposed nitrogen leaching loads appear to have been under-estimated. This will have resulted in the over-estimation of remaining assimilative capacity and thus the proposed area of irrigation that is possible in some catchments.

40 Although not presented in the WQS, it appears that an under-estimation of the nitrogen leaching losses from grazed dryland in the sub-catchment has resulted in an under-estimation of the proposed nitrogen leaching load and subsequent over-estimation of the remaining assimilative capacity. From undertaking the cross-check on the Ahuriri sub-catchment, I believe that the WQS has assumed that grazed dryland areas in the sub-catchment will only leach 2 kg N/ha/yr (which is the default nitrogen leaching value non-grazed shrubland[14]), rather than 2.6 kg N/ha/yr which is the mean modelled nitrogen loss from grazed dryland pastures from the six stations used in the baseline study[13]. Over the entire sub-catchment, this difference equates to 29,515 kg N/yr, which is not an insignificant amount when the remaining assimilative capacity is so low.

[14] WQS Rivers and Lakes Report, Appendix B.

CONCLUSIONS

41 On the basis of the discussion that has occurred in caucusing and the further evidence that has been presented by **Dr Robson**, **Dr Snow** and **Dr Monaghan**, it is my opinion that the assimilative capacity for each sub-catchment node should be calculated on the basis of the developed (and not the highly developed) scenario due to there being no scientific justification to use the highly developed setting in the OVERSEER model, and the likely gross over-estimation of soil nitrogen leaching losses that the highly developed setting likely produces.

42 Given the clear difference to what MWRL have presented in the WQS and to what I have I calculated for the assimilative capacity available and the areas of irrigation possible in the Ahuriri sub-catchment node, I believe that a cross-check similar to what I have done is required to be undertaken across all sub-catchment nodes.

43 The information (i.e. land use mix and areas draining to each sub-catchment node) required to undertake this exercise is not provided in the WQS, nor have MWRL been forthcoming in providing it when requested. However, I believe that the undertaking of this exercise is essential before any decision to grant consent is made.

44 Other than the removal of the highly developed scenario from Table 5, the conclusions and recommendations in my evidence in chief remain unchanged.

Dated: 30th November 2009

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Matthew Ryan