BEFORE THE ENVIRONMENT COURT

In the matter of	appeals under clause 14 of the First Schedule to the Resource Management Act 1991 concerning proposed One Plan for the Manawatu-Wanganui region.
between	**FEDERATED FARMERS OF NEW ZEALAND** **ENV-2010-WLG-000148**
and	**MINISTER OF CONSERVATION** **ENV-2010-WLG-000150**
and	**DAY, MR ANDREW** **ENV-2010-WLG-000158**
and	**HORTICULTURE NEW ZEALAND** **ENV 2010-WLG-000155**
and	**WELLINGTON FISH & GAME COUNCIL** **ENV-2010-WLG-000157** *Appellants*
and	**MANAWATU-WANGANUI REGIONAL COUNCIL** *Respondent*

SUPPLEMENTARY STATEMENT OF EVIDENCE OF DR JONATHON KELVIN FLETCHER ROYGARD ON THE TOPIC OF SURFACE WATER QUALITY – NON-POINT SOURCE DISCHARGES ON BEHALF OF MANAWATU-WANGANUI REGIONAL COUNCIL

Dated: 27th April 2012

horizons regional council

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SUPPLEMENTARY STATEMENT OF EVIDENCE OF DR JONATHON KELVIN FLETCHER ROYGARD ON THE TOPIC OF SURFACE WATER QUALITY – NON-POINT SOURCE DISCHARGES ON BEHALF OF MANAWATU-WANGANUI REGIONAL COUNCIL

Terms

TEB	=	technical evidence bundle
NV	=	notified version of POP
DV	=	decisions version of POP
MV	=	mediated version of POP
MCB	=	mediated compilation bundle

Introduction

1. Mr Willis on behalf of Fonterra has presented a table in his rebuttal evidence that compares[1] new modeling results with the modeling previously presented by Dr Roygard and Miss Clark for Horizons and separately by Dr Ausseil for Wellington Fish and Game. There are fundamental issues with the direct comparison of these results that lead to this being a table that compares ‘apples with oranges’.

2. The most obvious issue with the table comparing results is the use of a 10 year time period for the Fonterra modeling which accounts for a lower number of conversions than the 20 year modeling presented separately by Horizons and Wellington Fish & Game. Other issues with the table include the use of percentage reductions for different things. For example Fonterra report percentage reductions from the regional average loss from dairy farms whereas the Horizons modeling presents averages based on reductions from the higher average losses for dairy farms in the specified catchments. Further, the method Dr Scarsbrook uses to convert the losses to soluble inorganic nitrogen (SIN) loads is overly simplistic and incorrect. Overall the modeling presented by Mr Willis in Table 1 of his rebuttal evidence over-represents the possible gains of Dr

[1] Mr Willis evidence in reply, Table 1, Page 19

Ledgard's predicted reductions from dairying to overall loads of nitrogen in specified catchments.

This document presents:

- § how the modeling approaches differ.
- § comparable modeling for the proposed approaches put forward by Ms Barton and Fonterra.

3. The revised modeling presents Ms Barton's proposed approach over a 10 year timeframe and a more robust modelling of Dr Ledgard's predicted reductions over a 10 year time period. The modeling of the Fonterra approach builds on the information provided by Dr Ledgard. It is noted that the use of Dr Ledgard's modeling does not imply agreement with it.

How the modeling approaches differ?

4. The models differ primarily in three ways, the starting point for the current losses from dairy farming, the way these have been scaled up to a catchment level and the time frames. These are interrelated for some aspects as is further explained in the sections below.

Different approaches to the starting point for rates per hectare of existing dairy losses

<u>Dr Ledgard's modeling</u>

5. Dr Ledgard's modeling[2] (scenario 2) starts from the estimates of the average dairy loss for the region (22.8 kg N/ha/year). Applying a range of mitigations and assumptions, he concludes this average leaching rate for dairy farming will reduce from 22.8 to 20.6 kg N/ha/year. This reduction of 2.2 kg/ha/year translates to a 9.6% reduction on a per hectare basis from the estimated average

[2] Ledgard rebuttal evidence, Para 8, Page 3 and Appendix B.

loss from all dairy farms in the region[3] [((22.8-20.6)/22.8) = 9.6] as outlined in Table 1. Mr Willis reports this as an over 10% loss[4].

Table 1: Summary of Dr Ledgard's modelling.

Dairy farms in the Region have an average loss of 22.8Kg/ha/year	
Split into 2 groups	
Group 1 (Dr Ledgard's Option 1)	Group 2 (Dr Ledgard's Option 2)
25% have average losses of 33.8 kg/ha/year	75% have average losses of 19.3 kg /ha/year
These reduce by 7.6 to 26.2 kg/ha/year	These reduce by 1.1 to 18.7 kg /ha/year
25% of farms leach 26.5 kg/ha/year	75% of farms leach 18.7 kg/ha/year
Summarising (Dr Ledgard's scenario 2) Overall leaching is then (0.25 *26.2) + (0.75 * 18.7) kg N/ ha/year = 20.6 kg/ha/year	

<u>Dr Roygard and Miss Clark's modeling</u>

6. Dr Roygard and Miss Clark's modeling of dairy farming losses, starts with estimates of the average loss rate for dairy farms upstream of the site being modeled. These are based on the Overseer budgets available to Horizons Regional Council (Table 4 Roygard and Clark, 2011, TEB p5225) and estimate the current average leaching in this area based on a proportion of the farms in the area. For Manawatu at Hopelands, the estimate of average loss rate is 26.1 kg N/ha/year which is 14.4% higher than Dr Ledgard's starting point of 22.8 kg N/ha/year (based on the regional average from his data set). In the modeling of the Manawatu at Hopelands site, the Roygard and Clark modelling of the DVPOP limits applying to existing land area for dairy farming reduces the average loss from all dairy farms upstream of Hopelands from 26.1 kg/ha/year to 21.8 kg/ha/year (4.3 kg/ha/year). This is a 16.4% decrease. It is noted that this decrease includes the assumption that all farms less than 21.8 kg N /ha/year intensify to this level of loss.

7. Put in perspective of the 16.4% decrease from 26.1 kg/ha/year, Dr Ledgard's decrease of 2.2 kg N/ha/year would translate to 8.4% decrease from the 26.1 Kg N/ha/year average leaching loss from dairy farming upstream of Hopelands. Appendix 1 shows further information on the differences between the range of nutrient losses and proportion of farms estimated to have particular levels of loss for the region and for the area upstream of Manawatu at Hopelands.

[3] Noting Dr Ledgard's data set is for a small percentage of farms in the region and in the original presentation of the data he states the average N loss rate is 22.0 kg N/ha/year.
[4] Mr Willis evidence in reply Para 95, page 18.

Comparing the two approaches at the catchment scale for a specified zone

8. To put the different changes in N loss from dairy into the perspective of catchment outcomes, Table 2 below shows the workings of the application of Dr Ledgard's modelled per hectare reductions to a specified catchment, Manawatu at Hopelands. Table 2 also presents modelling for the proposed approach of Ms Barton over a 10 year timeframe allowing direct comparison of the results.

9. The modelling in Table 2 applies changes over 10 years with an intensification rate equivalent to there being 5.5% more area in dairy (converted from sheep/beef farms). The modelling in assumes all dairy farms, including conversions, reduce to 20.6 kg/ha/year for the application of Dr Ledgard's predicted reductions and all dairy farms including conversions average 21.8 kg N/ha/year for Ms Barton's approach. The 21.8 kg N/ha/year is derived by applying the DVPOP limits to the current proportion of dairy farming on each LUC class in the area upstream of Hopelands i.e. the assumption is conversions occur on to different LUC's in the same proportions as has occurred to date. [5]

10. The modelling (Table 2) for Ms Barton's approach over the 10 year period calculates, based on the use of the 26.1 kg/ha/year average dairy loss for the <u>zone</u>, that dairy farming contributes 262.7 tonnes SIN/year to the catchment for Hopelands. This is 35.3% of the load for the catchment (743.5 tonnes SIN). The 4.3 kg/ha/year (16.8%) reduction in leaching rate for dairy farms when the DVPOP LUC limits are applied to existing farms, translates to a 31 tonnes SIN/ha/year (11.8%) reduction in the nitrogen load contribution from dairy farming to the overall nitrogen loads for the catchment by 2018, once the conversions are accounted for. This 11.8% reduction in load from dairy farming reduces overall average annual SIN load at Hopelands by 5% (to 706.5 tonnes SIN/year) once all other land uses are included (Table 2).

11. The modelling of the Fonterra approach using the predicted reductions of Dr Ledgard (Table 2) for the 10 year period calculates based on the use of the 22.8 kg/ha/year, average dairy loss for the <u>region</u>, that dairy farming contributes

[5] It is noted that this assumption leads to a different average leaching rate when the DVPOP limits are applied to other catchments with different proportions of dairy farming on the various LUC classes.

229.6 tonnes SIN/year to the catchment for Hopelands. This is 33.1 tonnes (12.6%) less than estimated by the Roygard and Clark method modelling of Ms Barton's approach. The use of the regional average by Dr Ledgard does not fully account for the SIN load at Manawatu at Hopelands with these 33.1 tonnes equating to 4.5% of the overall load. Continuing the analysis noting this anomaly, the modelling of Dr Ledgard's predicted reductions suggest dairy contributes 32.3% of the reduced catchment load for the modelling of his approach (710.4 tonnes SIN/year). The 2.2 kg/ha/year reduction (9.6% of the regional average /ha/year) in leaching rate for dairy farms predicted by Dr Ledgard, translates to 10.7 tonnes SIN/ha/year (4.7%) reduction in the nitrogen load contribution from dairy farming to the overall nitrogen loads for the catchment by 2018, once the conversions are accounted for. This 4.7% reduction in load from dairy farming reduces overall average load at Hopelands by 2.4% (to 693.7 tonnes SIN/year) once all other land uses are included (Table 2).

12. Comparing the two approaches in terms of catchment level outcome, the approach put forward by Ms Barton is modelled to achieve a 5.0% reduction in average SIN load for the catchment over the ten year period. This is slightly more than twice the 2.4% reduction from the Fonterra approach. This conclusion, however still remains subject to the approach outlined by Dr Ledgard not accounting for all of the nitrogen load at the specified site. The following section remodels the data to adjust for this shortfall.

Table 2: Comparison of two approaches to modelling potential policies for nutrient management for the area upstream of the Manawatu at Hopelands monitoring site. Note the approach using Dr Ledgard's selection of the regional average loss from dairy farms does not account for 66.3 tonnes of SIN that is recorded in the catchment (the lower catchment load is shaded red). Numbers for the Fonterra approach for Sheep/beef and other (shaded yellow) are assumed from the Roygard and Clark modelling.

Manawatu at Hopelands		**Ms Barton's approach**				**Fonterra approach remodelled using Dr Ledgard's predicted reductions**			
		Sheep / beef	**Dairy**	**Other**	**Total catchment**	**Sheep / beef**	**Dairy**	**Other**	**Total catchment**
Land area in 2008	Ha	85677	20139	18530	124345	85677	20139	18530	124345
Land area in 2018 (5.5% dairy expansion from Sheep/beef)	Ha	84569	21246	18530	124345	84569	21246	18530	124345
Increase in area	Ha	-1108	1108	0	0	-1108	1108	0	0
Increase in area	%	-1.3%	5.5%			-1.3%	5.5%		
Leaching rate 2008	kg N/ha/yr	10.8	26.1	2.0	12.0	10.8	22.8	2.0	11.4
Leaching rate 2018	kg N/ha/yr	10.8	21.8	2.0	**11.4**	10.8	20.6	2.0	**11.2**
Percentage change in Leaching rate 2008 to 2018	%	0.0%	-16.4%	0.0%	-5.0%	0.0%	-9.6%	0.0%	-2.4%
Tonnes SIN contributed 2008	Tonnes SIN/yr	462.0	262.7	18.8	743.5	462.0	229.6	18.8	710.4
Tonnes SIN contributed 2018	Tonnes SIN/yr	456.1	231.7	18.8	706.5	456.1	218.8	18.8	693.7
Decrease in SIN load (2018-2008)	Tonnes SIN/yr	6.0	31.0	0.0	37.0	6.0	10.7	0.0	16.7
percentage change in SIN load contribution 2008 to 2018	%	-1.3%	-11.8%	0.0%	-5.0%	-1.3%	-4.7%	0.0%	-2.4%

Addressing the "missing SIN load" due to use of the regional average

13. To model the reductions from dairy farming for the approaches of Ms Barton (MWRC approach) and Mr Willis (Fonterra approach) on an even basis. Table 3 presents the modelling of Dr Ledgard's reductions from dairy farms on a per hectare basis to the estimated average leaching losses from dairy farms upstream of the Manawatu at Hopelands site. The modelling in Table 3 for the MWRC approach is exactly the same as for Table 2. For the Fonterra approach, the starting point is the same as that for the MWRC approach, in the case of dairy farms the average leaching rate is 26.1 kg N/ha/year.

14. The approach of the modelling in Table 3, then applies the same rationale as Dr Ledgard's 2.2 kg N/ha/year reduction for dairy farms. The 2.2 kg N/ha/year

average reduction predicted by Dr Ledgard was based on a number of assumptions and consideration was given to whether these still applied in the area the area upstream of Hopelands. To derive this 2.2 kg N/ha/year reduction, Dr Ledgard separated farms into two groups (see table 1). Group 1 was the 25% of farms with the highest leaching rates and these had an average leaching loss of 33.8 kg N/ha/year. This is very similar to average of 33.9 kg N/ha/year identified for the top 25% of farms in the Hopelands area (Table 4). For group 2, Dr Ledgard had average losses of 19.3 kg N/ha/year whereas the average loss rate in this group for the area upstream of Hopelands is estimated to be 23.5 kg N/ha/year. The reductions projected by Dr Ledgard for Group 2 contained a mixture of leaching reductions, intensification and no change and related to the bulk of the farms in the region. It was not possible to discern from Dr Ledgard's evidence if any greater level of change would be considered possible for this group, given the higher leaching rate compared the regional average for this group. For this analysis, the assumption is that Dr Ledgard's reduction of 2.2 kg/ha/year applies to the average loss rate in this area. Appendix 2 provides similar information on the Group 1 and Group 2 average leaching rates, range of leaching rates and the number of budgets that were available to estimate these for various sites modelled in the region by Dr Roygard and Miss Clark.

15. For both Ms Barton's and the Fonterra approaches, the modelling in Table 3 for the 10 year period calculates with the use of the 26.1 kg/ha/year average dairy loss for the area upstream of Hopelands, that dairy farming contributes 262.7 tonnes SIN/year to the catchment for Hopelands.

- Applying Dr Ledgard's predicted reduction of 2.2 kg N/ha/year to model the Fonterra approach, the average leaching rate results in a reduction of 8.9 tonnes or 3.4% of the load contribution from dairying. A 3.4% reduction from dairying results in a 2.0% improvement in water quality assuming all other aspects remain even.

- Applying the predicted reductions of Ms Barton's approach (4.3 kg N/ha/year to the average leaching rate, results in a reduction of 31.0 tonnes or 11.8% of the load contribution from dairying. An 11.8% reduction from dairying results in a 5.0% improvement in water quality assuming all other aspects remain even.

16. Comparing the outcomes of the two approaches for the Manawatu at Hopelands site from an even starting point, the approach proposed by Ms Barton is predicted to result in more than double the water quality improvement predicted for the Fonterra approach.

Table 3: Comparison of two approaches to modelling outcomes from potential policies for nutrient management for the area upstream of the Manawatu at Hopelands monitoring site. Scenarios presented in this table start from the same average loss from dairy farms in the area upstream of Hopelands. Numbers for the Fonterra approach for sheep/beef and other land uses (shaded yellow) are assumed from the Roygard and Clark modelling.

Manawatu at Hopelands	**Units**	**Ms Barton's approach**				**Fonterra approach remodelled using Dr Ledgard's predicted reductions**			
		Sheep/ beef	**Dairy**	**Other**	**Total catchment**	**Sheep/ beef**	**Dairy**	**Other**	**Total catchment**
Land area in 2008	ha	85677	20139	18530	124345	85677	20139	18530	124345
Land area in 2018 (5.5% dairy expansion from Sheep/beef)	ha	84569	21246	18530	124345	84569	21246	18530	124345
Increase in area	ha	-1108	1108	0	0	-1108	1108	0	0
Increase in area	%	-1.3%	5.5%			-1.3%	5.5%		
Leaching rate 2008	kg N/ha/yr	10.8	26.1	2.0	12.0	10.8	26.1	2.0	12.0
Leaching rate 2018	kg N/ha/yr	10.8	21.8	2.0	**11.4**	10.8	23.89	2.0	**11.7**
Percentage change in Leaching rate 2008 to 2018	%	0.0%	-16.4%	0.0%	-5.0%	0.0%	-8.4%	0.0%	-2.0%
Tonnes SIN contributed 2008	Tonnes SIN/yr	462.0	262.7	18.8	743.5	462.0	262.7	18.8	743.5
Tonnes SIN contributed 2018	Tonnes SIN/yr	456.1	231.7	18.8	706.5	456.1	253.8	18.8	728.7
Decrease in SIN load (2018-2008)	Tonnes SIN/yr	6.0	31.0	0.0	37.0	6.0	8.9	0.0	14.9
percentage change in SIN load contribution 2008 to 2018	%	-1.3%	-11.8%	0.0%	-5.0%	-1.3%	-3.4%	0.0%	-2.0%

Table 4: Average leaching rates for dairy as estimated by the subsets of farms with nutrient budgets available for Dr Ledgard's data set and the data set used by Dr Roygard and Miss Clark. The numbers in brackets show the range of leaching rates for the available. The question marks are estimates based on information from Dr Ledgard's evidence. There are 950 farms in the Region.

Selection of farms	**Average leaching loss estimates for all farms (based of subset of farms with nutrient budgets available)**		**Average leaching loss for highest 25% of farms based of subset of farms with nutrient budgets available)**		**Average leaching loss for lowest 75% of farms based of subset of farms with nutrient budgets available)**	
	Kg N/ha/year	Number of farms with N Loss limit numbers provided	Kg N/ha/year	Number of farms with N Loss limit numbers provided in this group	Kg N/ha/year	Number of farms with N Loss limit numbers provided in this group
Dr Ledgard's regional average	22.8 (8-47)	143	33.8 (27-47)	36?	19.3 (8-27)	107?
Roygard and Clark - Regional average	22.7 (4-55)	325	34.1 (28 – 55)	81	18.9 (4-28)	244
Roygard and Clark 2012 - Manawatu at Hopelands	26.08 (12-41)	57[6]	33.9 (30-41)	14	23.5 (12-30)	43

Comparing the approaches of Ms Barton and Mr Willis for other sites

17. To compare the approaches of Ms Barton and Mr Willis for other locations, the method of modelling used in the section above (with the same starting point) was applied to model outcomes three other sites in specified catchments. These were Manawatu at Weber Road (which is upstream of Manawatu at Hopelands), Makakahi at Hamua and Mangatainoka at SH2. It is noted that Makakahi at Hamua is upstream of the Mangatainoka at SH2 site. Other sites were not modelled due to time limitations.

18. For each of the sites modelled, the results shows that over the 10 year period, the approach of Ms Barton is predicted to have the greatest reductions in SIN load when compared to the outcomes predicted from the Fonterra approach (as modelled based on the predicted reductions of Dr Ledgard).

[6] There was a typo in the original table presented in evidence, this number should have been 61 not 47 and such the percentage farms in zones with budgets in table 34 of Roygard and Clark for the should be 41.5%. However, only 57 of these had n loss values associated with the budgets provided.

Table 5: Comparison of two approaches to modelling outcomes from potential policies for nutrient management for four sites in specified zones.

Area/Site	Ms Barton's approach			Fonterra approach remodelled using Dr Ledgard's predicted reductions		
	Percentage change in			Percentage change in		
	Leaching rate 2008 to 2018	Load from Dairy	overall load	Leaching rate 2008 to 2018	Load from Dairy	overall load
Upper Manawatu						
Manawatu at Weber Road	-20.4%	-16.0%	-4.4%	-8.2%	-3.1%	-1.2%
Manawatu at Hopelands	-16.4%	-11.8%	-5.0%	-8.4%	-3.4%	-2.0%
Mangatainoka subcatchment						
Makakahi at Hamua	-15.6%	-11.0%	-6.1%	-9.1%	-4.1%	-3.6%
Mangatainoka at SH2	-10.3%	-5.4%	-4.1%	-8.9%	-3.9%	-3.6%

Comment on the different approaches to scaling to the catchment level

19. Dr Scarsbrook tries, in his evidence in reply (para 20.3), to relate the modelling of Dr Ledgard's approach to a catchment level. Dr Scarsbrook's approach is based on an adjusted version of the linear relationship between the single loss limit scenarios presented by Dr Roygard and Miss Clark for the water quality outcomes over a 20 year period. Dr Scarsbrooks approach to accounting for the reduced amount of intensification (due to less area converted to dairying over the shorter time period) does not accurately model this change. This is due to the oversimplification of the approach taken by Dr Scarsbrook and the carrying through of the regional average dairy losses for the various zones instead of the changes to the average losses from dairy estimated from within the zones.

20. Figure 1 shows the change in the catchment SIN load for various single number limit approaches for all dairy farms when changing the modelling period from 20 years to 10 years in the Manawatu at Hopelands area. This differs to the relationship proposed by Dr Scarsbrook.

21. Figure 1 based on information for the Manawatu at Hopelands area, shows that when modelling the 10 year scenarios with 5.5% intensification, the reduced number of conversions compared to the 20 year modelling leads to the model results for the scenarios being improved (less degradation or more

improvement). Table 2 and Table 3 shows this for the DVPOP limits applied to existing and new dairy farms over the 10 year period in the Hopelands areas. The analysis presented by Dr Roygard and Miss Clark for Hopelands for twenty years for this scenario, scenario 4, predicts an improvement of 4.1% whereas the same scenario over 10 years is predicted to lead to an improvement of 5.0% over 10 years (Table 2, Table 3).

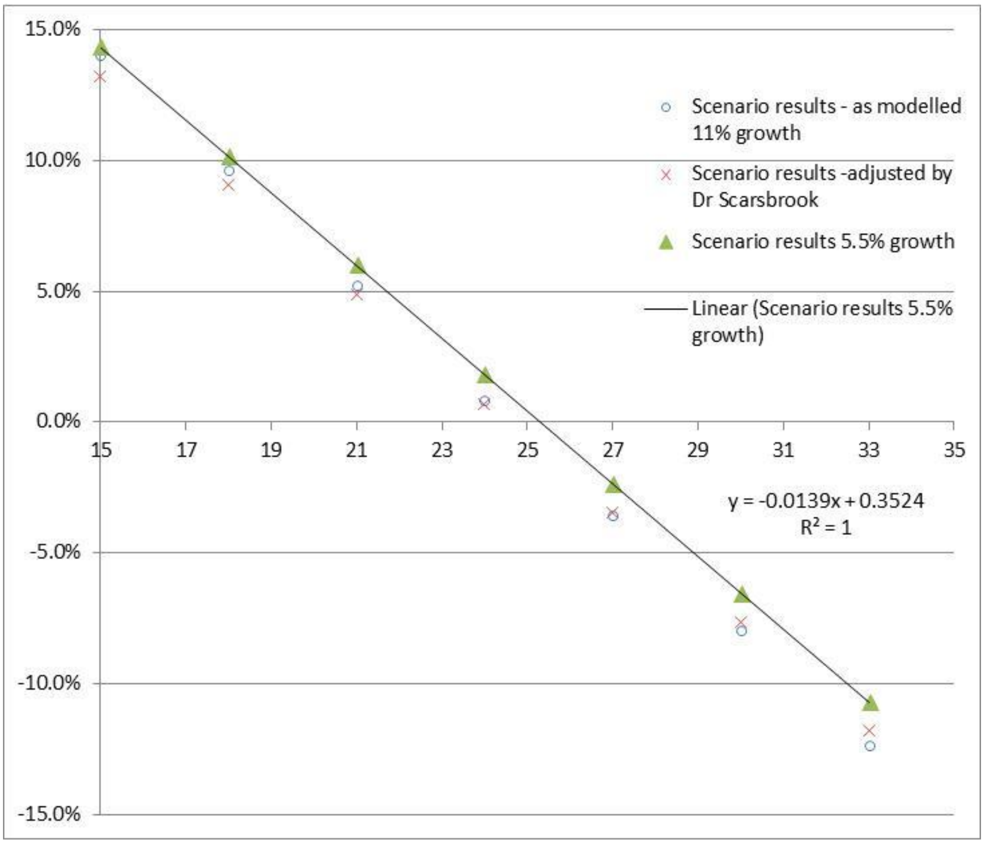

Figure 1: Plot of the percentage change in average SIN load at Hopelands (vertical axis) for various single number limits for dairy farming in the catchment upstream of Hopelands with three different modelling approaches Scenario analysis – as modelled 11% growth (Roygard and Clark), as adjusted by Dr Scarsbrook (rebuttal evidence) and remodelled with 5.5% intensification.

Comment on SIN loads and water quality trends

22. Dr Scarsbrooks evidence in reply Page 13, paragraph 19.3 states "*In the Manawatu River at Weber Road,* t*here has been a 3%* ***per annum reduction*** *in median SIN concentrations over the ten-year period 2001-2010. This 30% percent reduction in SIN load has been achieved under a more permissive regime than some submitter are requesting for the POP*". Dr Scarbrooks assumption that

a 3% reduction in median SIN concentration per annum translates to a 30% reduction in load is not robust. SIN Load is the product of the SIN flux i.e. concentration multiplied by flow. The reduction of concentration alone does not reduce necessarily load by the same magnitude.

23. The reduction of the median concentration at Weber Road is a positive sign for water quality in this area. A component of this reduction may be due to the regulatory approach to manage dairy farm effluent introduced by the Manawatu Catchment Water Quality Regional Plan (operative 1998). Dr Roygard and Ms McArthur (2008) calculated that the shift from discharging farm dairy effluent (FDE) to water to discharging FDE to land reduced SIN loads at Manawatu at Hopelands. These calculations estimated that at peak levels of discharge to water in 1998, FDE was calculated to be contributing 16.2 tonnes SIN/year, which reduced to 2.1 tonnes SIN/year in 2006. There are currently no consented FDE discharges to water in the upper Manawatu catchment meaning this contribution has reduced to 0 tonnes SIN/year. Put into the perspective of loads at Manawatu at Hopelands 16.2 tonnes SIN /year is 2.2 % of the load at Hopelands (743.5 tonnes/year) and 2.1 tonnes SIN/year is 0.2%. This shift and the improvement in the management of the land discharges is likely to have had a significant impact on the median concentration in the catchment, however may not have had such a large effect on load. The change in median concentration is likely be more pronounced as the removal of these point source FDE discharges at low flows, when they would have had there greatest effect on concentration, will likely have lowered concentrations at low flows. Overall however, the removal of these point source discharges at the higher flows will have had less effect and the predominant contribution to loads is made at higher flows.

Summary

24. Dr Ledgard has not provided modelling that relates to the specified areas for management of non point source inputs as identified by the DVPOP. The scaling up of this modelling by Dr Ledgard is not accurate and also carries through the errors associated with using the regional average nitrogen leaching rates for the

specified zones that are much lower than the estimated leaching rates for the farms in the specified zones.

25. The Roygard and Clark modelling uses estimates of the average loss rates of dairy farms in the specified zones being modelled and these are typically higher than the regional average ((Table 4 Roygard and Clark, 2011, TB p5225).

26. In using the regional averages as the starting point for percentage reductions, Dr Ledgard's percentage reductions are overstated.

27. When transferred into modelling into the specified zone for Manawatu at Hopelands catchment, Dr Ledgard's estimates do not fully account for all of the nitrogen loads at the catchment level, and translated to reductions at the catchment level about ½ of that of the approach of Ms Barton.

28. When transferred to three other sites within the specified catchment areas of the Manawatu Catchment (One upstream of Manawatu at Hopelands and two in the Mangatainoka) the proposed approach of Ms Barton had higher predicted reductions in terms of soluble inorganic nitrogen loads than the outcomes for the Fonterra approach as modelled based on the reductions from dairy farming predicted by Dr Ledgard.

Jon Roygard
SCIENCE MANAGER

Appendix 1: Estimates of nitrogen loss rates for dairy farms in the region and for the area upstream of Manawatu at Hopelands.

Figures 1 and 2 below show the range in leaching for the subset of nutrient budgets available to MWRC for the region (Figure 1) and for the area upstream of Hopelands

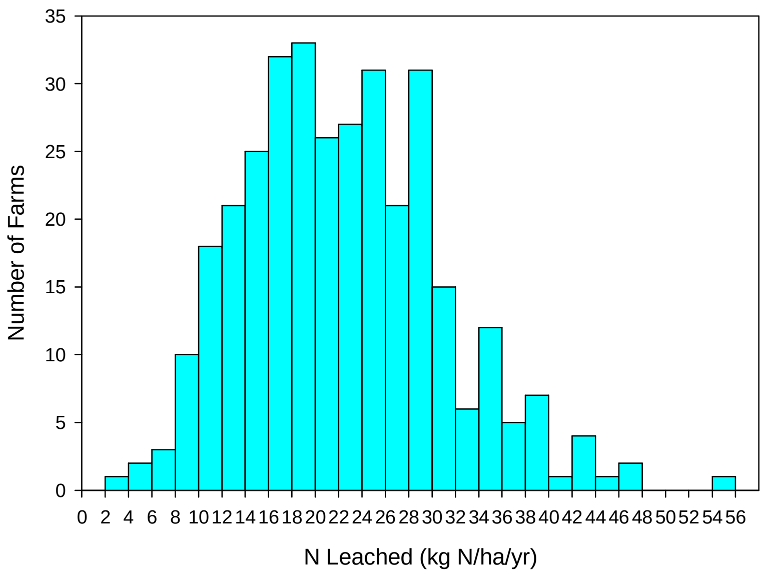

Figure 1: Regional summary of N (nitrogen) leaching from nutrient budgets collected by MWRC. n = 325 of 950. Average N Loss is 22.7.[7] kg N/ha/yr.

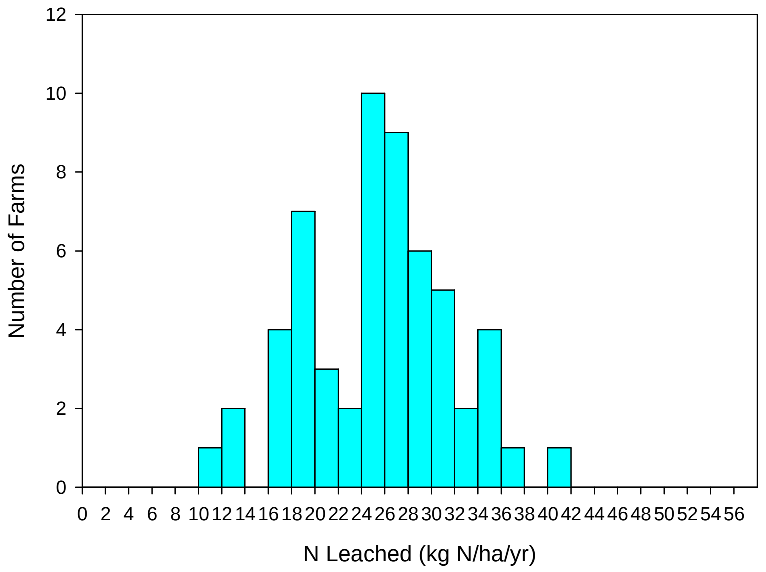

Figure 2: Summary of N (nitrogen) leaching from nutrient budgets collected by MWRC in the Manawatu Catchment upstream of Hopelands. n = 44 nutrient budgets of 147 farms. Average N loss is 26.1 kg N/ha/yr.

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[7] A value of 190 kg N/ha/yr leached has been removed from this dataset as the number did not make sense when compared to the leaching from the block summary.

Appendix 2: Average leaching rates for farms in the region and various areas upstream of monitoring sites.

Table 1 shows the variation in average losses for the "top 25% of farms" (highest leaching rates) and the average losses for the "other 75% of farms" (lowest leaching rates). The table also shows the range of data for the various sites and the number of budgets in these categories.

Table 1: Average leaching rates for dairy as estimated by the subsets of farms with nutrient budgets available for Dr Ledgard's data set and the data set used by Dr Roygard and Miss Clark. The numbers in brackets show the range of leaching rates for the avialable budgets in these categories).

Selection of farms	**Average leaching loss from available subset of farms**		**Average leaching loss for highest 25% of farms**		**Average leaching loss for lowest 75% of farms**	
	Kg N/ha/year	Number of farms with N Loss limit numbers provided	Kg N/ha/year	Number of farms with N Loss limit numbers provided in this group	Kg N/ha/year	Number of farms with N Loss limit numbers provided in this group
Dr Ledgard's regional average	22.8		33.8		19.3	
Roygard and Clark						
Regional average	22.7 (4-55)	325	34.1 (28 – 55)	81	18.9 (4-28)	244
Manawatu Catchment	**23.4 (8 – 46)**	**229**[8]	**33.9 (29-46)**	**57**	**19.9 (8-29)**	**172**
Manawatu at Weber Road	26.9 (14-41)	138	37.3 (35-41)	3	23.7 (14-33)	10
Manawatu at Hopelands	26.08 (12-41)	57[9]	33.9 (30-41)	14	23.5 (12-30)	43
Tiraumea at Ngaturi	28.6 (17-40)	5	40	1	25.8 (17-40)	4
Mangatainoka at Larsons Road						
Makakahi at Hamua	24.1 (13-38)	9	36.5 (35-38)	2	22.4 (13-30)	7
Mangatainoka at SH2	24.7 (11-40)	248	36.7 (30-40)	6	20.7 (11-29)	18
Mangahao at Ballance	34.8 (29-46)	4	46	1	31 (29 – 32)	3
Manawatu at Upper Gorge	25.3 (11-46)	1128	34.9 (30-46)	28	22.1 (11-30)	84
Waikawa Catchment	**16**	**1**				
Manakau at SH1						
Waikawa at North Manakau						
Waikawa at Huritini						
Rangitikei catchment	**21.8**	**448**	**32.6 (26-47)**	**11**	**18.2 (10-26)**	**33**
Rangitikei at Mangaweka						
Rangitikei at Onepuhi	26.4 (19-37)	8	36.5 (36-37)	2	23 (19-28)	6
Rangitikei at McKelvies	22.0 (10-47)	438	32.6 (26-47)	11	13.3 (10-26)	32

[8] There was an error in the initial table the number in the column number of budgets with N loss limits provided. The number stated is that number that provided budgets. The numbers in this table are the number that have N loss values in the budgets provided. NB. This does not change the averages used in the analysis.

[9] There was a typo in the original table this number should have been 61 not 47 and such the percentage farms in zones with budgets in table 34 of Roygard and Clark for the should be 41.5%. However, only 57 of these had n loss values associated with the budgets provided.