BEFORE HEARING COMMISSIONERS at CHRISTCHURCH

IN THE MATTER	of the Resource Management Act 1991
AND	
IN THE MATTER	of the proposed Variation 5 to the Proposed Canterbury Land and Water Regional Plan – Nutrient Management and Waitaki
BETWEEN	DairyNZ Limited
AND	Canterbury Regional Council

STATEMENT OF PRIMARY EVIDENCE OF DR BRUCE SYDNEY THORROLD FOR DAIRYNZ LIMITED

22 July 2016

Corporate Office: Private Bag 3221,

CONTENTS

1. EXECUTIVE SUMMARY

1.1 The proposed GMP N fertiliser proxy is not sufficiently accurate to be used in calculating N fertiliser requirements for current levels of farm production. As a consequence, the leaching amounts that the proxy will produce will also not represent GMP. This results in a policy that is, in my opinion, inequitable and likely to be ineffective at meeting its stated objectives of achieving GMP on farm, maintaining or improving water quality and providing equity and flexibility.

1.2 An alternative approach, based on N surplus is proposed. This approach does not calculate N fertiliser inputs required for current pasture production, as the GMP narrative has been interpreted. However it does identify farms running systems that are at higher risk of inefficient input use, and losses to water. In my opinion, the sliding approach to N reductions proposed reduces risks of inequity and inflexibility on farm. The absolute level of N input reduction (and consequent N loss to water) is likely to be greater than that obtained under the proposed proxy.

1.3 There are important aspects to implementation of the N surplus policy, especially avoiding the 'spiralling down' of GMP loss rates that must be included in a total policy package.

2. INTRODUCTION

2.1 My full name is Dr Bruce Sydney Thorrold.

2.2 I hold a Bachelor of Agricultural Science (Hons.1) (1984) majoring in Agronomy, and a Ph.D. in Soil Science (1994) from Lincoln University. I am employed at DairyNZ as Strategy and Investment Leader, responsible for investment into and oversight of research projects relating to farm systems and nutrient management. These include Pastoral21 (Steering Group Chair) and Forages For Reduced Nitrate Leaching (Governance Group Member). Prior to that I was a Senior Scientist at Dexcel and AgResearch, where I led research programmes including catchment studies at Whatawhata Research Centre, Best Practise Dairy Catchments, Oteramika Catchment Study and Lake Taupo. I spent five years deeply involved in the science, farmer-regional council negotiations and policy development for Waikato Regional Council Plan Change 5 – the Lake Taupo Variation.

Background

2.3 My involvement in Environment Canterbury's ("ECan") Plan Change 5 to the Canterbury Land and Water Regional Plan ("PC 5") commenced in 2013 when I became involved in the project through the Matrix of Good Management (MGM) Reference Group. I maintained involvement through that group and directly with the Programme Management Team through to the completion of the project. I was very active in discussions on the alternative proxies from August 2015 onwards.

2.4 I am familiar with the provisions of PC 5 to which these proceedings relate. In preparing my evidence I have reviewed Sheep, beef and deer modelling for the Matrix of Good Management - a technical summary (Snow et al., 2016) and the Section 42A Report prepared by ECan officials.

Code of Conduct

2.5 I have read the Environment Court's Code of Conduct for Expert Witnesses contained in the Environment Court's Practice Note 2014, and I agree to comply with it. In that regard, I confirm that this evidence is within my area of expertise except where I state that I am relying on the evidence of another person. I have not omitted to consider material facts known to me that might alter or detract from the opinions expressed in this evidence. In respect of paragraph 7.2(b) of the Code of Conduct, I record that I am an employee of DairyNZ.

3. SCOPE OF EVIDENCE

3.1 My evidence expands on the expert evidence provided by Dr Stewart Ledgard regarding the technical flaws associated with ECan's proposed Nitrogen fertiliser ("Nfert proxy"). In his evidence, Dr Ledgard proposes an alternative proxy based on the Nitrogen Surplus approach, and discusses important implementation considerations.

4. TECHNICAL ASSESSMENT OF THE PROPOSED NITROGEN FERTILISER PROXY

4.1 It is my opinion that the concept behind the Nfert proxy is sound in theory but has not been delivered in practise. The Nfert proxy is designed to calculate Nitrogen ("N") fertiliser requirements for current production levels (of milksolids, meat or other product) for <u>individual</u> farms. In my opinion the way that the proxy is being applied to individual farms requires a high standard of accuracy – even if the average is correct (and it's probably not), erroneous variability around the mean generates inaccurate and inequitable outcomes for individuals. This is important as the Good Management Practice ("GMP") Loss Rate or Baseline GMP Loss Rate are limits that each individual farmer has to meet.

4.2 In order to calculate N fertiliser requirements, the Nfert proxy uses data from the individual farm, and makes assumptions that are constant for all farms. The most important of these is an assumption of a uniform level of non-fertiliser N inputs (250 kg N/ha/yr from legume fixation and net mineralization of soil organic matter for grass/clover pastures) in the absence of N fertiliser for all Canterbury pastoral farms. From the equations in Snow et al.. (2016), this equates to a base annual pasture growth at zero fertiliser N of 8,070 kg DM/ha. This annual pasture yield is assumed constant for all ryegrass-clover pastures in Canterbury – regardless of soil type and fertility, climate and irrigation system.

4.3 Comparison with a range of measured data shows that pasture production cannot be assumed constant. The proxy substantially underestimates potential yield on irrigated sites especially under modern centre pivot systems (Table 1) and overestimates yield on some dryland sites.

Measurement location and Technique	Annual Pasture Growth	Reference
Winchmore Dryland No N fertiliser	5,870 kg DM/ha 1957-1970	Rickard & Radcliffe (1976)
Winchmore Irrigated Border dyke No N fertiliser	10,160 kg DM/ha 1957-1970	Rickard & Radcliffe (1976)
Lincoln dryland Cocksfoot-sub clover No N fertiliser	8,700-13,100 kg DM/ha 2002-2010	Mills et al.. (2015)
Lincoln irrigated – pivot Heavy clay soil Fertiliser at 200 kg N/ha	14,200 kg DM/ha 2001-2003	DairyNZ Facts and Figures (2009)
Lincoln irrigated – pivot Light sandy loam Fertiliser at 200 kg N/ha	17,600 kg DM/ha 2001-2003	DairyNZ Facts and Figures (2009)

Table 1: Measured annual pasture growth at a range of sites across Canterbury

4.4 The consequences of this constant base pasture yield are seen in the range of N fertiliser requirements calculated, and in the range of results produced through the Portal. For every 1,000 kg DM/ha that the base pasture assumption is incorrect, the Nfert proxy calculates a change in N fertiliser requirements of 51 kg N/ha (i.e. a response rate of 19.6 kg DM/kg N). This represents 20-25% of the average fertiliser N input to Canterbury dairy farms.

4.5 Figure 1 shows calculations (based on Snow et al., 2016) of the current Nfert proxy in comparison with fertiliser use for four hypothetical farms, all at GMP in terms of their efficient use of inputs. Calculations are based on each farm feeding the same amount of supplement for the same amount of milksolids (thus requiring the same amount of pasture harvested) but with different base pasture production levels covering the range for irrigated farms in Table 1 (10 to 13t DM/ha/yr). Consequently, different amounts of N fertiliser would be required to grow the pasture required to achieve this constant milksolids production.
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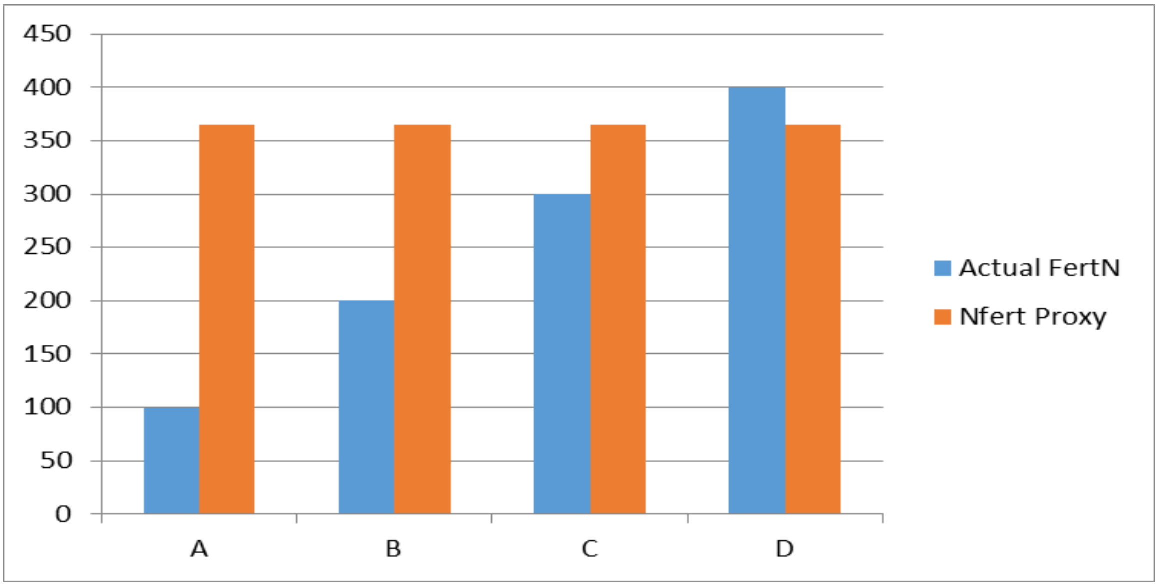

Figure 1 Comparison between 'Actual' and Nfert proxy fertiliser requirements for four hypothetical farms differing only in their inherent pasture production capacity

4.6 Figure 1 shows that the Nfert proxy calculates a constant level of N fertiliser input, reflecting the assumption of constant base pasture production. This amount is unrelated to, and substantially different from, the 'actual' requirements.

4.7 This pattern is consistent with the large range in N fertiliser amounts calculated under the Nfert proxy by Snow et al.. (2016) for Canterbury farms. Calculated amounts of required N fertiliser ranged from negative figures for low producing dryland sheep and beef farms to figures over 450 kg N/ha for high producing irrigated farms. Negative amounts are calculated where estimated pasture production was below the base of 8,070 kg DM/ha, and the Nfert proxy is coded to return 0 (zero) N fertiliser. The differences between current and Nfert proxy amounts are substantial, and can be either negative or positive.

4.8 Snow et al. (2016 pp32-35) rationalise the large decreases calculated on the basis of poor management of effluent blocks, and the large increases on the basis of 'high production' achieved by farms operating beyond GMP. Because the base assumption (8,070 kg DM/ha) is below pasture harvest levels on most Canterbury dairy farms (the median in the Ravensdown dataset is 13,900 kg DM/ha with a median N fertiliser amount of 213 kg N/ha), many of the modelled farms have higher N fertiliser requirements calculated than their actual use. It is my opinion that it is the assumption of a low and constant base production that is producing many of the large positive deviations from current rates calculated by the Nfert proxy for dairy farms. In contrast, the negative Nfert calculations returned for some sheep and beef farms reflect the base pasture assumption being erroneously high for these farms.

4.9 It should not be inferred from this that Nfert proxy modelled decreases in Nfert for individual dairy farms therefore are either accurate or conservative. Assumptions about pasture yield, N fertiliser response rates and feed utilisation affect all calculations.

4.10 The wide range of results produced, and the deviations from current fertiliser use, are further illustrated in Figure 2, using the Matrix of Good Management (MGM) dataset for dairy held by Ravensdown. The Nfert proxy results have been calculated outside the portal using formula derived from Snow et al. (2016). Note that the N fertiliser levels returned by the Farm Portal would be different, since the Nfert proxy works at block level.

4.11 In implementing the Nfert proxy ECan has limited calculated N inputs to 450 kg N/ha (i.e. to the industry-agreed maximum amount of 50 kg N/ha/month for the nine month period of August to April). For a substantial proportion (5%) of the farms in the Ravensdown dataset the Nfert proxy calculates higher rates than 450 kg N/ha/yr (Figure 2), an amount not seen in practice. This is a further indication of actual base pasture production (or non-fertiliser N available for pasture growth) on these farms being higher than assumed in the Nfert proxy.

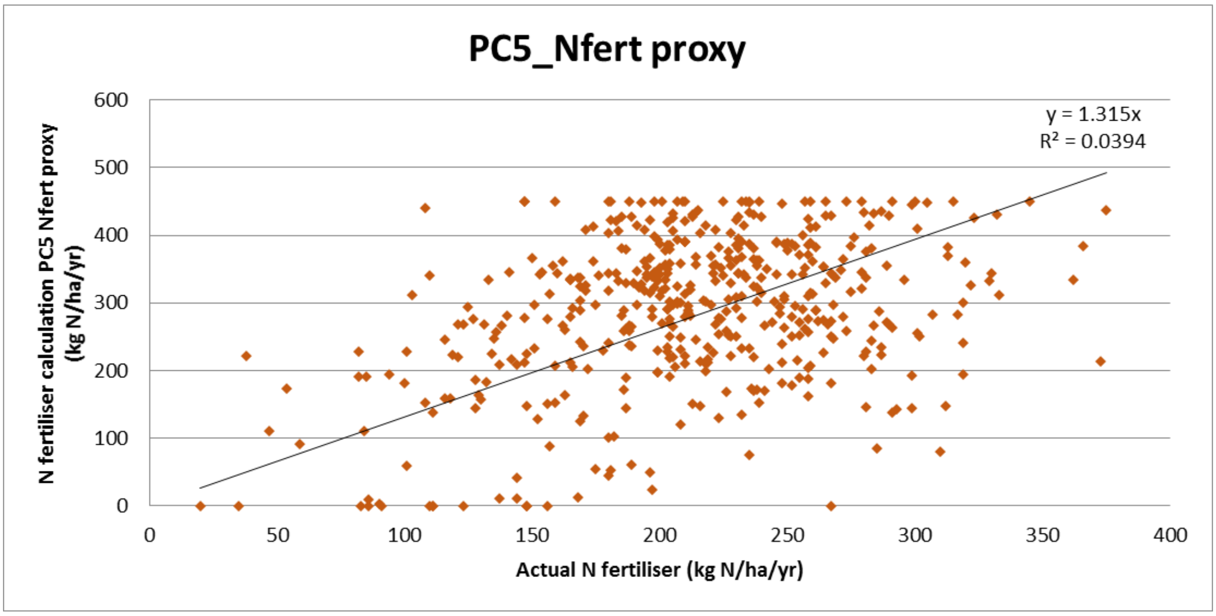

Figure 2: Estimated annual fertiliser amount using the relationship at farm level shown in Table 3 of Snow et al.. (2016), compared with actual N fertiliser amount used on farms in the MGM Ravensdown dataset.

4.12 I support the fundamental aim of the approach in the PC5 Nfert proxy. That is, to identify those farms that are not at GMP and are not matching nutrient inputs with production demand, leading to pasture wastage, low production responses and N leaching that is higher than it could be. This drive to improve efficiency is at the heart of DairyNZ's Research, Development and Extension programmes. The reality is that the Nfert proxy cannot distinguish between those farms that have low pasture harvest because they are inefficient (i.e., not achieving GMP because of low responses to inputs or inefficient pasture harvest) and those farms that are operating at GMP (i.e., are utilising inputs and pasture well) but have lower pasture production for reasons of soil type, rainfall (or irrigation system) or temperature.

4.13 In addition to errors in the fundamental assumption around pasture production the Nfert proxy has not been validated against real data. In the S42A report (at Appendix E) it is claimed that the proxy cannot be validated. I do not accept that this is the case. At the least, the critical assumption around the calculation of pasture production in the absence of N fertiliser could have been validated. Initial attempts to validate calculations with APSIM were not accepted by the MGM Reference Group and Project Management Team. Instead the modelling team has rationalised Nfert proxy outputs for individual farms by noting that large amounts of effluent are being used on some blocks thus reducing N fertiliser requirements, or by suggesting that other farms are operating beyond GMP when their milksolids production was relatively high. Given the high apparent response rate to N fertiliser (i.e. 19.6 kg DM/kg N fertiliser) it is my opinion that a more likely explanation of the cases where N fertilizer requirements are above current is that these farms have higher base pasture production than the Nfert proxy assumes and are hence seen by the Nfert proxy as needing larger N inputs.

4.14 The unavoidable errors that the assumed constant base pasture production produces, along with the sensitivity of the Nfert proxy to error in data collection covered in Dr Metherell's evidence, is likely to undermine farmer trust and confidence in the Nfert proxy. This could have implications for the credibility of the PC 5 process, the Farm Portal and OVERSEER.

4.15 Not only is the Nfert proxy fundamentally flawed as a result of incorrect assumptions and absence of validation, it is inequitable. This is illustrated by comparing the four hypothetical farms in Figure 1. The range in N fertiliser required is 300 kg N/ha for farms all operating at GMP, and all producing the same current MS production. This range is generated by the erroneous assumption of constant pasture production and produces results that penalize the farm (D) with low potential yield and conversely estimates (much) higher and unnecessary fertiliser N amounts for the farms with high pasture growth potential. The consequence of these wrong assumptions is that farms are treated inequitably and the Portal is not reflecting actual GMP at the scale of individual farms.

5. ALTERNATE PROXY BASED ON NITROGEN SURPLUS

5.1 DairyNZ and the Fertiliser Association of New Zealand promoted an alternative N Fertiliser modelling proxy based on N surplus during the MGM project, after we realised in early August 2015 that the proposed proxies were seriously flawed. The N surplus approach was considered by the MGM Project Management Group and was seen as having some merit. However, under severe time constraints, ECan decided to adopt the current Nfert proxy on the basis that it was better aligned with the philosophy of GMP as expressed in the agreed narratives, and had support from many of the project team members and representatives of other sectors.

5.2 It is stated in the Snow et al.. (2016) report that the Governance Group adopted the proxy and its parameters at its 10th November 2015 meeting. Discussions with industry Governance Group members indicate that agreement was reached to move forward with the proxy, given the time pressures, but that agreement was not reached on the proxy itself or the parameters. DairyNZ wants to be clear that our opposition to the existing proxy has been clear and consistent since August 2015.

5.3 As set out above, it is my opinion that the Nfert proxy may be better aligned with the GMP narrative in theory, but is not equitable, and does not adequately quantify GMP annual amounts of fertiliser N on individual farms in practice. Having considered a range of options during the MGM project (Pinxerhuis et al. 2015) and subsequently, it is my opinion that a proxy based on N surplus will best meet the policy objectives of Plan Change 5 and results in a more robust message to farmers around improving efficiency of N fertiliser use.

5.4 N surplus represents the difference between N in inputs and N in outputs. As such it represents the pool of N 'left' in the farm system that is at risk of being lost to the environment (e.g. through leaching of soluble N as a result of soil drainage). N surplus has been used in other parts of the world to drive improving efficiency in farm systems with reduced environmental risk (e.g. Schröder et al.. 2008). The proposed method for calculating N surplus and associated GMP N fertiliser required (NsNfert) is set out below. This method excludes estimates of N fixation that would be included in more complete N balance calculations. This is because N fixation is very difficult to measure at farm scale, and making assumptions would re-introduce the problems with the current Nfert proxy.

5.5 The N surplus (Ns, kg N/ha/yr)) for a farm is calculated as:

a) Nadjust = Nfert minus any reductions in Nfert due to removing all applications in May-July and capping monthly inputs of N (fertiliser plus effluent) to 50 kg N/ha to pastoral blocks.

b) Ns = Total N inputs (Nin) – Total N outputs (Nout)

c) Nin = (Nadjust + Neff + Nsup) (kg/N/ha)

d) Nout = (Nproduct + Neffex) (kg N/ha)

e) Neff and Nsup are N imported to the farm in effluent and supplement respectively.

f) Nproduct is sum of N exported in milk, meat or liveweight gain, crops or supplements. Including any change in supplement stored on farm.

g) Neffex is exported effluent

h) All values are obtained from the data entered by the farmer into their OVERSEER file submitted to the Farm Portal, or calculated by OVERSEER.

5.6 NsNfert is calculated as:

a) If Ns < 125, NsNfert = Nadjust

b) If Ns >= 125, NsNfert = Nadjust – (Ns-125)*0.4

c) If Ns >= 125, all existing fertiliser applications are then multiplied by the ratio NsNfert / Nadjust. This means that fertiliser types and distribution across the months and blocks are maintained. In essence this reduces the N Surplus to a maximum of 125 kg N/ha/yr.

5.7 This N Surplus proxy should be able to be placed directly into the Portal in place of the current Nfert proxy. Sequencing of the proxies in the portal is important. The Nadjust calculation is performed before the NsNfert calculation.

5.8 The effect of this N Surplus proxy on N fertiliser inputs has been estimated for two industry datasets. These are from Ravensdown and Fonterra. The results are shown in Figure 3 for the larger (474 farms) Ravensdown dataset. Overall N fertiliser is reduced by 7% on dairy farms, with reductions in the higher input farms of 15-20%. This decrease is in addition to decreases resulting from removing winter fertiliser applications and reducing N inputs onto effluent blocks. A 7% reduction in N fertiliser is substantially greater than we calculate would be achieved through the current Nfert proxy. We estimate the current N fertiliser proxy is calculating an increase of average fertiliser inputs of 36% for the Ravensdown dataset and 12% for the Fonterra dataset.

5.9 This is consistent with the results presented by ECan Officers in the Section 42A report, specifically Appendix E: Farm portal and Schedule 28. The analysis by Snow et al. (2016) of the farms with large reductions in N leached due to the Nfert proxy indicated that reducing fertiliser applications to effluent blocks was a significant factor in lower fertiliser requirements and N leaching. The proposed N Surplus proxy should also achieve gains by capturing the effluent applications (effectively at block level) within the monthly 50 kg N/ha maximum.

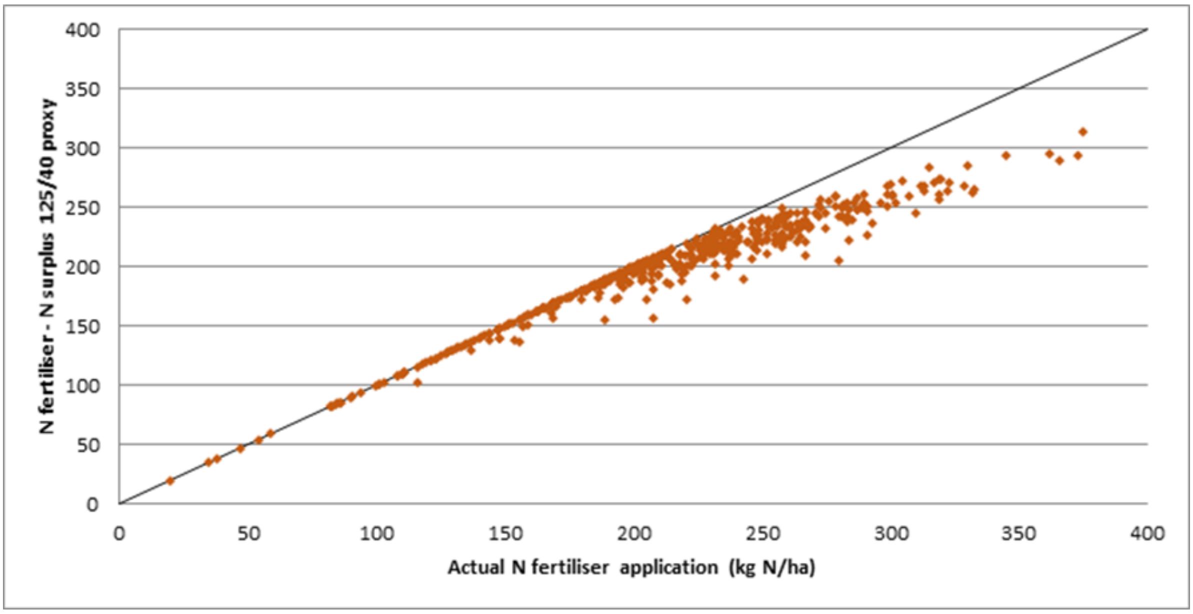

Figure 3: Difference between actual and NsNfert calculated annual amounts of N fertiliser using a cap of N surplus of 125 kg N/ha/yr with a 40% reduction in Ns above that threshold

5.10 An important element of this proposal is equation 5.5a, which prevents farms with an N surplus below the threshold from increasing their surplus. Analysis in the S42A report (at Appendix E) indicates that this control will lead to the proposed N Surplus proxy generating lower N losses to water than the current proposal.

5.11 Neither fertiliser proxy should be expected to produce large reductions in N leached on average due to both calculating leaching with lower N inputs but current production levels (i.e. assuming improved efficiency by reduced inputs with constant outputs). Because production, and therefore feed consumption is maintained, there is little reduction in N cycling or N leaching. Reductions in N fertiliser boosted pasture intake are replaced in OVERSEER by increased intake of existing, legume fixation driven pasture.

5.12 The choice of the threshold values for the N Surplus proxy is a matter of judgement. In recommending the 125 kgN/ha/yr threshold and 40% reduction five main factors have been considered:

a) The ECan policy objective to reduce N leaching to maintain or improve water quality. The dairy industry supports this policy objective;

b) The ECan policy and dairy industry objective for farmers to move to GMP;

c) The need for equity between dairy farms. Given that neither of the N fertiliser modelling proxies can unequivocally identify those farms that are furthest from GMP, it is important that the degree of change sought is reasonably balanced with the risks. In my view, the proposed thresholds and reductions do align the degree of change with the degree of risk. Greater reductions are required for farms that have higher surpluses, and higher surpluses are associated with higher leaching risk and greater risk of mismatch of nutrient supply and plant demand;

d) Aligning the amount of change required with the timeframes for change. There is some uncertainty still about when farmers need to be meeting their four year rolling average GMP targets. Those farmers who need to be at their four year rolling average for Baseline GMP in four years' time, will need to be fully implementing these practice changes in the 2017/18 season. This suggests that relatively small changes (compared to the 30-40% N leaching reductions likely to be required in some zones post-GMP) are all that can reasonably be expected to be implemented in the timeframe available. This is particularly the case for those farms with the highest N surpluses who are being required to make the greatest change;

e) Maintaining on-farm flexibility prior to changes required beyond GMP. In several sub-regions farmers are facing large reductions in N leaching after getting to GMP. The size of these reductions is currently not clear given that there may be substantial gains achieved by farmers getting to GMP, especially with irrigation practices. Research is also developing new options for farmers. The GMP proxies should not (by definition) require farmers to build infrastructure (e.g. barns) or make radical system change to achieve GMP targets. Because of the technical difficulties in calculating GMP annual amounts of N fertiliser from first principles, we are recommending an approximation that is based on judgement regarding thresholds and reductions. It is my opinion, based on farm systems research (Neal et al. (2016) and economic modelling in Mr Neal's evidence, that the level of reductions being generated by the N Surplus proxy does fit within the range where farmers can achieve these gains through GMP practices not system re-design, albeit at some cost if milksolids production is not able to be maintained at a lower N surplus.

5.13 It is my view the N Surplus proxy as proposed can be applied directly to all pastoral farms. Evidence from the Ravensdown dataset is that few if any sheep, beef and deer farms will have an N surplus greater than 125 kg N/ha/yr, but where they do the same risks apply as for dairy farms.

5.14 Application of an N surplus method to arable or horticultural farms is also possible, but would possibly require different thresholds. It is known that the same surplus results in higher N leaching from crops than for pasture (Schröder et al.. 2008). No attempt has been made to quantify N Surplus thresholds for cropping.

5.15 The question of model validation is important. As noted above, there has been no validation of ECan's current Nfert proxy, despite significant assumptions being made. There is no validation required for the N surplus approach. It is a simple mass balance, and aims only to calculate the difference between known quantities. All subsequent predictions of N leached are carried out by OVERSEER, which has been subject to validation tests in other projects.

5.16 The question of accuracy of data inputs is more important. The advantage of the N Surplus proxy is that all the data inputs can be measured on farms with at least reasonable accuracy. Where this is not the case currently (e.g. feed brought in from support blocks) there are well documented methods for doing this.

5.17 Implementation of the N Surplus proxy needs to done in a way that avoids an annual downward spiralling of GMP Loss Rate and the N leaching target for individual farms. Rule 4.38A requires:

"…farming activities to operate at or below the Good Management Practice Loss Rate, in any circumstance where that Good Management Practice Loss Rate is less than the Baseline GMP Loss Rate…."

The 'sliding' nature of the proposed N Surplus method means that N Surplus will decline in the first year of implementation. As a consequence, if NsNert is re-calculated after Year 1 on the basis of a lower N surplus this would lead to a further reduction in NsNfert and GMP loss rate, until the N Surplus reaches 125 kg N/ha/yr.

5.18 For example a farm that started with a surplus of 200 kg N/ha would have a Baseline GMP that was based on fertiliser inputs that were 30 kg N/ha/year lower than Baseline. When these reductions were implemented in Year 1, the farm would then have an N surplus of 170 kg N/ha – leading to further reduction on GMP Loss Rate if this was recalculated annually. And so on until the farm reached the threshold. This 'spiralling down' is not the intent of the policy. Once GMP Baseline Loss Rate is calculated, it needs to be locked in as the farm target for the period of the consent.

5.19 The philosophy of GMP has always been that it is not related to total level of inputs, production or N leaching. It is about the practices with which nutrient supply and demand are matched regardless of input level. In implementing and auditing GMP it is important that farmers are not marked down because they have used different balances of inputs to achieve the Baseline GMP leaching target. For example, decreased bought in supplements and increased N fertiliser to maintain feed supply but at a lower cost. I disagree with the ECan S42A analysis that states in Section 6.21,

> *"Fundamentally, in my opinion, the GMP Loss Rate number is inseparable from the GMPs, in that all other things being equal, the GMP loss rate is only able to be achieved through undertaking the appropriate practices on farm."*

5.20 The nature of farm systems is that the GMP Loss Rate / Baseline GMP Loss Rate can be achieved by a number of methods that may be GMP in total, but may not replicate the balance of methods used to calculate GMP loss rate in the Portal. The direction given to farmers needs to recognise a range of options to achieve the GMP Loss Rate / Baseline GMP Loss Rate. In my opinion, any prescription of the 'how' should be avoided.

Some farmers will already have invested in infrastructure (e.g. barns, variable rate irrigation) that allows them to manage N leaching at levels beyond GMP. For some this will be captured in their Baseline N measurements, for others these investments will have been made towards the end or after the Baseline period. In implementing the policy, I believe that farmers should be able to capture the benefits of these investments in meeting their Baseline GMP Loss Rate and not have them 'capitalised' into Baseline with additional gains then required based on N surplus. Exactly how this could be done in the Portal requires further discussion in any implementation phase.

5.21 Not all farms are able to be modelled satisfactorily in OVERSEER. This is dealt with in detail in evidence from Dr Metherell and Mr Cullen. Consequently, in my opinion, there can be no assurance that the Farm Portal will generate fair and accurate GMP limits for all farming systems. I support the expert evidence provided by Mr Willis, on behalf of Fonterra Co-operative Limited, that an alternate pathway is required to enable affected farms to have their N loss limits defined by a means other than the Farm Portal.

Dr Bruce Thorrold
22 July 2016

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