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 MR MARK NEAL FOR DAIRYNZ LIMITED

22 July 2016

DairyNZ

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CONTENTS

1. EXECUTIVE SUMMARY

1.1 The economic impact of meeting Matrix of Good Management ("MGM") Good Management Practice ("GMP") loss rates (as defined by the Portal) in Part A, varies significantly from farm to farm. An alternative N fertiliser proxy may achieve similar reductions in N loss to the current proxy, but at a lower overall cost to farms, and should therefore be preferred from an economic perspective.

1.2 If the expected gains from MGM GMP are realised, there is likely to be less need to perform additional mitigation beyond MGM GMP at a further cost, as for example in Waitaki (Part B).

1.3 There remains a number of aspects of Proposed Plan Change 5 to the Canterbury Land and Water Regional Plan ("CLWRP") that are likely to lead to significant economic impacts, and these need to be considered in a final decision on how proxies and the regulatory framework should be implemented.

2. INTRODUCTION

2.1 My full name is Mark Beaumont Neal.

2.2 I am employed by DairyNZ Limited (DairyNZ) as a Farm Systems Specialist, working across research and development at the interface of farm, financial and environmental impacts.

2.3 I have been employed with DairyNZ since July 2014.

Qualifications and Experience

2.4 I hold a degree in Agricultural Economics (First Class Hons) from the University of Sydney (1999). I have completed the Intermediate Sustainable Nutrient Management course, which uses the OVERSEER model. I also have training in the use of Farmax, a farm modelling tool.

2.5 At the University of Sydney, for my final year thesis, I created a whole farm model of a dairy farm to analyse optimal management decisions. I later published an advanced version of this model in the Journal of Dairy Science (2007), and expanded it to consider risk in both climate and prices in a later publication for the Australasian Dairy Science Symposium (2010).

2.6 I have published research on farm modelling, and presented at numerous conferences on a range of work on the scientific, economic and environmental aspects of dairy farm systems. A list of my papers, publications and industry presentations is attached as Appendix 2 to my evidence.

2.7 At the University of Queensland, I worked with the Risk and Sustainable Management Group on, amongst other projects, a sophisticated economic model of land use, farm profits and resource use operating at a catchment level to evaluate alternative property rights regimes.

2.8 I was responsible for developing the economic and optimisation capability in the DairyNZ Whole Farm Model, which is used for modelling research projects around farm systems, both by DairyNZ and with other industry partners.

2.9 In terms of Environment Canterbury ("ECan") planning processes, I note that I was previously involved in Section 13 Ashburton (Variation 2), and South Canterbury Coastal Streams (Variation 3). There I reviewed the modelling that was performed by either Mr Alfredo Adler under contract for DairyNZ, or Tai Chikazhe (DairyNZ) together with Carla Muller and Angela Harvey of DairyNZ. The aim of that modelling was to determine the cost of mitigation under the proposed rules, checking those results with farmer and industry groups.

2.10 I have extensive practical dairy farming experience, both with my families' dairy operation of a 700 cow dairy farm in Australia, and have managed grazing-based dairy operations in North America and South America.

Background

2.11 I am familiar with ECan's Plan Change 5 to the CLWRP with respect to nutrient management and economic farm impacts in particular. I have not been involved with the development of the MGM project, although other members of DairyNZ have been involved in various capacities.

Code of Conduct

2.12 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.

3. SCOPE OF EVIDENCE

3.1 My evidence will deal with the following:

(a) An introduction to how Plan Change 5 will impact farming operations
(b) A section on the method of analysis, describing how effects were modelled
(c) Modelling results as they apply to Part A

(d) Modelling results as they apply to Part B
(e) Economic impacts not directly modelled
(f) Conclusions

4. INTRODUCTION

4.1 Plan Change 5 describes the process whereby narrative GMP on-farm is incorporated into modelled GMP nitrogen (N) loss rates from individual farms. Achieving GMP N loss rates will affect farm systems. The presumption is that farmers can reach the portal-based N loss number at low cost, and largely without infrastructure investment.

4.2 Two modelling proxies have the largest impact on Farm N loss from analysis of our modelling work. These are the irrigation proxy and the N fertiliser proxy. The irrigation proxy generally leads to a large reduction in N loss, due to more efficient irrigation, which leads to reduced levels of drainage that generates N leaching. The costs and practicalities of this are not covered in this evidence, with the evidence of Mr Andrew Curtis and Mr Ian McIndoe covering some of the technical and practical aspects.

4.3 The fertiliser proxy, and specifically N fertiliser, can have a large effect, but one which varies significantly from farm to farm. A number of farms were modelled for Part A and Part B to consider the likely costs from meeting MGM GMP loss rates as impacted by the N fertiliser proxy.

5. METHOD OF ANALYSIS

5.1 To estimate the effects of Plan Change 5 (parts A and B) on dairy farms, a group of 22 farms had OVERSEER files run through the MGM GMP tool (“the Farm Portal”) to consider the impact of proxies. Seven representative dairy farms were then modelled in detail. The process used real farm information to calibrate a Farmax and OVERSEER models (OVERSEER Version 6.2.2), and mitigations were then carried out from an appropriate base, after accounting for MGM modelling proxies, as described in the following section. This process was undertaken by Tai Chikazhe, a farm systems modeller working in DairyNZ, under the supervision of myself and Carla Muller. We both reviewed his work as part of DairyNZ’s internal review process.

5.2 The mitigation approach was to follow a process of de-intensification. This would start with a reduction in N fertiliser, which would result in lower grass growth, and so a pro-rata reduction in stocking rate was carried out. The diet of the cow (and hence milk production) was kept constant, consistent with the managerial ability currently being exhibited. Having said this, some progress in skills is implicitly assumed to manage the more frequent and rapid swings in feed supply from surplus to deficit and back again with lower stocked systems.

5.3 This modelling approach is transparent, reasonably consistent with current managerial ability and does not require irreversible investment in infrastructure (e.g. barns, discussed further in section 9.5). It uses actual farms, and largely matches modelling approaches taken in DairyNZ submissions to Variation 2 and Variation 3.

5.4 One of the assumptions in the modelling work was that the dairy farms were modelled as dairy platforms. Specifically, the area of land that milking cows used during the lactation period was used as the basis for the modelling. This was to produce consistent and transparent results, whereas in reality, many farms own or lease runoff areas, or alternatively use paid grazing, which are reasonably independent to decisions made to manage the milking platform.

5.5 An assumed average milk price of $6.00 per kg milksolids was used. This was a lower average price than used in previous submissions, reflecting medium term market sentiment (e.g., average of the last five seasons for Fonterra' payout, including dividend, is $6.00). However, this is still significantly higher than that received in the last two production years, and also being significantly higher than the price currently forecast for the current production season.

Treatment of modelling proxies

5.6 The irrigation proxy was applied to all farms, creating a new OVERSEER file, but this was assumed to have no cost in the absence of expertise around the estimation of any applicable infrastructure or upskilling costs. It was also assumed to have no impact on pasture production (positive or negative). Hence the same Farmax file as the current base would still apply.

5.7 The remaining proxies, including the N fertiliser proxy, were then applied. This then generated a new GMP N loss rate, and a new OVERSEER file. However, the new OVERSEER file did not represent an actual farm system, as in many cases N fertiliser (an input) was reduced, without affecting milksolids production (output). Therefore, the Farmax file was then modified to create a farm system that could be achieved in practise, using the least cost methodology as applied previously (e.g. Variation 2 and 3) to meet the MGM GMP N loss rate. This reduction in profit modelled in Farmax was then an estimate of the cost of achieving MGM GMP (excluding the cost of achieving the irrigation proxy). Generally this would be at the same or less cost than actually following the Portal recommendations to change N fertiliser use.

5.8 Further mitigations were then carried out to estimate the cost of a 10% and 20% reduction beyond MGM GMP.

6. MODELLING RESULTS – PLAN CHANGE 5: PART A

6.1 The OVERSEER files for 22 farms were run through the GMP tool, which allows either one proxy, or all proxies to be applied, before returning the modified OVERSEER file, with an associated N loss. Two farms would not create a working OVERSEER file. These files were run through with either the N fertiliser proxy first, or the irrigation proxy first, and then with all proxies applied (Table A.1, in Appendix 1). It does not allow selection of proxies to apply together, only one or all. The percentage reduction in N loss as a result of applying the N fertiliser proxy, or applying all proxies after irrigation, were similar, giving confidence that these were the main factors affecting the results[1].

6.2 The irrigation proxy (when applied first by itself) led to an average reduction of 22%, with a range from an increase of 20%, to a reduction of 66%. If the N fertiliser proxy was applied first, followed by remaining proxies (including irrigation), the percentages were similar (average -19%, range from +23 to -65%).

6.3 The N fertiliser proxy (when applied first by itself) led to a reduction in N loss of 0%, but with a wide range of +69% to -30%. This was similar to the effect of applying all other proxies after irrigation (average -4%, range + 71% to -36%).

6.4 The average impact of all proxies was a 23% reduction in N loss (range +77% to -70%). Six farms had an MGM GMP N loss higher than their base. If it was assumed that farmers had to meet the lower of the MGM GMP from the portal or current practise, the reduction in an average 29% (range 0 to -77%)

6.5 Seven farms were modelled in detail. More detailed summaries are provided in Appendix 1 (some of these were also used for Part B). In brief, the application of N fertiliser proxies on individual farms can lead to a significant reduction in N loss relative to the application of irrigation proxies alone (e.g. up to 30%), although the average is close to zero (see Table A.1).

6.6 The impact of the N fertiliser proxy was to reduce N fertiliser in many cases. For example, for a selection of farms (He, M, H and P), where N fertiliser was originally between 246 and 312 kg N per hectare, the N fertiliser proxy reduced this by an average of 100kg N/ha (-40%), but for one farm the reduction was 193 kg N (-72%).

6.7 The portal does not consider the impact on the farm system of doing this. In other words, a reduction in N fertiliser (as per the portal) will be likely to reduce pasture growth (as per evidence of Dr Stewart Ledgard), and lead to a reduction in revenue and/or an increase in

[1] There was a change in Overseer version used by the Portal during our modelling process, before we had fully completed our table. Therefore, some differences in percentages may reflect gaps in the table rather than differences due to the order of applying proxies.

costs. The impact of a reduction in N fertiliser was modelled in two ways; Firstly, using our normal modelling methodology to achieve the same reduction in N loss at least cost. Secondly, it was modelled using the N fertiliser reductions proposed by the Portal. Using the least cost methodology, meeting the same N loss can cost up to 16% of farm earnings before interest and tax. For some farms the second approach of using the Portal was similar, but in other cases it was, as expected, more expensive (e.g. Farm H cost 3% by least cost, but 5% by using MGM GMP recommendations for N fertiliser use. Farm P; 10% by least cost, 13% by MGM GMP fertiliser use.)

6.8 It should be noted that the effect of interest and lower milk prices (as currently occurring) magnify the impact on profit and cashflow. Some caution needs to be applied when extrapolating these results due to the range of outcomes seen in practice (some farms have large impacts, but the proportion of these is unknown), and also the uncertain impact of updates to OVERSEER and their interaction with modelling proxies. For example, when the Portal version changed from 6.2.1 to 6.2.2, one farm went from a Portal reduction in N loss of 10% to no reduction being required.

Alternate modelling proxy

6.9 An alternate N fertiliser proxy is proposed in the evidence of Dr. Thorrold. The alternate proxy retains the GMP factors that lead to the most reduction in N loss (e.g. limiting N fertiliser application on blocks where there are significant amount of N applied as effluent; Snow et al.. 2016), and incentivises efficient use of N, but does not penalise individual farmers for variation in productive capacity beyond their control. Although we were unable to test large numbers of farms with the precise formulation if GMP embodied in the alternative N proxy (without access to the mechanics of the Portal), I expect that the outcomes using the alternative will approach a similar impact (on average) in terms of reduction in N loss, but with less impact on farm profit.

6.10 The current proxy has significant variability in impact between farms that is difficult to explain in terms of how good management practise is (or is not) being practised on farm, and the lack of transparency between practise and requirements does not make good policy. I expect the alternative proxy to be more easily linked to actual practise, and so where there is significant variation in what is the portal N loss between farms, this would be more easily explained.

7. MODELLING RESULTS – PLAN CHANGE 5: PART B

7.1 Three actual farms were modelled for Part B – two in the Lower Waitaki catchment, and a third in a close (and related) catchment to account for a different irrigation system. It was found that to meet MGM GMP (costing only the fertiliser proxy component) would cost between 0% and 10% of farm earnings (average 4%). GMP, as per the Portal, modelled on average a 41% reduction in N loss, although this varied significantly (10% to 76%) and was mostly attributed to the irrigation proxy. To reduce N loss 10% beyond MGM GMP cost between 3% and 13% of earnings (average 8%).

8. ECONOMIC IMPACTS NOT DIRECTLY MODELLED

8.1 I list here a number of economic impacts that were not modelled directly, but that in my professional opinion, are significant in terms of affecting which will be the most appropriate solution.

8.2 The Farm Portal can give the appearance of unpredictability with respect to what is required. In other words, it may generate uncertainty, which reduces the likelihood of investment (or asset replacement) in farms that are affected, as it would in any business (e.g. Bloom et al.., 2007). However, I am unable to quantify this and apportion the impact of current milk price uncertainty, existing regulatory uncertainty, and that uncertainty related to the Portal as proposed to operate.

8.3 Fonterra notes the impact of multiple seasonal impacts, such as drought, leading to a "sinking lid" effect that limits future profitable opportunities. While there may be environmental gains relative to the costs of shutting out the future profitable options (in some catchments), the question of whether this is the intent of GMP-related methodologies (to operate as a catchment limit) has been raised elsewhere in the evidence of Mr Gerard Willis.

8.4 Furthermore, it is not clear that the appropriate economic perspective is driving the choice of fertiliser proxies. For example, the science presented by Dr Stewart Ledgard in his evidence shows that there is a poor link between N fertiliser use (an input) and N loss (the outcome we wish to reduce). In this case, certain regulations on N fertiliser use are likely to be a poorly targeted approach.

8.5 Related to the previous matters is a view expressed by the Officers Report that the only way farmers can get to the GMP loss rate is by doing a prescribed range of activities. For example, a quote from p.32, para 6.21 of the Officer's Report:

> *"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."*

This reasoning seems at odds with the overall intent on using OVERSEER, i.e. that an outcome-focussed model gives farmers the ability to meet the desired outcome (e.g. a GMP loss rate) with flexibility to do that at least cost, within the resources and skills that they have. So the economic perspective should be better stated that farmers ***could*** get to the GMP loss rate by a range of methods, but that MGM GMP ***should*** allow this to be achieved at low cost, and generally without significant capital investment. In other words, farmers adopt the MGM GMP practices not because it is the only way of achieving the GMP loss rate, but because it is the cheapest way to meet that goal.

8.6 While performing our analysis, it became clear that there were some OVERSEER base files that did not appear to work to the spirit of the GMP rule for fertiliser. For example, one file had applied solids and effluents to the effluent block, but had also applied the same amount of N fertiliser to the effluent and non-effluent blocks, with the effect that total N was applied at a much higher rate on the effluent block. This runs counter to the GMP that effluent nutrient is taken into account. However, we were unable to establish whether the farm ***actually*** had done what was written up in the OVERSEER file, or whether there was simply no effort to record any adjustments that were made on the farm. Hence I have some concerns that baseline files may lead to Portal numbers that are inappropriate due to poor recording of baseline data, although I am unable to quantify this.

8.7 The farm modelling is performed at a longer term average, but using average debt loads and average cost structures would place most farms (up to 85%) running at a cash deficit (DairyNZ 2016). This means farms that need to make modest changes, as judged by cashflow in an average year, may struggle to implement change in the current milk price situation. This could be a factor in determining the timetable for further action, as per comments in the Officers Report (6.184)

> *"… That said, if individual farmers or industry are able to provide evidence to the hearing, showing how such a timeframe could cause undue hardship or would be prohibitively costly, particularly in the light of the risk of not meeting CLWRP water quality outcomes in a reasonable timeframe, that would be helpful".*

8.8 It is acknowledged that a common impact of the N proxy is a reduction in N fertiliser use. The modelling done by DairyNZ assumes that there is a positive response to N fertiliser (which agrees with the science and evidence of Dr Stewart Ledgard), and so the withdrawal of this will lead to a reduction in pasture growth, leading to some combination of decreases in revenue or increases in costs, and hence a reduction in profit, and spending in the local community. However, in some catchments, there will not be a need to reduce N loss, so costs may be imposed by the proposed MGM GMP that do not provide a net benefit to community (i.e. benefit to water quality does not outweigh costs to farmers and the economy on which the local community relies).

8.9 Although N fertiliser is less flexible than purchased supplement at delivering feed at a time of need, it is often cheaper than purchased supplement. Insofar as the MGM GMP focus on monthly fertiliser distracts from profitable opportunities to substitute cheaper N-grown grass for more expensive supplement, it puts farmers at risk of missing opportunities to improve profitability where it may have negligible impact on the environment.

8.10 There are a number of research projects being carried out with regards to alternative forages (e.g. Forages for Reduced Nitrate Leaching) that could lead to reduced nitrate leaching. The nitrogen requirements of these plants may differ significantly to existing ryegrass clover pastures. Thus an inflexible view of N fertiliser and its benefit relative to environmental risks, how this is modelled in OVERSEER, and how it interacts with GMP's, may slow the uptake of these alternatives even though they are a net benefit to the environmental outcomes that are sought, at a lower cost than alternatives.

8.11 There is the potential for the Portal and associated modelling proxies to deliver either unexpected results or propose options that may be difficult to implement for a small number of farms. Therefore, resorting to prohibited status for activities not complying could lead to excessively costly impacts on a small number of farmers and their operations. In this sense, a lower cost solution that does not extend environmental footprint could be the alternative pathway proposed in the evidence of Mr Gerard Willis.

9. CONCLUSIONS

9.1 The Section 32 report for Plan Change 5 does not make a strong economic case for the choice of individual modelling proxies. There is a cost associated with the implementation of those proxies, and this was modelled. The proposed alternative is likely to achieve a similar reduction in N loss, at a lower cost to the farm business, and so should therefore be preferred. A final decision should consider the costs that were explicitly modelled, and those that are foreseeable, but were not able to be estimated.

9.2 The reduction in N loss achieved by dairy farmers by operating at GMP in the Lower Waitaki catchment is likely to be greater than anticipated by ECan. Therefore, the requirement for dairy farmers to make reductions beyond GMP may not be necessary when the gains from GMP are taken into account."

Mark Neal
22 July 2016

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APPENDIX 1 – Farm Modelling

1. Results from applying proxies

Table A.1: The N loss effect of applying proxies

Farm	Ident.	Base (Pre MGM) kg N loss/ha	Irrigation Proxy Only kg N loss/ha	N fertiliser proxy only kg N loss/ha	All proxies applied kg N loss/ha	% Reductions, Irrigation proxy then all: Base to Irri	Irri to all	Total Base to all	% Reductions, N proxy then all: Base to N	N to all	Total Base to all	Farms at minimum of Base and Portal
*1^*	*HE*	*51.5*	*54.4*		*36.6*	*6%*	*-33%*	***-29%***			***-29%***	***-29%***
2		27.0	24.6	28.9	28.0	-9%	14%	**4%**	7%	-3%	**4%**	***0%***
3		42.1	37.6	40.0	37.4	-11%	0%	**-11%**	-5%	-6%	**-11%**	***-11%***
*4^*	*H**	*84.1*	*28.3*		*20.0*	*-66%*	*-29%*	***-76%***			***-76%***	***-76%***
5		45.7	48.1	32.0	33.0	5%	-31%	**-28%**	-30%	3%	**-28%**	***-28%***
*6^*	*M*	*59.1*	*26.4*		*16.8*	*-55%*	*-36%*	***-72%***			***-72%***	***-72%***
7		47.5	42.4	62.1	55.7	-11%	31%	**17%**	31%	-10%	**17%**	***0%***
8		94.7	73.4	74.6	59.4	-22%	-19%	**-37%**	-21%	-20%	**-37%**	***-37%***
9		79.7	95.5	65.5	80.3	20%	-16%	**1%**	-18%	23%	**1%**	***0%***
10		32.8	17.4	27.8	15.6	-47%	-10%	**-53%**	-15%	-44%	**-53%**	***-53%***
11		33.6	35.0	56.9	59.7	4%	71%	**77%**	69%	5%	**77%**	***0%***
12		120.9	43.0	138.0	48.4	-64%	13%	**-60%**	14%	-65%	**-60%**	***-60%***
13		87.4	#	#	#							
14		119.1	90.3	95.9	68.3	-24%	-24%	**-43%**	-19%	-29%	**-43%**	***-43%***
15		112.8	50.5	121.7	55.9	-55%	11%	**-50%**	8%	-54%	**-50%**	***-50%***
*14^*	*O*	*78.9*	*49.5*		*51.6* #	*-37%*	*4%*	***-35%***			***-35%***	
*17^*	*G*	*12.2*	*11.5*		*12.2*	*-6%*	*6%*	***0%***			***0%***	***0%***
18		80.4	61.4	62.8	46.4	-24%	-25%	**-42%**	-22%	-26%	**-42%**	***-42%***
19		65.1	49.3	70.7	54.3	-24%	10%	**-17%**	9%	-23%	**-17%**	***-17%***
20		53.2	44.3	52.4	46.5	-17%	5%	**-13%**	-2%	-11%	**-13%**	***-13%***
*21^*	*P**	*150.9*	*121.6*		*93.4*	*-19%*	*-23%*	***-38%***			***-38%***	***-38%***
*22^*	*R**	*41.5*	*37.6*		*37.4*	*-9%*	*-1%*	***-10%***			***-10%***	***0%***
					Average	**-22%**	**-4%**	**-24%**	**0%**	**-19%**	**-24%**	**-28%**
					Max	20%	71%	77%	69%	23%	77%	0%
					Min	-66%	-36%	-76%	-30%	-65%	-76%	-76%

^Overseer Version 6.2.2 and portal 6.2.1 (June 2016)
All other farms: Overseer Version 6.2.2 and portal 6.2.2 (20 July 2016)
Farms in italics with an identifier were modelled in detail
*Farms in (or near) lower Waitaki catchment, #Not working in current portal

2. Modelling summaries by farm

Waitaki

Farm P

The application of MGM irrigation proxy alone led to a 19% reduction in N loss. From that point, a further 23% reduction in N loss was implied by the application of the remaining proxies, with effects largely due to the N proxy.[2]

The starting point for Farmax and OVERSEER modelled mitigation was assumed to be the current farm, but with the irrigation proxy applied[3]. To meet the Portal number (i.e. with the application of other proxies, such as the N proxy), required a 19% reduction in N loss, at a costs of 10% of earnings before interest and tax[4]. This cost was based on reduced N fertiliser leading to less pasture grown, and a pro rata reduction in stocking rate (a least cost methodology).

To move from MGM GMP as per the portal, to 10% below (for N loss), led to a 13% reduction in earnings before interest and tax (relative to current practise).

These effects were calculated at an average milk price, assumed at $6.00/kg MS. It should be noted that the effect of interest and lower milk prices magnify the impact on profit and cashflow. For example, assuming a $4.25 milk price and a $0.30 dividend for this season, the farm, if an average size for the South Island (190ha), with the average debt loading of 40%, makes a loss after interest costs of -$18,000 based on current operations. Applying MGM GMP increases the loss by $51,000 to -$69,000.

Farm R

The application of MGM irrigation proxy alone led to a 9% reduction in N loss. From that point, a further 1% reduction in N loss was implied by the application of the remaining proxies, with effects largely due to the N proxy.

The starting point for Farmax and OVERSEER modelled mitigation was assumed to be the current farm, but with the irrigation proxy applied, and an adjustment to fertiliser based on GMP. This farm was, according to the only information available, applying the same amount of N fertiliser to the effluent and non-effluent blocks. It was assumed that a reasonable GMP would reduce N fertiliser to take into account the effluent application. This was modelled, and then the irrigation proxies applied to create a base file. From this point, applying the N proxy was only a further 1% reduction in N loss, and a 1% reduction in farm earnings before interest and tax.

To move from MGM GMP as per the portal, to 10% below (for N loss), led to a 3% reduction in earnings before interest and tax.

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[2] Proxies can be applied either singly, or as a whole, using the tool available.
[3] No attempt was made to account for investment or training cost, or a reduction or increase in pasture grown, as a result of applying the changes proposed by the irrigation proxy.
[4] Interpolation was used where the steps in Farmax and Overseer modelling did not match the required reductions exactly.

These effects were calculated at an average milk price, assumed at $6.00/kg MS. It should be noted that the effect of interest and lower milk prices magnify the impact on profit and cashflow, although at GMP there was little effect on farm operations, and modest impacts at GMP less 10% when compared with Farm P.

Farm H

(This is near the Waitaki catchment and is used to represent a different irrigation type for the Waitaki catchment)

The application of MGM irrigation proxy alone led to a 64% reduction in N loss. From that point, a further 18% reduction in N loss was implied by the application of the remaining proxies, with effects largely expected due to the N proxy.

The starting point for Farmax and OVERSEER modelled mitigation was assumed to be the current farm, but with the irrigation proxy applied. To meet the Portal number (i.e. with the application of other proxies, such as the N proxy), required a 29% reduction in N loss, at a costs of 3% of earnings before interest and tax, using a least cost approach.

If the reduction in N fertiliser proposed by the proxies is carried out (by fertiliser reduction, rather than least cost to meet the number), farm earnings before interest and tax would fall by 5%.

To move from MGM GMP as per the portal, to 10% below (for N loss), led to a 9% reduction in earnings before interest and tax.

These effects were calculated at an average milk price, assumed at $6.00/kg MS. It should be noted that the effect of interest and lower milk prices magnify the impact on profit and cashflow. For example, assuming a $4.25 milk price and a $0.30 dividend for this season, the farm, if an average size for the South Island (190ha), with the average debt loading of 40%, makes a significant loss after interest costs. Although the impact of MGM GMP was modest relative to farm P (increasing the loss by roughly $10,000), it would still increase the loss when cashflow would be under significant pressure.

Other Canterbury catchments

Farm M

The application of MGM irrigation proxy alone led to a 55% reduction in N loss. From that point, a further 36% reduction in N loss was implied by the application of the remaining proxies, with effects largely due to the N proxy.

If the reduction in N fertiliser proposed by the proxies is carried out, farm earnings before interest and tax fall by 16%.

Modelling showed an alternative strategy that could meet the same N loss outcome using our standard methodology was at similar reduction in farm earnings before interest and tax. Again, subsequent reductions became much more expensive.

Farm G

The application of MGM irrigation proxy alone led to no reduction in N loss. From that point, no further reduction in N loss was implied by the application of the remaining proxies.

The cost associated with meeting the portal number is low, reflecting only the cost of plan preparation.

A 10% reduction in N loss from the portal N loss is around a 10% reduction in profit per hectare, which is more costly than typically expected. One factor is the lower profit per hectare on this farm at the base than average for all farms, but it is still within the range of observed farm earnings.

Farm O

The application of MGM irrigation proxy alone led to a 37% reduction in N loss. From that point, a 4% increase in N loss was implied by the application of the remaining proxies, with effects largely due to the N proxy.

Modelling showed a 10% reduction in N loss from current would costs 4% of farm earnings before interest and tax.

Farm He

The application of MGM irrigation proxy alone led to a 6% increase in N loss. From that point, a 33% reduction in N loss was implied by the application of the remaining proxies, with effects largely due to the N proxy.

If the reduction in N fertiliser proposed by the proxies is carried out, farm earnings before interest and tax fall by 78%, which is more costly than typically expected. One factor is the lower profit per hectare on this farm at the base than average for all farms, but it is still within the range of observed farm earnings.

Modelling showed an alternative strategy that could meet the same N loss outcome as the portal using our standard methodology was at a 45% reduction in farm earnings before interest and tax.

APPENDIX 2

Papers, Publications and Industry Presentations

- Neal, M. and Cooper, S. (2016) Modelling the Risk, Return and Resiliency of Future Dairy Farm Systems, Presented at the Conference of the Australian Agricultural and Resource Economics Society, Canberra, February 2016.
- Neal, M., Kay, J.K., Peel, S., McCarthy, S. (2016) A decision support tool for autumn management in a spring calving pasture-based dairy system, Australasian Dairy Science Symposium, Sydney, November 2016.
- Neal, M. Knowing today to plan for tomorrow: From the market to farm systems, Invited Keynote Presentation, INALE Forum, Montevideo (Uruguay), June.
- Neal, M. (2015) Statement of Primary Evidence Of Mark Neal For Fonterra Co-Operative Group Limited And DairyNZ Limited, Variation 3, November.
- Neal, M. (2015) Statement of Primary Evidence Of Mark Neal For Fonterra Co-Operative Group Limited And DairyNZ Limited, Variation 2, 15 May.
- Neal, M. (2015) Teaching examples for the state contingent approach to production under uncertainty, Presented at the Conference of the Australian Agricultural and Resource Economics Society, Rotorua, February 2015.
- Neal, M. (2014) Mobile milking: Potential application and spatial land use implications, 2014 Australian and New Zealand Spatially Enabled Livestock Management Symposium, Hamilton.
- Neal, M. (2014) Technological innovation, Dairy Research Foundation Symposium, June 19-20, Pokolbin (Repeated for OneFarm Webinar and DairyNZ Seminar Series)
- M.B. Neal, J.S. Neal, W.J. Fulkerson (2010) Optimal Choice of Dairy forages: Considering risk, Proceedings of the 4th Australasian Dairy Science Symposium 2010 151
- Neal, M. (2010), LiDAR technology for mapping farms and understanding drainage, Dookie Campus, University of Melbourne Field Days
- Neal M, Neal J, Fulkerson WJ. (2007) Optimal choice of dairy forages in eastern Australia. Journal of Dairy Science. 2007 Jun;90(6):3044-59.
- Chapman, D. F.; Malcolm, L.R.; Neal, M; Cullen, B. R. (2007) Risk and uncertainty in dairy production systems: Research concepts, tools and prospects. In: D.F. Chapman, D.A. Clark, K.L. Macmillan, D.P. Nation, eds. 'Meeting the Challenges for Pasture-Based Dairying', Proceedings of the 3rd Australasian Dairy Science Symposium, Melbourne, VA. Australia, National Dairy Alliance. Pp 476-491.
- Neal, M (2007) Estimating Complex Production Functions: The Importance of Starting Values, Paper presented at 51st Annual Australian Agricultural and Resource Economics Conference, February, Queenstown
- Neal M, (2006) The potential cost to New Zealand dairy farmers from the introduction of nitrate-based stocking rate restrictions. International Association of Agricultural Economists, August 12-19, Gold Coast.
- Neal, M. J. Neal, and W. Fulkerson (2006) Choosing the best forage species for a dairy farm – The Whole-farm approach., Joint ADSA ASAS Meeting, July 6-13 Minneapolis, Minnesota
- Neal and WJ Fulkerson (2006) "Traits and the Farm System, Paper presented at 50th Annual Australian Agricultural and Resource Economics Conference, February, Sydney One size fits all"? – The Relationship Between the Value of Genetic

- Neal, M., Drynan, R., Fulkerson, W., Levy, G., Wastney, M., Post, E., Thorrold, B., Palliser, C., Beukes, P., and Folkers, C. (2005) Applying differential evolution techniques to a whole-farm model to assist optimal strategic decision making, MODSIM 2005, 12-16 December, Melbourne.
- Beukes, P., Neal, M. , Drynan, R., Fulkerson, W., Levy, G., Wastney, M., Post, E., Thorrold, B., Palliser, C., and Folkers, C. (2005) Comparing Risk for Different Dairy Farm Management Systems in Taranaki, Proceedings of the New Zealand Grasslands Association Conference, 11-13 October, New Plymouth
- Beukes, P., C. Palliser, W. Prewer, V. Serra, J. Lancaster, G. Levy, C. Folkers, M. Neal, B. Thorrold, M. Wastney (2005) Use of a Whole Farm Model for Exploring Management Decisions in Dairying, MODSIM 2005, 12-16 December, Melbourne.
- M Neal, W Fulkerson, and R Drynan (2005) How much feed-related capital is profitable?, Dairy Research Foundation Symposium, Camden
- Neal, M. , Drynan, R., Fulkerson, W., Levy, G., Wastney, M., Post, E., Thorrold, B., Palliser, C., Beukes, P., and Folkers, C. (2005) Optimisation of a Whole-farm Model, Paper presented at 49th Annual Australian Agricultural and Resource Economics Conference, 9-11 February, Coffs Harbour
- Neal, M, Fulkerson, W, and Drynan, R, (2005) How can farm returns rise?, Australian Dairyfarmer, March-April
- "Optimizing return in a whole-farm model under conditions of risk" Australian Dairy Science Conference, Shepparton, Friday, 27 February 2004
- Neal, M (2004) Re-ranking of individual firms using alternative performance measures: The case of New Zealand dairy farms, Proceedings of the Asia-Pacific Productivity Conference, Brisbane, 14-16 July
- "Ranking of individual firms using alternative performance measures" ANU PhD Conference Canberra, Thursday, November 11 2004
- Neal, M (2004) Optimising return in a whole-farm model under conditions of risk, Paper presented at 48th Annual Australian Agricultural and Resource Economics Conference, 11-13 February, Melbourne
- Neal, M. (2003) Maximizing profit: a farm systems approach, in Proceedings of the Dairy Research Foundation Symposium, University of Sydney, Camden 2-4 October 2003
- Neal, M. "Integrating economics into a whole-farm model" Waikato University Student Research Conference Hamilton, 22 October 2003
- Neal, M (1999) Modelling Seasonal Production on a New South Wales Dairy Farm, Undergraduate thesis - BAgrEc, University of Sydney.