

Farming Under Nitrate Leaching Limits

‘A case study of the effects of meeting potential nitrate leaching limits in a Canterbury dairy farming situation’



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1.0 Executive Summary

This report investigates the impact that altering the farm system of Singletree Dairies in mid Canterbury to achieve a predicted nitrogen leaching loss in Overseer of 24kgN/ha/year will have on both the operation management of the farm and the financial effects of this.

Singletree Dairies currently has a predicted leaching loss of 32kgN/ha/year and through the implementation of more pivot irrigation, increasing the area that effluent is applied along with altering nitrogen fertiliser management in April and May the level of leaching loss can be reduced to 24kgN/ha/year. The management and financial implications of these alterations are minor and are viewed as quite achievable.

When modelled on a 'light' soil with an available water holding capacity of 60mm, the leaching estimate for Singletree Dairies increased to 62kgN/ha/year. Significant management alterations are required to reduce leaching to the desired 24kgN/ha/year – notably a decrease in stocking rate from 3.76cows/ha to 2.90 cows/ha. The financial implications at a farm level of these alterations were not as great as initially thought with a reduction in return on asset from 6.91% to 6.75%.

Singletree Dairies is able to continue to operate profitably under the level of nitrogen leaching suggested in this document, however there is likely to be a decrease in production levels in dairy farming areas of light soils which may affect the local communities the greatest.

2.0 Introduction

The number of dairy cows in New Zealand over the past 15 years has increased by approximately 50% from 3.06 million dairy cows in the 1996/97 season to 4.63 million dairy cows in the 2011/12 season. Over the same period, the area that is used for dairy farming has increased by 30% from 1.27 million hectares to 1.64 million hectares and production increased by 90% from 880 million kilograms of milksolids (kgMS) to 1,685 million kgMS (DairyNZ, 2012). In essence, dairy farming in New Zealand has expanded but also become more intensive with more cows per hectare and more milksolids per cow.

In the Canterbury region there has been a marked increase in the area occupied by dairy farming as shown in figure 1 below due to the expansion of irrigation and perceived more favourable returns than alternative land use options. On average dairy farms in the Canterbury region are stocked at 3.44 cows/ha producing 1,361kgMS/ha, 21% and 32% above the New Zealand average respectively (DairyNZ, 2012) and hence can be considered intensive dairy farming.

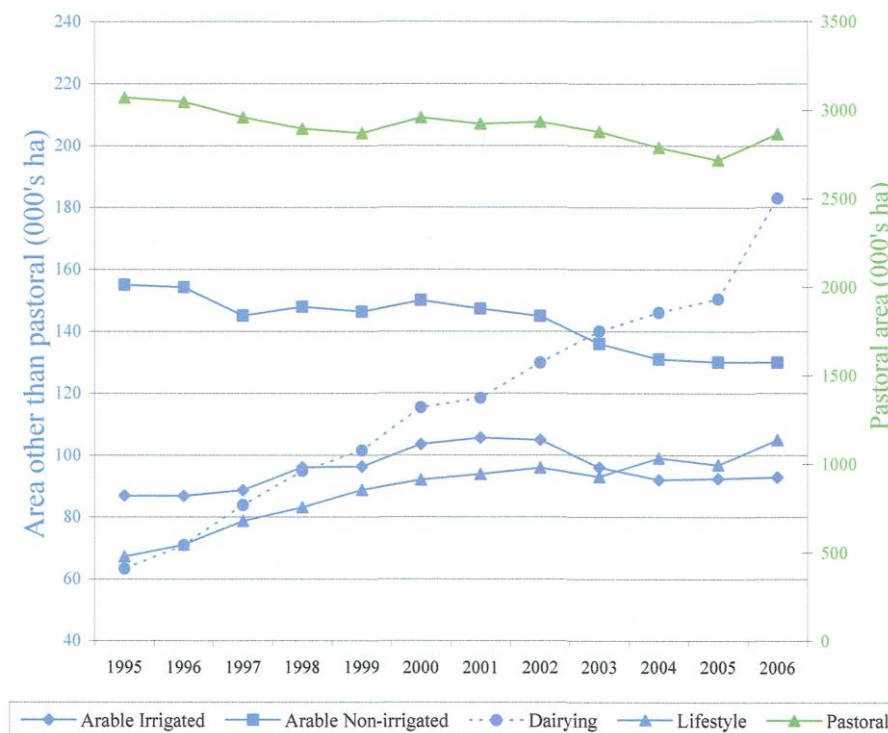


Figure 1. Land Use Change in Canterbury (Jenkins, 2007)

With the expansion and intensification of dairy farming in Canterbury there have been associated environmental concerns especially around water quality, in particular nitrate concentrations in groundwater (Jenkins, 2007). Elevated nitrate concentrations in drinking water can lead to a condition known as methaemoglobinaemia or Blue Baby syndrome (Canterbury District Health board). Under the New Zealand government's National Policy Statement for Freshwater Management 2011 there have been a number of regional councils that have suggested (and in some cases implemented) limits on the amount of nutrients that are able to be discharged or 'lost' to the water system. The Canterbury region is one of these and in the Mid-Canterbury region the Hinds catchment appears to be the first area for implementation.

There has been a lot of work carried out on modelling what the impacts of limiting nutrient leaching will be on a catchment wide basis and the resulting implications of this but there appears to be limited work on the effects to on farm management and the impact it will have on the operation, profitability and viability of individual dairy farms. Current work around the impacts of limiting nitrate leaching focuses on average across the region reductions, e.g. 10% or 20% reduction across the catchment but there appears to be a lack of the publicly available information on what the impact is likely to be on individual farms if they have to make a significant reduction in nitrate leaching.

This document looks to focus on exploring the impact of imposing nitrate leaching limits on dairy farms (using a case study of 'Singletree Dairies') in the Canterbury region. This exploration will include both the farming system and the resulting financial impact of any alterations to the farm system.

3.0 Measuring Nitrate Leaching

Currently the most common method being utilised throughout New Zealand to estimate nutrient loss is based around the computer modelling program Overseer. The Overseer computer model calculates and estimates the nutrient flows in a productive farming system and identifies risk for environmental impacts through nutrient loss, including run off and leaching, and greenhouse gas emissions (www.overseer.org.nz).

Different nitrate leaching limits are being suggested for different areas throughout New Zealand, the best example that relates to this document is work in the Hinds catchment area just south of Ashburton. The Hinds plains catchment leaching load is estimated to be 3,000 tN/yr which is equivalent to approximately 24 KgN/ha/yr (Scott, 2013). It will be assumed in this exercise that a similar limit would be applied to other catchments in the Mid-Canterbury district.

The average leaching rates of different agricultural land uses are shown in table 1 below. From this table we can conclude that many dairy farms will need to reduce their nitrogen leaching rates to achieve targets such as those suggested in the Hinds catchment.

Table 1. Nitrogen Leaching Rates from Agricultural Land Uses (Di and Cameron, 2002)

LAND USE	LEACHING RATE (kgN/ha/yr)
Forest	5 - 15
Cut grassland	6 - 49
Grazed pastures: sheep	6 - 41
Grazed pastures: dairy	47 - 110
Arable cropping	4 - 107
Ploughing of pastures	14 - 102
Horticulture	70 - 180

4.0 Singletree Dairies

Singletree Dairies has been used as a case study to model the impacts of applying nitrate leaching limits and the resulting effects on both the management of the property and any financial impacts of this. Singletree Dairies is considered to be a good example of a 'normal' dairy property in the Mid-Canterbury region and faces the same challenges as most farms in the district should nitrate leaching limits be implemented.

Singletree Dairies Ltd is a spray irrigated dairy farm located 15km north-east of Ashburton. Key parameters of Singletree Dairies Ltd are as follows:

- 465ha effective
- 1750 cows peak milked (3.76 cows/ha)
- Spring calving
- Irrigation is 50% roto-rainer, 45% pivot, 5% long line sprinklers (4mm/day)
- 8 full-time staff (including equity manager)
- Basic but quality infrastructure
- 500kgDM/cow of imported supplement made up of grass silage and maize silage
- All cows wintered off farm for 65 days
- Located on Lismore Silty Loam with available waterholding capacity of 88mm

5.0 Overseer Calculations

With initial assistance from Angela Darke and Micheal Keaney from Ballance Agri-Nutrients, the nutrient status of Singletree Dairies was entered into the Overseer computer modelling programme. The Overseer Farm Nutrient Budget report can be found in appendix 1 and shows nitrogen loss to be 32kgN/ha/year. As mentioned earlier on page 6 this investigation will use a target Nitrogen leaching limit of 24kgN/ha/year and hence if such a limit were imposed then Singletree Dairies would have to decrease its nitrogen leaching by 8kgN/ha/year.

There are a range of elements that will influence the level of nitrate leaching predicted by Overseer such as soil type, stocking rate, cows wintered on or off, nitrogen fertiliser – amount and timing, irrigation type, effluent system and area, nitrification inhibitors (DCD's), supplement use.

Several factors were altered in Overseer to see the resulting impact on the predicted nitrogen leaching of Singletree Dairies. The following factors were chosen to reduce the predicted nitrogen leaching from 32kgN/ha/year to 24kgN/ha/year:

1. Change 120ha of roto-rainer irrigation to pivot irrigation
2. Increase effluent area to cover 330ha applied through pivot irrigators
3. Remove application of any nitrogen fertiliser in the month of May
4. Reduce application of Nitrogen fertiliser in April from 28kgN/ha to 18kgN/ha

6.0 Implications of Changes

The four factors described above were chosen as they are the most likely to be actually carried in the near future of the operation of Singletree Dairies. The following outlines the impact of the likely changes

6.1 Changing 120ha currently irrigated by Roto-rainer to Pivot Irrigation

This change can be viewed as a stand-alone decision irrespective of any nutrient limits. Pivot irrigation would mean the removal of 20 roto-rainer runs, reducing the labour required. Pivot irrigation is expected to result in increased pasture production over the summer period on Singletree Dairies especially given the level of water available is 4mm/day rather than the more standard 4.5-5mm/day required to maximise pasture growth. Pivot irrigation will require less energy costs and will use less water over the season.

An estimated cost of implementing the pivot irrigation system would be \$300,000 or \$2,500/ha. Assuming the pivot irrigation area grows 15% more (75kgDM/ha/day compared to 65kgDM/ha/day) pasture over the 180 days of irrigation it can be assumed that 1800kgDM is grown each year. Assigning a cost of \$0.30 per kilogram of drymatter (kgDM) (the cost of the supplement that would otherwise be required) this equates to \$540/ha. Considering just the extra drymatter grown and not taking into account labour savings, lower electricity costs or the volume of water required there would be a payback on this investment in 5 years.

6.2 Increase effluent area to cover 330ha applied through pivot irrigators

This would involve an effluent upgrade that would see solids separated from the liquid and the resulting liquid stored in a new pond that would likely be big enough to hold 30 days storage. This would be an expensive option at an estimated cost of \$250,000 (taken from farmers who have installed similar systems recently) although this cost is likely to be incurred in the future to reduce compliance risks as the original effluent system is becoming outdated and marginally appropriate to the current size of the farm. There are alternative options however which would see an acceptable upgrade for a likely cost of around \$150,000 although this would not allow the effluent to be spread across such a big area.

An average dairy cow produces \$25 worth of nutrients annually as farm dairy effluent (DairyNZ FarmFact 7-22) which equates to \$44,000 worth of nutrients on Singletree Dairies. Currently this is not being as well utilised as effectively it could be and having the ability to evenly apply effluent across 330ha (70% of the farm) would in time allow for a decrease in fertiliser applications across this area of the farm, in turn also leading to a drop in nutrient leaching.

6.3 Remove application of any nitrogen fertiliser in May

Overseer is particularly sensitive to nitrogen fertiliser applications in the 'shoulder' (late autumn & early spring) months and during the winter. Removing the May application of nitrogen fertiliser reduced the nitrate leaching of Singletree Dairies by 3kgN/ha/year. Removing this application would lead to a reduction in pasture grown on the farm and would need to be replaced with a form of supplement. At an 8:1 pasture growth response to nitrogen and assuming a cost of \$800/ton of urea applied this feed is costing approximately \$0.22/kgDM compared to maize silage that costs \$0.33/kgDM fed out. Removing the nitrogen fertiliser application of 21kgN/ha is likely to cost Singletree Dairies approximately \$8,600 assuming an average pasture response to nitrogen fertiliser of 8:1.

6.4 Reduction of Nitrogen fertiliser in April from 28kgN/ha to 18kgN/ha

The reduction of nitrogen fertiliser application in April is likely to have a similar impact to that of removing the May application of nitrogen fertiliser. The likely response of the extra 10kgN is approximately 8:1 or slightly less (assuming diminishing returns with every extra unit of nitrogen applied) so 80kgDM/ha less would be grown in the month of April, again with the cost of replacing this with Maize silage a resulting cost to Singletree Dairies of approximately \$4,000 would occur.

7.0 Light Soils

The predicted nitrate leaching in Overseer is largely affected by soil type and in particular available water holding capacity (AWC) of that soil. The soil type is currently taken from S-map Online run by Landcare research, in the area where Singletree Dairies is located it is estimated that 75% of the soil in the area has AWC of 88mm and the other 25% is 66mm, or in the case of a prominent dairy area such as Bankside (near Dunsandel), a large area of the soil is estimated to have an AWC of 56 mm.

Further changes were made to Singletree Dairies modelling in Overseer in an attempt to replicate a scenario of dairy farming on a light soil and the impact this would then have. After giving Singletree Dairies a soil with AWC of 60mm, the resulting nitrate leaching predictions from the Overseer model showed a nitrate leaching of 62kgN/ha/year (appendix 2) – almost double the leaching loss of the original model.

Scenarios were then altered in Overseer in an attempt to reduce the predicted nitrate leaching down to the desired level of 24kgN/ha. After the same alterations as in the original Singletree Dairies overseer budget were made; increasing pivot area, increase effluent area, remove May nitrogen and reduce April nitrogen, the predicted nitrate leaching was reduced to 51kgN/ha.

The following further alterations had to be made to get the predicted nitrogen leaching to 24kgN/ha:

1. Remaining 100ha of roto-rainier irrigation changed to pivot (-3kgN/ha)
2. Removal of April and August nitrogen fertiliser application (-5kgN/ha)
3. Reduce nitrogen fertiliser inputs by 20% to 160kgN/ha (-2kgN/ha)
4. Apply DCD nitrification inhibitor (-5kgN/ha)
5. Reduce cow numbers to 1,350 cows = 2.9cows/ha; resulting production reduced to 1,290kgMS/ha (-10kgN/ha)
6. Reduce supplement purchase to only 100ton of maize silage (-2kgN/ha)

Please note that this scenario relies on the ability to apply DCD nitrification inhibitors that are currently not permitted but may be in the future.

8.0 Impact of Reducing Leaching on Light soil

The impact of reducing the nitrate leaching assuming Singletree Dairies had light soils would be very large assuming the characteristics described previously. The changes to the farm operation could be summarised as operating at approximately 80% of the original operation. The feed that has to be harvested to achieve the production outcomes under each system are 14,900kgDM/ha/year under the status quo system and 13,300kgDM/ha/year under the low stocking rate system to achieve 24kgN/ha leached on light soils.

Further investigation into the likely impact of the above changes to the financial performance of the farm showed that the impact may not be as significant as initially appears. When the financial analysis was carried out compared to actual financials for Singletree Dairies at status quo, there were cost savings of approximately \$660,000, the main items leading to this saving are:

- \$300,000 worth of supplement not required
- \$100,000 of winter grazing saved due to wintering less cows
- \$80,000 of labour through removal of two labour units
- \$90,000 less nitrogen and fertiliser costs
- \$50,000 less grazing of replacement stock due to lower numbers required
- \$40,000 other (includes extra cost of more silage harvested on farm and DCD application)

Table 2 below illustrates the income, expenditure and margin of each operation (see appendix 3 for more detailed budget), noting that the return on assets (ROA) of the status quo and low stocking rate to be 6.91% and 6.75% respectively.

Table 2 Financial comparison of Low Stocking rate and Status Quo on Singletree Dairies

Scenario	1350 cows	1750 cows
Stocking rate (cows/ha)	2.90	3.76
kgMS/cow	450	420
kgMS/ha	1,306	1750
Payout (inc div)	\$ 6.50	\$ 6.50
Stock Sales	\$ 112,000	\$ 145,000
Stock Sales per kgMS	\$ 0.18	\$ 0.20
Cost of Production	\$ 3.33	\$ 3.70
Income - Expenses per kgMS	\$ 3.35	\$ 3.00
Value of assets per kgMS	\$ 49.72	\$ 43.39
ROA	6.75%	6.91%

9.0 Conclusions

From the analysis carried out in this document I have confidence that Singletree Dairies could meet a leaching limit of 24kgN/ha/year and would remain profitable in doing so. Some of the alterations that would need to be made to meet the nitrate leaching targets make sense to carry out due to other tangible benefits regardless of nitrate leaching limits. Increasing the area of centre pivot irrigation and expanding the area that effluent can be applied to have the potential to grow more pasture from less fertiliser inputs at what appears to be an economic cost.

The reduction in fertiliser nitrogen applied in May and April however appear to make sense only in order to achieve nitrate leaching targets. Although the response rate of pasture growth to nitrogen fertiliser is lower during the months of April and May (compared to more favourable growing times such as spring) the cost of the nitrogen fertiliser applied is outweighed by the extra feed grown, with a cost of approximately \$12,600 to Singletree Dairies when these applications are altered.

When Singletree Dairies was modelled through Overseer assuming it was based on light soils, the change to the farming operation to meet a nitrate leaching limit of 24kgN/ha was quite dramatic. Although the changes appeared to be dramatic, upon further investigation the impact financially of these changes are not as marked as initially thought, with a return on asset only decreasing from 6.91% to 6.75%. It must be noted that the availability of applying DCD nitrification inhibitors is an important factor in this scenario as this contributes a reduction in nitrate leaching of 5kgN/ha.

Under both scenarios, Singletree Dairies should be able to continue to operate as a profitable dairy farm, however this would be much easier and greater flexibility allowed with the higher available water holding capacity of the soil.

The financial impact of reducing the stocking rate to 2.90 cows/ha was less than originally anticipated and further study into the operation of such systems in the Canterbury region would be interesting and worthwhile.

10.0 Discussion

The reduction in nitrate leaching on Singletree Dairies will be felt on farm, both operationally and financially but to a level that is manageable, with the greatest impact (especially on the light soil scenario) possibly felt wider in the community and economy which is consistent with work by Howard, Romera & Doole, 2013 who suggested even a 10% reduction in allowable nitrate leaching would have a major impact on the community.

Howard *et al.* found that to meet reduction targets of nitrate leaching, milk production would have to decrease, and with it money that would normally be spent in the community. Howard *et al.* concluded that an 11% decline in milk production in the Selwyn-Te Waihora catchment would wipe approximately \$55-60 million of milk revenue from that catchment. The findings from this report are consistent with this, as to meet the nitrate leaching targets assuming a light soil type resulted in a production reduction of 135,000kgMS worth \$900,000. With the reduction of production from less cows being farmed, two full-time jobs would be removed which also has an impact on people and the community. In the case of Singletree dairies, the local school has approximately 40 students – 7 of which come from families employed on Singletree Dairies – if two of these families are removed this has a large impact on the school.

The characteristics of the soil, in particular the available water holding capacity have a large influence on the nitrate leaching of a farm predicted in the overseer computer model. For this reason I believe actual mapping of soil through systems such as electromagnetic soil mapping will become a vital starting point to farmers – especially those on lighter soils.

A positive outcome that would come out of implementing nitrate leaching limits (along with the predicted environmental outcomes) is that farmers will be forced in to making more from less. A good example of this would be the reduction in nitrogen fertiliser use will reduce nitrate leaching (albeit timing of application has more impact) therefore farmers will have to get more from the fertiliser when they do put it on. Currently there is no significant financial incentive to reduce the nitrogen fertiliser applied as is shown in this document that even at less favourable response rates, feed grown from nitrogen is still economic. However with a reduction in nitrogen fertiliser I believe we would see greater uptake of other products that increase the utilisation of nitrogen applied such as SustainN, LessN or combining nitrogen applications with ProGibb applications. This would mean that less nitrogen is applied but a very similar output maintained.

The level of water applied and how it is applied is important to the level of drainage predicted and actually occurring – I believe systems such as pivot irrigation and variable rate irrigation will become much more common to get the most out of water being applied. As explained in this document this has tangible production and financial benefits as well as nitrate leaching benefits.

It would be irresponsible and detrimental to the New Zealand dairy industry (and agricultural in general) to allow regulation of nitrate leaching to be implemented without proper participation in the consultation process. The dairy industry needs to lead by illustrating what impacts limiting nitrate leaching will have on farm and then how this impact is likely to affect the wider community and economy. Those involved in the setting of recommended limits or practices can only work from the information available to them and hence we have a responsibility as an industry to ensure we are providing this. From this point there needs to be a development from communities of what

levels are acceptable in terms of environmental and economic values before setting these standards. To some extent this is happening under the Zone Committees and Zone Implementation Plans although I believe that how well the issues are understood by the wider public and the balance of outcomes leave room for improvement. It is in the interest of everyone that the right balance is struck, if the financial implications of any leaching limits are too great for dairy farmers or any farmers for that matter, then there are going to be huge flow on effects for all of the New Zealand.

11.0 Further Work

It is very difficult to estimate the exact nitrate leaching of a dairy farm due to the biological nature of farming – there are so many variables to take into account and no one year is the same as the previous. As an example you can use stocking rate for instance, this needs to then include the size of the cow (do we now need to weigh our cows to get the input data for Overseer), genetic worth of cows –some more efficient than others, production per cow, if you feed your cows less will they create less leaching compared to a high input cow eating 25kgDM, calving date – do we need to put in accurate calving dates - not everyone will have this data – who collects the data and who do you trust to get it accurately as it makes a large difference.

This document has focused on the dairy farm impact of nitrate leaching limits but has not taken into account the impact on the environment of wintering cows off farm. It was suggested by Micheal Keaney from Ballance Agri-Nutrients that a wintering property and a dairy farm on similar soils will have quite similar nitrate leaching. It will would be irresponsible to focus further efforts only on the dairy platform as through wintering off farm we could just be ‘exporting’ the problem.

Micheal Keaney also mentioned that there is currently work being carried out developing a computer programme that runs the scenarios for you so you know what to changes are required to achieve targets specific nutrient targets – this would save a lot of time and be very beneficial to farmer. However like any computer programme it can only be as good as the numbers that are entered and hence it is important for farmers to have a sound understanding of how overseer works and how nitrogen systems work on their farm.

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