An Impact Assessment of One Plan policies and rules on farming systems in the Tararua District and the Manawatu Wanganui Region

26th June 2017

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Growing for Good

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1. Acknowledgements

This report was prepared by Terry Parminter of KapAg Ltd. Most of the farming systems analyses were carried out by Stefan Bryant of BakerAg and Scott Ridsdale of RD Consulting. The report would not have been possible without their hard work.

Fergus Rutherford of BakerAg provided advice on property valuation.

Lynette Baish, Helene Lowe and Ian McNabb at Horizons provided client support and feedback for the report. They made it very much a team effort.

Katie Bicknell, lecturer in applied econometrics at Lincoln University, has checked the report to ensure that the appropriate methods for this analysis have been applied.

Despite my very heart-felt appreciation for the above people, they are in no way responsible for the opinions expressed in this report. I take full responsibility for its contents.

2. A Guide for Readers

This report has been prepared for the Councillors of the Manawatu-Wanganui Regional Council and for the staff working with them in policy development for the One Plan. The report may also help to inform discussions between the Council and industry and environmental groups. It will have done its job if this report helps makes Council's decisions easier and not harder.

In this report I have focussed on the financial implications to farmers of changes in the consenting process. For that reason the report describes its results at the farm scale. They have not yet been multiplied up to the whole of the catchment or the region, although that is possible at some stage in the future. I have not addressed the cultural outcomes, environmental outcomes and the needs of other social groups that might be described in other work.

After the summary and introduction, the next section of the report describes its purpose and how I went about responding to that. You may prefer to go straight to the results section and that should be able to be read without referring to any of the other chapters. The farm data is difficult to present clearly. I expect that if you have a lot of farming experience, that I have not provided enough information and if you have no farming knowledge, there may not be quite enough.

After the results section there is a discussion and conclusions section. Like the results section this is intended for you to be able to jump straight in and read from here. There are no recommendations in the discussion. Like this report, it is intended to be informative rather than directive. I have included a graph in here summarising the results to save people having to flick back to the results section. The last chapter is about the assumptions and limitations and ways in which this report could be improved still further.

3. Executive Summary

This report has been prepared for the Councillors of the Manawatu-Wanganui Regional Council and for the staff working with them on policy implementation and a review of the One Plan. In this report I have focussed on the financial implications to farmers of meeting the requirements of the intensive farming land use provisions in the One Plan following the Regional Council's response to a recent declaration by the Environment Court specifying opportunities for improvement. For that reason the report describes its results at the farm scale. They have not yet been multiplied up to the whole of the catchment or the region, although that will be possible at some stage in the future.

The purpose of this report is to "calculate the costs associated with applications for intensive land use activities and the economic impact of mitigations to reduce nitrogen leaching likely to be incurred as a result of the recommended improvements in the consenting process." It is a small-scale study of on-farm economic impacts associated with Council's intensive land use consenting and policy framework. It is intended to provide information to Council staff implementing and reviewing the existing rules and policies in the One Plan. For the latter, further work at a catchment and regional scale will be needed.

The author responded to the project brief by focussing on four dairy farms in the Tararua District and two arable farm systems in the Rangitikei District. These farming systems have been described and mitigations applied to achieve the standards in Table 14.2 and Table E2 of the One Plan. Appendix A of this report includes a copy of Table 14.2 . The costs of applying for the modified landuse consents have also been calculated. Taken together these form the basis of the discussion and conclusions towards the end of the report.

To determine the costs to individual farmers of obtaining and implementing their landuse consents, a farm management approach was taken in this report. This approach involved considering the operation of specific farming systems and attaching costs and returns to each of those operations. These costs and returns are then accumulated into an operational profit. The operational profit of farms before and after they have obtained a landuse consent is the main method used to show its economic impact. Some of the mitigations involve significant capital investments. These changes are evaluated in this report by calculating the return on capital on the farms before and after the mitigations have been introduced. The farms each have a calculated capital value and some commentary is provided on how that might be affected on farms that have been modified like these.

The process that was used involved selecting suitable farm systems, determining the changes needed in those systems for them to apply to the Council for a consent, and then evaluating the costs of introducing those changes. The farms were not existing farms. Instead each model farm was created around a particular farm system. The models were synthesised from many different farms known to exist in the region and adjusted to represent dairy farming systems that can be found in the Tararua District and arable farms in the Rangitikei District. These districts were selected because that is where most of the unconsented farms can be found.

The farm management changes between the base farms and the adjusted farms will require many farmers to grow their capability in managing pasture cover and pasture quality. The costs of a change in capability has not been included in this analysis.

The analytical results that were used were:

Farm Model: Self-contained dairy farm

This farm model has all the heifers grazed off the farm for 12 months from 9 months of age. It assumes that there has already been some adjustment to reducing its environmental footprint by grazing half the dairy cows off the farm over winter. Regular soil tests are taken and maintenance phosphate fertiliser is applied. A summer forage crop of turnips is grown to manage a possible risk of a dry summer. On average 30kg N/ha is applied in early spring and autumn to extend pasture production in those seasons.

To meet Table 14.2 in the One Plan, the farm has to reduce the number of dairy cows from 270 to 140 animals. It can no longer apply nitrogen fertiliser and must stop all cropping. The farm is expected to no longer bring in feed supplements for the cows. Instead it harvests 288 tonnes of pasture DM and sells most of this off the farm. The sale of surplus feed is a very important part of pasture management on this farm because animal consumption has dropped to almost 6,000 kgDM/ha/yr. Without harvesting surplus feed, the quality of the pasture would fall and in a few years pasture composition would suffer.

The farm started with leaching 32 kgN/ha and was modified to be leaching only 18 kgN/ha, a reduction of 44%. These changes reduced the expected farm profit from $1,627/ha to $629/ha, a drop of over 60%. The return on assets dropped from 5.3% to 2.0%.

The self-contained farm model has had to reduce its labour but it has surplus pasture available for alternative landuses, and therefore its adaptability might increase overall. Nitrogen conversion efficiency has increased to 66% and so it can be expected to be more sustainable in its use of natural resources. However, its profitability is not enough to support the level of debt found on many farms in this region. The return on assets is insufficient to attract off-farm investment, should that be required for future improvements. Unless farms like this have less than half the amount of debt as the model farm, they will not survive the changes required to address Table 14.2 .

Farm Model: Low-intensity dairy farm

The low-intensity dairy farm is very common in the Tararua District and in the region generally. In this model there are more cows and they have greater production than the self-contained farm. On this farm there is more supplementary feed (260 tonnes DM) brought onto the farm and greater use is made of cropping in both winter and summer. Over the whole farm more than 100 kgN/ha is applied, mainly to lengthen the grass growing season in spring and autumn.

To meet Table 14.2 in the One Plan, the farm has to reduce the number of cows from 400 to 250 animals. They will also need to reduce nitrogen fertiliser applications toan average of 5 kgN/ha/yr and stop importing supplementary feed and growing a winter crop. The summer crop remains, and 443 tonnes of DM are conserved. Three quarters of the conserved feed is sold off the farm to maintain pasture quality.

The farm started with leaching 42 kgN/ha and was modified to be leaching only 17 kgN/ha, a drop of 60%. These changes reduced the expected farm profit from $1,848/ha to $1,064/ha, a drop of over 40%. The return on assets dropped from 6.4% to 3.7%.

The low intensity farm model has not reduced its labour and it has surplus pasture available for alternative landuses. It's adaptability might increase overall. Nitrogen conversion efficiency has increased to 56% and so it can be expected to be more sustainable in its use of natural resources. However, its profitability is not enough to pay tax and support the level of debt found on many farms in this region. The return on assets is insufficient to attract off-farm investment, should that be required for future improvements. Unless farms like this can reduce the amount of debt below that of the model farm they will not survive the changes required to address Table 14.2 .

Farm Model: Moderate-intensity dairy farm

This farm has 600 cows and achieves high production. The farm imports 757 tonnes DM, grows winter and summer crops and applies an annual application of over 150 kgN/ha.

To achieve Table 14.2 in the One Plan this farm has a covered barn installed for all the cows so that they can be housed all year. Although inside for much of the time, the cows are grazed outside for fixed periods throughout the year – 8 hours per day while lactating and 2 hours per day over winter. The farm imports the same amount of supplementary feed as it did previously and harvests another 38 tonne of supplements to maintain production. Dairy effluent is applied across the whole of the milking platform and nitrogen fertiliser applications reduced to 50 kgN/ha.

The farm started with leaching 54 kgN/ha and was modified to be leaching only 17 kgN/ha, a drop of almost 70%. These changes reduced the expected farm profit from $2,283 /ha to $1,745/ha, a drop of almost 25%. The return on assets dropped from 7.0% to 5.0%.

The moderate intensity farm model has not reduced its labour but it has had to increase its overall pasture utilisation. Its adaptability might therefore decrease overall. Nitrogen conversion efficiency only increases slightly to 27% and so there is not much improvement expected in the sustainable use of natural resources. However, the profitability of this farm is sufficient to support its expected level of debt and it has sufficient return on assets to provide financial security for its owners.

Farm Model: Irrigated high-intensity farm

The irrigated high intensity dairy farm in the base model has 640 cows and has a centre pivot irrigator and a feed pad. The farm imports 757 tones DM per year as a supplement or 1,180 kgDM/cow. It uses 187 kgN/ha of nitrogen a year.

To meet the requirements of Table 14.2 in the One Plan this farm has built housing for the cows so that they can be kept inside all year. The farm already had a feed pad and so the effluent system for housing the animals was already in place. While they are lactating, the cows are grazed outside for up to 8 hours per day. The amount of imported supplements on this farm is increased to 1,170 tonnes DM and 22 tonnes of supplements are made on the farm.

The farm started with leaching 64 kgN/ha and was modified to be leaching only 17 kgN/ha, a drop of over 70%. These changes reduced the expected farm profit from $2,456/ha to $1,850/ha, a drop of 25%. The return on assets dropped from 6.8% to 4.8%.

The irrigated high intensity farm model has not reduced its labour but it has had to increase its overall pasture utilisation. Its adaptability might therefore decrease overall. Nitrogen conversion efficiency only increases slightly to 28% and so there is not much improvement expected in the sustainable use of natural resources. However, the profitability of this farm is sufficient to support its expected level of debt and it has sufficient return on assets to provide financial security for its owners.

Farm Model: Arable farm with livestock

Both the arable farms are larger than the typical farms to be found in the Manawatu. Making them larger makes it easier to compare these farms with the dairy farms that have a similar size. This farm specialises in grain production over summer. It has been able to do that without irrigation. Half of the farm is used for growing barley and in winter it has been growing ryegrass for finishing livestock. The farm finishes lambs and heavy cattle over a 12 month period. Over the year 150 kgN/ha is applied to the cropping area or an average of 60 kgN/ha across the whole farm.

The changes required to meet Table 14.2 in the One Plan are to dispose of all the livestock and harvest as silage and hay the permanent pasture and ryegrass green crop. The area in barley had to be reduced from 100ha to 70 ha. Over a whole year 1,399 tonnes of pasture dry matter was made and exported from the farm.

The farm started with leaching 39 kgN/ha and was modified to be leaching only 24 kgN/ha, a drop of almost 40%. These changes decreased the expected farm profit from $915/ha to $477/ha, a decrease of 47%. The return on assets dropped from 2.6% to 1.3%.

The arable with livestock farm model has not reduced its labour but it has become dependent on the supplementary feed market. Its adaptability might therefore decrease overall. Nitrogen conversion efficiency has increased to 89% and so natural resource sustainability has also increased. The profitability of this arable farm is insufficient to support its expected level of debt and it has insufficient return on assets to provide much financial security for its owners.

Farm Model: Arable farm with potatoes

This model farm was again large for a cropping farm. This time there were no livestock and instead two different rotations were modelled. The second rotation of potatoes and brussels sprouts required a total application of 428 kgN/ha over a year. The other rotation of maize silage and winter oats for forage only needed 110 kgN/ha. Irrigation was used over summer on the potato crop and 500mm/yr was used.

The changes required for meeting Table 14.2 in the One Plan included reducing the amount of nitrogen fertiliser going on to the potato rotation (332 kgN/ha) and better timing fertiliser applications to align with crop requirements. A new rotation growing barley for grain was introduced to replace some of the area originally in a high nitrogen feeding crop (potatoes). To reduce drainage from excess irrigation a moisture probe was installed and a water budget put in place. This reduced the amount of water needed to 380mm/yr.

The farm started with leaching 60 kgN/ha and was modified to be leaching only 25 kgN/ha, a drop of almost 60%. These changes reduced the expected farm profit from $3,192/ha to $1,152/ha, a drop of over 64%. The return on assets dropped from 8.2% to 3.0%.

The arable with potato farm model has some reduction in casual labour and it has had to increase the range of crops being grown. Its adaptability might therefore increase overall. Nitrogen conversion efficiency has increased to 94%, a big improvement in the sustainable use of its natural resources. However, the profitability of this farm is insufficient to support its expected level of debt and it has insufficient return on assets to provide financial security for its owners.

Costs of Consents

There are expected to be four consent application pathways for farmers:

- An existing farm may already be able to meet the conditions and standards of a controlled activity in the One Plan. That means that it can show that it will be able to meet the cumulative nitrogen leaching maximum in Table 14.2 of the One Plan and has appropriate mitigation of waterway contamination from phosphorus, sediment, and E.coli. The application will need to provide enough evidence from Overseer® to support the Council approving a controlled consent. The main costs will be for an agricultural consultant to describe the existing farm system and carry out a standard AEE. This should show that the farming business can operate within the effects anticipated by the One Plan with effects less than minor. The total cost for a consent application is likely to be about $10,600.

- Some existing farms may be able to meet the leaching caps in Table 14.2 of the One Plan and mitigate any potential waterway contamination from phosphorus, sediment, and E.coli but their mitigations cannot be calculated using Overseer. These will require extra preparation work to quantify the benefits of these mitigations. Such farms will need to apply for a restricted discretionary consent that shows calculations of the effectiveness of their mitigations. Generally the size of the benefits from these mitigations will be quite site specific and so information about the site as well as the mitigation will need to be provided. For example, the use of high carbon ditches to intercept nitrogen leaching will depend on the hydrology of the site. An agricultural consultant working with a farmer can provide the Council with this information with the support of industry scientists. The total cost for a consent application is likely to be about $13,900.

- Farms that can meet the nitrogen leaching caps in Table 14.2 within four years will need to address through their AEE the effects of the four year delay in meeting the Table. The additional costs for these farmers are generated from needing the advice of a professional ecologist and obtaining information from the Council about the cumulative effects for the catchment. The total cost for a consent application is likely to be about $13,800.

- The farms that are not anticipated to meet the nitrogen caps in Table 14.2 will need to apply for a restricted discretionary consent and prepare a very robust AEE. They will need to employ technical expertise to show that their effects on the environment are less than minor. The total cost for a consent application is likely to be about $21,000. It is probable that these applications could be publically notified and an additional deposit for this will need to be made to Horizons. The deposit may be around $8,000 in addition to these costs.

These costs could easily vary by 20% either up or down depending upon the complexity of the work involved.

Adaptability, Sustainability and Viability

The model farm systems are changed significantly in order to meet the criteria for consents in the One Plan. The self-contained dairy farm, the low intensity dairy farm and the arable farm with potatoes might become more adaptable as a result of these changes. All of the model farms improved their efficiency of nitrogen use for production. They might therefore be considered to have become more sustainable production systems.

However, all of the model farms became less profitable as a result of introducing the mitigations necessary to comply with the conditions in the One Plan. The self-contained dairy farm and the low intensity dairy farm do not have sufficient profit to remain viable at typical industry levels of debt. All the model farms returned less than 5% on assets except for the moderate intensity dairy farm (ROA=5%). Therefore, all their owners now lack future financial security from their investment in these farming businesses. The reduced profitability is likely to result in a downward pressure on the future property values for these farms.

4. Introduction

This report and the work described, was produced at the request of the Manawatu Wanganui Regional Council (Horizons). A summary of the brief for this work is provided in Appendix A.

The One Plan for managing all the natural resources in the Manawatu Wanganui Region became fully operational in 2012. It was called the One Plan because it combined the previous regional policy statement (RPS) and the regional plan (RP) in one document. There are two chapters relating to the management of freshwater in the region. Chapter five has the objectives and policies for water quality to achieve the values and standards in Schedule B, Table 1 and Schedule E, Table 2. It could be considered the RPS part of the plan. Chapter 14 has the policies and rules relating to discharges to land and water. It is the RP part of the plan. The One Plan sets out a framework for managing water quality in fresh water and seeks to control the effects of both point source and non-point source discharges to maintain good water quality and enhance poor water quality. Through the One Plan, intensive farming land users require resource consents in the targeted water management sub-zones identified in the Plan.

Landuse consents for dairy and arable farms consider four main risk areas from non-point sources affecting waterways. These are: nitrogen losses, phosphorus losses, sediment and pathogens (e.g. E.coli). The latter three are managed through the adoption of good management practices. and nitrogen losses are managed through the cumulative nitrogen leaching maximums set out in Table 14.2. Applicants for land use consents use the Overseer software package and farm system inputs to model on-farm nitrogen leaching loads and determine their activity status for the consenting process.

Dairy and arable farmers have been applying to Horizons for landuse consents to continue their existing or establish new farming activities in the region. Horizon's consenting process was challenged in the Environment Court earlier this year and their decision identified some opportunities for improving Horizon's processes. Changes to the consenting processes are likely to have economic implications for applicants and Horizon's intends to quantify these as much as possible.

This report was commissioned in June 2017 to "calculate the costs associated with applications for intensive land use activities and the economic impact of mitigations to reduce nitrogen leaching likely to be incurred as a result of the recommended improvements in the consenting process." A summary of the project brief is provided in Appendix A.

The author responded to the project brief by focussing on four dairy and two arable farm systems. These farming systems have been described and mitigations applied to achieve the standards in Table 14.2 and Table E2. The costs of applying for the modified landuse consents have also been calculated. Taken together these form the basis of the discussion and conclusions towards the end of the report.

In order to progress this report in the time available some assumptions have had to be made and these are described in the penultimate chapter. There are some limitations to the report, particularly if its results are being applied outside the original brief. Finally, in the last chapter there is some further reading to assist those readers that want to examine further the principles behind this study.

5. Purpose

Natural resource management in the Manawatu Wanganui Region requires both voluntary efforts by land owners and their compliance with the policies and rules contained in the One Plan. The policies and rules in the One Plan are intended to achieve natural resource improvements benefiting the values of all people in the region. Achieving these improvements now and in the future requires time, effort and resources. Farmers will face new and additional costs in order to mitigate the impact on waterways of their farming activities.

The purpose of this report is to "calculate the costs associated with applications for intensive land use activities and the economic impact of mitigations to reduce nitrogen leaching likely to be incurred as a result of the recommended improvements in the consenting process." It is a small-scale study of on-farm economic impacts associated with Council's intensive land use consenting and policy framework and it is intended to provide information to Council staff considering implementation of the existing rules and policies; and preparing for future One Plan development. For the latter, further work at a catchment and regional scale will be needed. A summary of the project brief is included in Appendix B.

6. Problem Solving Approach

To determine the costs to individual farmers of obtaining and implementing their landuse consents, a farm management approach was taken in this report. This approach involved considering the operation of specific farming systems and attaching costs and returns to each of those operations. These costs and returns are then accumulated into an operational profit. The operational profit of farms before and after they have obtained a landuse consent is the main method used in this report to show its economic impact. Some of the mitigations involve significant capital investments. These changes are evaluated by calculating the return on capital on the farms before and after the mitigations have been introduced. The farms each have a calculated capital value and some commentary is provided on how that might be affected on farms that have been modified like these to achieve Table 14.2 in the One Plan.

The problem solving approach used here involved selecting suitable farm systems, determining the changes needed in those systems for them to apply to the Council for a consent, and then evaluating the costs of introducing those changes. The farms were not existing farms. Instead each model farm was created around a particular farm system. The models were synthesised from many different farms known to exist in the region and adjusted to represent farming systems that can be found in the Tararua and Rangitikei Districts. These districts were selected because that is where most of the remaining unconsented farms can be found for dairying and cropping respectively.

Four dairy farm systems were selected to reflect the different farm systems to be found in the Tararua District. The dairy farms were standardised for land area, rainfall and soil types. Each farm was then adjusted to reflect the differences in farm system and matched to the expected nitrogen loss rate.

The analysis followed the following steps for each dairy farm:

(i). The base farm was established in Overseer®, compared to the initial specifications and modified if necessary to better fit these.
(ii). The farm was entered into Farmax® and the stock reconciliation checked and the supplementary feed inventory checked.
(iii). Any changes in Overseer as a result of the Farmax exercise were made.
(iv). The farm's operational profit and loss account was finalised to provide the base farm information summarised in the results section.
(v). The farm in Overseer was modified until it could achieve the nitrogen loss profile in year 20 of Table 14.2
(vi). The modified farm was again checked in Farmax.
(vii). Any consequential changes in Overseer were made.
(viii). The farm's new operational account was finalised and compared to the base farm account
(ix). Return on capital was calculated.

The two cropping farm systems were processed in a similar way to the four dairy farms.

The analyses have included considerable changes in the way that farming – both dairy and arable will need to be done in the future. The adjustments require growing farming capability and building new expertise amongst the professionals advising them. The structures and costs of human development have not been addressed in these analyses.

In this report the initial state of each of the farming businesses has been compared with those same farming businesses in year 20 of Table 14.2. At the end of year 20 each of the farms would be fully compliant with the intensive land use rules in the One Plan. Between year 1 and year 20 in Table 14.2 the model farms would need to step down their nitrogen leaching by almost 25%. However, due to the length of time involved, on many farms, the completion of this transition process is likely to occur after there have also been changes in farm ownership. The uncertainty of the transition is increased by a possible plan review of the One Plan during that time and structural adjustments in the market to accommodate the adaptations required in farming systems.

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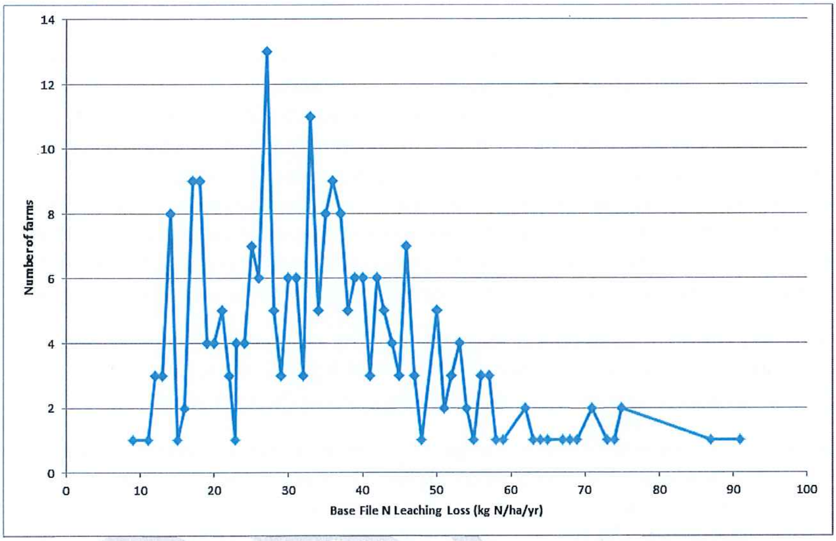
7. Results

7.1 Farming Systems

There were no figures from industry available to guide the development of representative dairy farms in the region. However, Horizons were able to provide a chart of base file nitrogen losses found in the region and this was used to guide the development of the model farms (Figure 1).

Figure 1. Base file nitrogen leaching of resource consents currently granted in the Horizons region.



The data below 20 kgN/ha in Figure 1 are likely to be from specialist dairy farms or discrete parcels of land on part-farm's that required consenting rather than whole-farms. The figures above 60 kgN/ha are likely to be from high-input farms in high rainfall areas and on soils with a propensity for high nitrate leaching.

Farm consultant's in the region work with a range of farm systems, from low intensity to high intensity systems. For this study, different dairy farm systems were matched with the likely nitrogen loss rates to be found in Tararua District (Table 1). The table highlights that only four combinations of farm systems and nitrogen losses were selected in this study. However they are spread out across the table. Although other combinations of farm systems and nitrogen loss rates might be possible in the region it was hoped that their results could be approximated using the results of this study.

The two arable farms were modelled as farms similar in size to the dairy farms (200 ha). One arable farm included livestock as a significant source of its nitrogen losses, the other arable farm had no livestock but did have potatoes and brussels sprouts as the most significant sources of its nitrogen losses.

Table 1. Selected dairy farm systems and their associated nitrogen loss rates

Expected Annual Nitrogen Loss (kgN/ha)	Dairy System			
	Type 1-2 System	Type 2-3 System	Type 3-4 System	Type 3-4 System
30 kgN/ha	Self-contained			
40 kgN/ha		Low intensity		
50 kgN/ha			Moderate intensity	
70 kgN/ha				Irrigated

The non-irrigated Tararua dairy farms shared the same soil types and had an annual average rainfall of 1200-1300mm. The irrigated dairy farm was modelled in a slightly drier area in the Tararua District. It had an average annual rainfall 100mm lower than the other dairy farms, and used irrigation to add an additional 600mm. The three most intensive farm models included runoffs for grazing replacement animals and wintering non-lactating (dry) cows. The runoffs were also sometimes used for cropping and making surplus grass into supplementary feed. The self-contained farm had no runoff. In Table 14.2 the dairy farms all had the same mix of land classes. The milking platforms were: LUC II (20%), LUC III (65%) and LUC IV (15%). The runoffs were: LUC III (40%) and LUC IV (60%). The dairy farms had to operate inside a leaching cap by year 20 of 18 kgN/ha per year.

The Rangitikei arable farms were both on the same soil type in an area receiving about 900mm annual rainfall. The arable farm with irrigation added a further 500mm/ha. In Table 14.2 the cropping farms each operated on LUC II with a leaching cap in year 20 of 21 kgN/ha.

There were no farms modelled that in their initial state could reach Table 14.2 in the One Plan without making some changes to their farming practices. The expected trajectory in nitrogen leaching loss of the farms modelled is shown in Figure 2. In the Figure all the dairy farm models have to be leaching below 24 kgN/ha by year 1, and the arable farms below 27 kgN/ha. By year 20 the dairy farms have to be below 18 kgN/ha and the arable farms below 21 kgN/ha. The modelled dairy farms in Tararua District had to reduce their nitrogen leaching to between 60-25% of their current leaching. The modelled arable farms in the Rangitikei District had to reduce their nitrogen leaching to 50-35% of their current leaching.

In the next section a one page summary of each of the farms is provided before their farm systems have been modified to achieve the expected results in Table 14.2. The summary of each farm is divided into four sections. At the top is a description of the farm infrastructure and soils. This includes the amount of maintenance fertiliser required annually that has been calculated by Overseer.

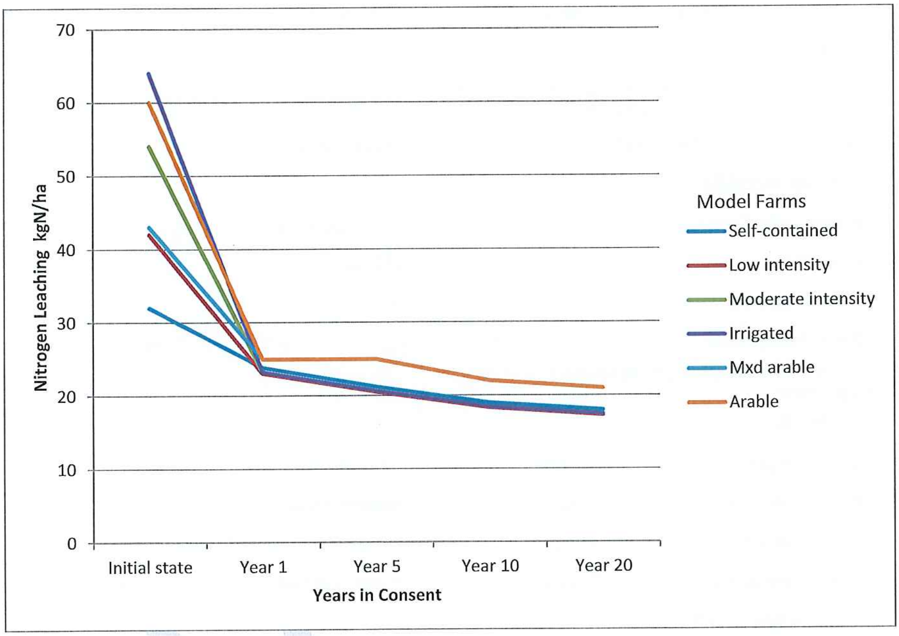
The next sections are labelled "herd" and "pasture and feed". For each farm the balance between feed supply and animal requirements has been checked in Farmax to ensure that it is a feasible farming system and that it is in a stable equilibrium.

The "nutrients" section of each farm summary provides results from the nutrient budget in Overseer. This includes both nitrogen losses to water (mainly as leaching) and phosphorus losses to water (mainly as runoff).

The final section in the summary addresses the operational profit for each of the farms. See Appendix E for some of the financial assumptions applied in this analysis. Each dairy farm has milk and livestock income. They have fixed farm overheads such as repairs and maintenance, land costs such as weed spraying, and livestock costs such as animal health.

The depreciation costs for plant and machinery, and the costs of labour and drawings are all in the fixed farm overheads. The farmers' operational profits are what they use to reinvest in the farm and to repay mortgages and loans.

Figure 2. The nitrogen-loss trajectory of all the models in this study



The farm's return on assets (ROA) indicates how much better (or worse) the farm might be if it is compared with selling the farm and investing the money in an alternative business. Even money in the bank can return around 5% to its investor and most of the farms started out in this study earning their owners above that amount.

The arable farm models have profiles that have similar information to the dairy farms except that the description of the cropping rotations has also been included.

7.2 Base-line Farm Results

PRODUCTION SYSTEM	Self-Contained			
INFRASTRUCTURE				
Farm Area	125 ha	**Milking platform**	120 ha	
Feedpad	N/A	**Effluent system and area**	Sump, to pond and travelling irrigator	17 ha
		Irrigation system	N/A	
Soils	Dannevirke SL	Flat	Fert (PKS): 32.38.07	102 ha
	Matamau SL	Rolling	Fert (PKS): 29.51.20	18 ha
HERD				
270 cows	59 replacements (grazed off for 12 months from 9 months of age)	**Cow wintering**	Half the herd for 2 months	
86,163 kgMS	718 kgMS/ha MP	319 kg MS/cow		
PASTURE AND FEED				
Pasture eaten (Overseer)	10,010 kgDM/ha/yr			
Imported feed	23 T DM			
Winter forage crop	N/A			
Summer forage crop	6 ha	Crop - Turnips	10 T/ha yield	
Imported feed and grazing off as a percentage of the total feed offered	21%			
NUTRIENTS				
Clover nitrogen	136 kg/ha	**Other nitrogen**	5 kg/ha	
Imported nitrogen	30 kg/ha	**Available nitrogen**	171 kg/ha	
Surplus nitrogen	119kg/ha	**Nitrogen conversion efficiency**	29 %	
Lost nitrogen to water	32 kg/ha	**Phosphorus losses**	0.6 kg/ha	
OPERATIONAL PROFIT				
Farm fixed overheads	$151,230	**Milk income**	$551,444	
Land operational costs	$96,605	**Livestock income**	$25,822	
Livestock & feed costs	$135,284	**Operational profit**	$195,291	
Farm working expenses	$4.45/kgMS	**Per eff. hectare**	$1,627	
		Per cow	$723	
Capital Value (total assets)	$3,685,428	**Return on assets**	5.3%	

PRODUCTION SYSTEM		Low Intensity			
INFRASTRUCTURE					
Farm Area	210 ha				
Milking platform	150 ha	Irrigation system and area	N/A		
Runoff	50 ha	Effluent system and area	Sump, to pond and travelling irrigator	25 ha	
Soils	Dannevirke SL	Flat	Fert (PKS): 27.22.06	127.5 ha	
	Kopua SL	Flat	Fert (PKS): 26.31.10	20 ha	
	Matamau SL	Rolling	Fert (PKS): 25.33.15	52.5 ha	
HERD					
400 cows	91 replacements grazed on runoff from weaning until 23 months		Cow wintering	Half herd on MP, half herd on RO on crop	
144,312 kgMS	962 kgMS/ha MP		361 kg MS/cow		
PASTURE AND FEED					
Pasture eaten (Overseer)			10,644 kgDM/ha/yr		
Pasture conserved			50 T DM		
Imported feed T DM			260 T DM		
Winter forage crop			9 ha	Kale	12 T DM/ha yield
Summer forage crop			9 ha	Turnips	10 T DM/ha yield
Imported feed and grazing off as a percentage of the total feed offered			13.2%		
NUTRIENTS					
Clover nitrogen		93 kg/ha	Other nitrogen	28 kg/ha	
Imported nitrogen		101 kg/ha	Available nitrogen	222 kg/ha	
Surplus nitrogen		171kg/ha	Nitrogen conversion efficiency	23 %	
Lost nitrogen to water		42 kg/ha	Phosphorus losses	0.7 kg/ha	
OPERATIONAL PROFIT					
Farm fixed overheads		$228,250	Milk income	$923,595	
Land operational costs		$184,957	Livestock income	$40,350	
Livestock costs		$180,971	Operational profit	$369,682	
Farm Working Expenses		$4.12/kgMS	Per eff. hectare	$1,848	
			Per cow	$936	
Capital Value (total assets)		$5,810,922	Return on assets	6.4%	

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PRODUCTION SYSTEM	Moderate Intensity			
INFRASTRUCTURE				
Farm Area	262 ha	Milking platform (MP)	200 ha	
		Runoff (RO)	50 ha	
Feedpad	N/A	Effluent system and area	Sump, to pond and travelling irrigator	42 ha
		Irrigation system and area	N/A	
Soil Type	Dannevirke SL	Flat	Fert (PKS): 24.05.03	170 ha
	Kopua SL	Flat	Fert (PKS): 24.25.08	20 ha
	Matamau SL	Rolling	Fert (PKS): 25.30.16	60 ha
HERD				
600 cows	136 calves grazing on the runoff from weaning with half grazed off for a further 12 months of age from 11 months old.		Cow wintering	Half herd on MP, half herd on RO on crop
240,677 kgMS	1203 kgMS/ha MP		401 kg MS/cow	
PASTURE AND FEED				
Pasture eaten (Overseer)	11,753 kgDM/ha/yr			
Pasture conserved	30 T DM			
Imported feed T DM	757 T DM			
Winter forage crop	14 ha	Kale	12 T DM/ha yield	
Summer forage crop	14 ha	Turnips	10 T DM/ha yield	
Imported feed and grazing off as a percentage of the total feed offered	26%			
NUTRIENTS				
Clover nitrogen	72 kg/ha	Other nitrogen	65 kg/ha	
Imported nitrogen	151 kg/ha	Available nitrogen	288 kg/ha	
Surplus nitrogen	222 kg/ha	Nitrogen conversion efficiency	23 %	
Lost nitrogen to water	54 kg/ha	Phosphorus losses	0.7 kg/ha	
OPERATIONAL PROFIT				
Farm fixed overheads	$396,050	Milk income	$1,540,331	
Land operational costs	$243,751	Livestock income	$64,011	
Livestock costs	$393,708	Operational profit	$570,834	
Farm Working Expenses	$4.29/kgMS	Per eff. hectare	$2,283	
		Per cow	$951	
Capital Value (total assets)	$8,183,862	Return on assets	7.0%	

PRODUCTION SYSTEM		High Intensity with Irrigation		
INFRASTRUCTURE				
Farm Area	210 ha	Milking platform (MP)	150 ha	
		Runoff (RO)	50 ha	
Feedpad	Yes	Effluent system and area	Sump, to pond and travelling irrigator.	90 ha
		Irrigation system and area	Centre pivot	80 ha
Soils	Dannevirke SL	Flat	Fert (PKS): 24.14.00	170 ha
	Kopua SL	Flat	Fert (PKS): 23.15.07	20 ha
	Matamau SL	Rolling	Fert (PKS): 28.47.18	60 ha
HERD				
640 cows	145 calves grazing on the runoff from weaning with half grazed off for a further 12 months of age from 11 months old.		Cows wintered off	Half herd on MP, half herd on RO on crop
281,376 kgMS	1407 kgMS/ha MP		440 kg MS/cow	
PASTURE AND FEED (Milking platform)				
Pasture eaten (Overseer)		13,103 kgDM/ha/yr		
Pasture Conserved		38 T DM		
Imported feed T DM		757 T DM		
Winter forage crop		15 ha	Kale	12 T DM/ha yield
Summer forage crop		15 ha	Turnips	10 T DM/ha yield
Imported feed and grazing off as a percentage of the total feed offered		29%		
NUTRIENTS				
Clover nitrogen		63 kg/ha	Other nitrogen	73 kg/ha
Imported nitrogen		187 kg/ha	Available nitrogen	323 kg/ha
Surplus nitrogen		247 kg/ha	Nitrogen conversion efficiency	24 %
Lost nitrogen to water		64 kg/ha	Phosphorus losses	0.8 kg/ha
OPERATIONAL PROFIT				
Farm fixed overheads		$473,350	Milk income	$1,800,806
Land operational costs		$280,322	Livestock income	$72,250
Livestock costs		$505,504	Operational profit	$613,881
Farm Working Expenses		$4.48/kgMS	Per eff. hectare	$2,456
			Per cow	$959
Capital Value (total assets)		$9,053,006	Return on assets	6.78%

PRODUCTION SYSTEM		Arable with Livestock		
INFRASTRUCTURE				
Farm Area	210 ha	Permanent pasture	100 ha	
Effective farm area	200 ha	Cropping area	100 ha	
		Irrigation	Nil	
Animals				
Cattle sold store	80	Cattle sold prime	220	
Lambs sold store		Lambs sold prime	1,200	
CROPS				
Rotation				
Spring Sown Barley 100ha		8 T/ha/yr		
Autumn Sown Annual Ryegrass 100ha		6 T/ha/yr (grazed)		
NUTRIENTS				
Clover nitrogen		78 kg/ha	Other nitrogen	2 kg/ha
Imported nitrogen		88 kg/ha	Available nitrogen	168 kg/ha
Surplus nitrogen		115 kg/ha	Nitrogen conversion efficiency	31 %
Lost nitrogen to water		45 kg/ha	Phosphorus losses	0.3 kg/ha
OPERATIONAL PROFIT				
Farm fixed overheads		$128,250	Cropping income	$269,730
Land operational costs		$98,265	Trading sheep & wool income net of purchases	$44,020
Livestock costs		$7,841	Trading beef income net of purchases	$240,221
Cropping costs		$136,710		
Operational profit		$182,905		
Per eff. hectare		$915		
Capital Value (total assets)		$7,125,000	Return on assets	2.6%

PRODUCTION SYSTEM		Arable with Potatoes		
INFRASTRUCTURE				
Farm Area	210 ha	Permanent pasture	Nil	
Effective farm area	200 ha	Cropping area	100 ha	
		Irrigation	Travelling Irrigator	100 ha
Animals				
Cattle sold store	Nil	Cattle sold prime	Nil	
Lambs sold store	Nil	Lambs sold prime	Nil	
CROPS				
Rotation				
Spring Sown Maize Silage 100ha		17 T/ha/yr		
Autumn Sown Forage Oats 100ha		7 T/ha/yr		
Rotation				
Spring Sown Potatoes 100ha		55 T/ha/yr		
Autumn Sown Brussel Sprouts		12 T/ha/yr		
NUTRIENTS				
Clover nitrogen		2 kg/ha	Other nitrogen	7 kg/ha
Imported nitrogen		280 kg/ha	Available nitrogen	289 kg/ha
Surplus nitrogen		31 kg/ha	Nitrogen conversion efficiency	89 %
Lost nitrogen to water		50 kg/ha	Phosphorus losses	0.8 kg/ha
OPERATIONAL PROFIT				
Farm fixed overheads		$175,050	Cash Cropping income	$1,690,272
Land operational costs		$39,500	Forages Sold	$461,700
Cropping costs		$1,299,000		
Operational profit		$638,422		
Per eff. hectare		$3,192		
Capital Value (total assets)		$7,785,000	Return on assets	8.2%

7.3 Mitigations for Reducing Environmental Effects under the One Plan

The least difficult mitigating practices to introduce on farm are operational changes that don't disrupt existing farming systems. These are generally also the most preferred by farmers. However, to achieve larger reductions in nitrogen losses, farmers may need to make system changes. The dairy farm systems have not been optimised to minimise their costs of production. Instead farm practices have been introduced that suit the existing systems and the assumed managerial capability required to operate them at their current level of efficiency. Opportunities for farmers to increase cow performance are assumed to equally exist both now and in the future and have not been changed in this analysis.

In higher rainfall areas and free-draining soils such as can be found in the Tararua District, capital investments may have to be made to enable the farm system to be adapted further to meet Table 14.2 in the One Plan. The mitigations applied to each dairy farm system in this report are shown in Table 2. Further information on these practices can be found in Appendix C.

The dairy farms were each expected to have one or more wetlands and riparian areas that could be fenced off from livestock. The fenced wetlands and riparian areas could protect native habitat and also trap runoff coming from farms containing sediment and phosphorus. The farms are expected to have to provide extra cutoffs along farm races and around the farm dairy to ensure that stormwater travels across grassy paddocks before entering water channels. The grassy paddocks act as filters. On some farms, drains may be converted to swales to increase nutrient filtering. Some drains may be shortened to stop them discharging directly into streams. Instead they may be able to allow water to run over grassy areas or riparian vegetation. As part of their consent, each model farm is expected to invest $10,000 towards these mitigations.

The model dairy farms were assumed to be fully fenced from waterways, including their run-offs. This mitigation was considered the main way of reducing E.coli losses into nearby waterways and so no further action was taken.

Table 2. The mitigations applied on the dairy farms in the order in which they were applied

	Dairy Farm System			
Mitigations	Self-contained	Low intensity	High intensity	Irrigation and high intensity
Operational practice changes				
Remove nitrogen fertiliser from the effluent area	✓	✓	✓	✓
Remove winter applications of nitrogen (April to July inclusive)	✓	✓	✓	✓
Reduce nitrogen to a maximum of 60 kgN/ha	✓	✓	✓	✓
Aggressive summer culling of cows	✓	✓	✓	✓
Replace high protein feed with low protein	✓	✓	✓	✓
System practice changes				
Spread effluent to reduce rates to 100kgN/ha	✓	✓		
Remove all nitrogen fertiliser and export surplus feed	✓	✓		
Irrigation applications optimised				✓
Winter cows off the farm	✓	✓		
Reduce cow numbers and bring grazed off heifers home to replace them	✓	✓	✓	✓
Reduce overall stocking rates	✓	✓	✓	✓
Use a stand-off pad in wet winter weather			✓	✓
Structural practice change				
Covered feed pad			✓	✓
Housed cows with duration controlled grazing			✓	✓

The arable farms had simple crop rotations on the two different blocks on each farm. For the mitigations added to the arable farms see Table 3. Further information on these practices can be found in Appendix D. On the mixed livestock arable farm, in order to reduce nitrogen leaching enough for Table 14.2, all the livestock had to be removed from the system and surplus stock feed sold off the farm. The arable farm with potatoes was able to reduce some nitrogen use and reduce its use of irrigation by installing a moisture meter and water budgeting. On this farm the area in the potato crop rotation also needed to be reduced. It was replaced with a grain crop rotation that included a green mulch to incorporate some nitrogen back into the soil organic matter.

Both of the arable farms avoided having extended fallow periods between crops. They provided enough space to add a bund around their intensively cropped areas to reduce runoff containing sediment and nutrients from running into nearby waterways.

Table 3. The mitigations applied on the arable farms in the order in which they were applied

	Arable Farm System		Notes on Overseer
Mitigations	Arable with livestock	Arable with potatoes	
Operational practice changes			
Use minimal tillage and direct drilling between crops in rotation	✓	✓	Able to be modelled in Overseer
Minimise nitrogen applications to industry good practice	✓	✓	Able to be modelled in Overseer
Apply nitrogen fertiliser in side dressings		✓	Not able to be modelled
Spread nitrogen applications of over 45kgN/ha over several weeks.	✓	✓	Difficult to model
Add a bund between the block and waterways to catch runoff	✓	✓	Difficult to model the effect of a bund but reduced crop area can be included.
System practice changes			
Install moisture metering probe and move to active water management	✓	✓	Able to be modelled in Overseer
Replace fallow periods with actively growing crops or 'green mulch'	✓	✓	Able to be modelled in Overseer
Remove livestock	✓		Able to be modelled in Overseer
Harvest and export surplus green feed as fodder	✓	✓	Able to be modelled in Overseer
Replace heavy nitrogen feeding crops with grain crops		✓	Able to be modelled in Overseer

7.4 Mitigated Farm Results

PRODUCTION SYSTEM		Self-Contained		
INFRASTRUCTURE				
Farm Area	125 ha	**Milking platform (MP)**	120 ha	
Feedpad	N/A	**Effluent system and area**	Sump, to pond and travelling irrigator	17 ha
		Irrigation system and area	N/A	
Soils	Dannevirke SL	Flat	Fert (PKS): 28 0 06	102 ha
	Matamau SL	Rolling	Fert (PKS): 35 71 21	18 ha
HERD				
140 cows	28 replacements grazed on the farm from weaning to calving, but wintered off as yearlings (May-July)		**Cows wintering**	Half the herd for 2 months
49,522 kgMS	496 kgMS/ha MP		354 kg MS/cow	
PASTURE AND FEED				
Pasture eaten (Overseer)		6,028 kgDM/ha/yr		
Imported feed		Nil		
Supplements Made		288 TDM	**Supplements Exported**	212 TDM
Imported feed and grazing off as a percentage of the total feed offered		11.3%		
NUTRIENTS				
Clover nitrogen		127 kg/ha	**Other nitrogen**	2 kg/ha
Imported nitrogen		0 kg/ha	**Available nitrogen**	129 kg/ha
Surplus nitrogen		43 kg/ha	**Nitrogen conversion efficiency**	66 %
Lost nitrogen to water		18 kg/ha	**Phosphorus losses**	0.5 kg/ha
OPERATIONAL PROFIT				
Farm fixed overheads		$131,230	**Milk income**	$316,940
Land operational costs		$94,973	**Livestock income**	$13,718
Livestock & feed costs		$103,128	**Income from Capital Released**	$21,095
Operational profit		$75,510	**Income from Exported Supplements**	$53,100
Per eff. hectare		$629		
Farm Working Expenses		$6.65/kgMS		
Capital Value / Employed		$3,695,428	**Return on assets**	2.0%

PRODUCTION SYSTEM		Low Intensity		
INFRASTRUCTURE				
Farm Area	210 ha	Milking platform	150 ha	
		Runoff	50 ha	
Feedpad	N/A	Effluent system and area	Sump, to pond and travelling irrigator	25 ha
		Irrigation system and area	N/A	
Soils	Dannevirke SL	Flat	Fert (PKS): 32.44.08	127.5 ha
	Kopua SL	Flat	Fert (PKS): 26.31.10	20 ha
	Matamau SL	Rolling	Fert (PKS): 28.38.19	52.5 ha
HERD				
250 cows	55 replacements grazed on runoff from weaning until 21 months, but with all heifers off for the months of May, June and July		Cows wintering	100 % of cows off for 2 months
100,364 kgMS	669 kgMS/ha MP		401 kg MS/cow	
PASTURE AND FEED				
Pasture eaten (Overseer)		5,835 kgDM/ha/yr	Imported feed T DM	0
Supplements Made		443 TDM	Supplements Exported	293 TDM
Summer forage crop		9 ha	Turnips	10 T DM/ha yield
Imported feed and grazing off as a percentage of the total feed offered		12.5%		
NUTRIENTS				
Clover nitrogen		119 kg/ha	Other nitrogen	4 kg/ha
Imported nitrogen		5 kg/ha	Available nitrogen	128 kg/ha
Surplus nitrogen		56kg/ha	Nitrogen conversion efficiency	56%
Lost nitrogen to water		17 kg/ha	Phosphorus losses	0.6 kg/ha
OPERATIONAL PROFIT				
Farm fixed overheads		$210,150	Milk income	$642,333
Land operational costs		$160,732	Livestock income	$25,593
Livestock & feed costs		$185,842	Income from Capital Released	$28,424
Operational profit		$212,813	Income from Exported Supplements	$73,188
Per eff. hectare		$1,064		
Farm Working Expenses		$5.55/kgMS		
Capital Value / Employed		$5,820,922	Return on assets	3.7%

PRODUCTION SYSTEM		Moderate Intensity		
INFRASTRUCTURE				
Farm Area	262 ha	**Milking platform**	200 ha	
		Runoff	50 ha	
Barn with Feed Pad	Used Feb – Aug	**Effluent system and area**	Sump, to pond and travelling irrigator	170 ha
		Irrigation system and area	N/A	
Soils	Dannevirke SL	**Flat**	Fert (PKS): 31.0.0	170 ha
	Kopua SL	**Flat**	Fert (PKS): 32.13.20	20 ha
	Matamau SL	**Rolling**	Fert (PKS): 23.20.06	60 ha
HERD				
550 cows	120 replacements grazed on runoff from weaning with half grazed of at 11 months from May to May		**Cows wintering**	All cows wintered on – grazing 2 hours/day and then in barn
238,892 kgMS	1194 kgMS/ha MP		434 kg MS/cow	
PASTURE AND FEED				
Pasture eaten (Overseer)		10,779 kgDM/ha/yr	**Imported feed T DM**	814 T DM
Supplements Made		38 TDM	**Supplements Exported**	nil
Summer forage crop		12 ha	Turnips	10 T DM/ha yield
Imported feed and grazing off as a percentage of the total feed offered		25.7%		
NUTRIENTS				
Clover nitrogen		136 kg/ha	**Other nitrogen**	58 kg/ha
Imported nitrogen		51 kg/ha	**Available nitrogen**	245 kg/ha
Surplus nitrogen		222 kg/ha	**Nitrogen conversion efficiency**	27 %
Lost nitrogen to water		17 kg/ha	**Phosphorus losses**	0.8 kg/ha
OPERATIONAL PROFIT				
Farm fixed overheads		$419,900	**Milk income**	$1,528,099
Land operational costs		$267,897	**Livestock income**	$57,451
Livestock costs		$395,261	**Other income**	$-
Cost of Additional Capital		$65,958		
Operational profit including capital cost		$436,321	**Profit per eff. hectare**	$1,745
Farm Working Expenses (incl cost of additional capital)		$ 4.82/kgMS		
Capital Value / Employed		$8,784,602	**Return on assets**	5.0%

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PRODUCTION SYSTEM		High Intensity with Irrigation		
INFRASTRUCTURE				
Farm Area	262 ha	Milking platform	200 ha	
		Runoff	50 ha	
Barn with Feed Pad	Used from Feb through to Aug	Effluent system and area	Sump, to pond and travelling irrigator.	170 ha
		Irrigation system and area	80 ha centre pivot	
Soils	Dannevirke SL	Flat	Fert (PKS): 03.02.03	170 ha
	Kopua SL	Flat	Fert (PKS): 23.15.06	20 ha
	Matamau SL	Rolling	Fert (PKS): 31.20.20	60 ha
HERD				
620 cows	136 replacements with half grazed off from 1 May for 12 months		Cows wintered off	Nil (all wintered on in barn)
277,200 kgMS	1386 kgMS/ha MP		470 kg MS/cow	
PASTURE AND FEED (Milking platform)				
Pasture eaten (Overseer)	11,207 kgDM/ha/yr		Imported feed T DM	1,170 T DM
Supplements made T DM	Nil		Supplements Exported	Nil
Summer forage crop	15 ha		Turnips	10 T DM/ha yield
Imported feed and grazing off as a percentage of the total feed offered	32%			
NUTRIENTS				
Clover nitrogen	135 kg/ha		Other nitrogen	83 kg/ha
Imported nitrogen	51 kg/ha		Available nitrogen	269 kg/ha
Surplus nitrogen	194 kg/ha		Nitrogen conversion efficiency	28 %
Lost nitrogen to water	17 kg/ha		Phosphorus losses	0.8 kg/ha
OPERATIONAL PROFIT				
Farm fixed overheads	$495,250		Milk income	$1,790,445
Land operational costs	$295,839		Livestock income	$70,839
Livestock costs	$533,105		Income from Capital	$
Cost of Additional Capital	$74,512		Income from Exported Supplements	
Operational profit including capital cost	$462,578			
Per eff. hectare	$1,850			
Farm Working Expenses	$5.00/kgMS			
Capital Value/Employed	$9,731,656		Return on assets	4.8%

PRODUCTION SYSTEM		Arable with Livestock		
INFRASTRUCTURE				
Farm Area	210 ha	Permanent pasture	150 ha all harvested & exported for pasture silage	
Effective farm area	200 ha	Cropping area	50 ha	
		Irrigation	Nil	
Animals				
Cattle sold store	Nil	Cattle sold prime	Nil	
Lambs sold store	Nil	Lambs sold prime	Nil	
CROPS				
Rotation				
Spring Sown Barley 50ha		8 T/ha/yr		
Autumn Sown Annual Ryegrass 50ha		6 T/ha/yr (harvested and sold as baleage)		
Supplements Made		1,549 TDM		
Supplements Exported		1,549 TDM		
NUTRIENTS				
Clover nitrogen		61 kg/ha	Other nitrogen	2 kg/ha
Imported nitrogen		38 kg/ha	Available nitrogen	101 kg/ha
Surplus nitrogen		11 kg/ha	Nitrogen conversion efficiency	89 %
Lost nitrogen to water		20 kg/ha	Phosphorus losses	0.2 kg/ha
OPERATIONAL PROFIT				
Farm fixed overheads		$128,250	Cropping income	$119,880
Land operational costs		$76,800	Sale of Surplus Feed	$277,500
Livestock costs		$0		
Cropping costs		$95,760		
Cost of Additional Capital		$1,098		
Operational profit including capital cost		$95,472		
Per eff. hectare		$477		
Capital Value (total assets)		$7,135,000	Return on assets	1.3%

PRODUCTION SYSTEM		Arable with Potatoes		
INFRASTRUCTURE				
Farm Area	210 ha	Permanent pasture	nil	
Effective farm area	200 ha	Cropping area	200 ha	
		Irrigation	Travelling Irrigator	100 ha
Animals				
Cattle sold store	Nil	Cattle sold prime	Nil	
Lambs sold store	Nil	Lambs sold prime	Nil	
CROPS				
Rotation				
Spring Sown Maize Silage 100ha		17 T/ha/yr		
Autumn Sown Forage Oats 100ha		7 T/ha/yr		
Rotation				
Spring Sown Potatoes 10ha		55 T/ha/yr		
Autumn Sown Brussel Sprouts 10ha		12 T/ha/yr		
Rotation				
Spring Sown Barley 90ha		7 T/ha/yr		
Autumn Sown Annual Rye 90ha		5 T/ha/yr		
NUTRIENTS				
Clover nitrogen		1 kg/ha	Other nitrogen	4 kg/ha
Imported nitrogen		186 kg/ha	Available nitrogen	191 kg/ha
Surplus nitrogen		11 kg/ha	Nitrogen conversion efficiency	94 %
Lost nitrogen to water		19 kg/ha	Phosphorus losses	0.4 kg/ha
OPERATIONAL PROFIT				
Farm fixed overheads		$175,050	Cash Cropping income	$819,538
Land operational costs		$39,500	Forages Sold	$191,250
Cropping costs		$564,812		
Cost of Capital		$1,098		
Operational profit		$230,328		
Per eff. hectare		$1,152		
Capital Value (total assets)		$7,795,000	Return on assets	3.0%

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7.5 Changes in Farm Profitability

All the modelled farms had reduced profitability after making the system changes. In Table 4 the future profitability of the self-contained and low intensity dairy farms and the arable farms are very dependent on being able to sell their surplus feed to other livestock farmers.

Table 4. Summary of profit, capital and labour changes between the base farm models and their profitability after farm system adjustments

Farms	Self-Contained ($)	Low Intensity ($)	Moderate Intensity ($)	High Intensity with Irrigation ($)	Arable with Livestock ($)	Arable with Potatoes ($)
Base Total Income	578,411	963,860	1,604,343	1,873,057	553,971	2,151,972
Base Total Expenses	383,120	594,178	1,033,509	1,259,176	371,066	1,513,550
Base Profit	**195,291**	**369,682**	**570,834**	**613,881**	**182,905**	**638,422**
Base Profit / ha	1,627	1,848	2,283	2,456	915	3,192
Extra Income (from invested capital)	21,095	28,424	N/A	N/A	N/A	N/A
Extra Income (from exported supps)	53,100	73,188	N/A	N/A	277,500	191,250
Additional Capital Costs	N/A	N/A	65,958	74,512	1,098	1,098
Adj Income (From Produce)	330,646	67,925	1,585,337	1,861,284	119,880	819,538
Total Adj Expenses	329,331	556,724	1,083,058	1,324,194	300,810	779,362
Change in Expenses	-53,789	-37,454	49,549	65,018	-70,256	-734,188
Adjusted Future Profit	**75,510**	**212,813**	**436,321**	**462,578**	**95,472**	**230,328**
Adjusted Future Profit / ha	629	1,064	1,745	1,850	477	1,152
Change In Profit	-119,781	-156,869	-134,513	-151,303	-87,433	-408,094
Change In Profit / ha	-998	-784	-538	-605	-437	-2,040
% Change in Profit	-61%	-42%	-24%	-25%	-48%	-64%
Net Capital Investment	10000	10000	600740	678650	10000	10000
Base Capital Value	3,685,428	5,810,922	8,183,862	9,053,006	7,125,000	7,785,000
Base Return on Assets	5.3%	6.4%	7.0%	6.8%	2.6%	8.2%
New Capital Employed	3,695,428	5,820,922	8,784,602	9,731,656	7,135,000	7,795,000
Adjusted Return on Assets	2.0%	3.7%	5.0%	4.8%	1.3%	3.0%
Change in ROA	-61%	-43%	-29%	-30%	-48%	-64%
Base Farm Labour	Owner plus casual	Owner plus 1 FTE	Owner plus 3 FTE	Owner plus 3 FTE	Owner plus casual	Owner plus casual
Adjusted Future Labour	Owner	Owner plus 1 FTE	Owner plus 3 FTE plus casual	Owner plus 3 FTE plus casual	Owner plus casual	Owner plus casual

Two of the dairy farmers have additional income provided from the capital value of the livestock that they sold. The more intensively managed farms with greater supplementary feed inputs are able to consider housing their cows. In these models the cows were able to be housed and effluent systems expanded for less than $1,200 per cow.

On current valuations, all the initial farms were expected to return over 5% on capital except for the arable farm with livestock. After the farm systems had been adjusted, all the dairy farm models had returns drop to 5% or less than assets. The results suggest that there will be a contined downward pressure on dairy farm valuations to readjust for improved returns on assets.

It is common in the dairy industry for farmers to have about $21/ kgMS of debt on their farms. Based upon an interest rate of 7% that would mean each of the model farms has the following annual interest payments.

Self-contained: $126,660

Low intensity: $212,139

Moderate intensity: $353,795

Irrigation and high intensity: $413,623

Arable with livestock: $157,576

Arable with potatoes: $530,134

All of the model farms in their base operation would be able to pay this amount of debt from their profit. After the farms have been adjusted to achieve Table 14.2 only the dairy farms at moderate to high intensity could still cover this amount of debt. The low intensity dairy farm might need a slight reduction in debt to survive. The self-contained dairy farm and the two arable farms would need to almost halve their debt.

The reduction in profitability of the modelled farms in order to meet the requirements of Table 14.2 is likely to reduce their market value while they are under these constraints. In the case of farms where their intensive use and profitability is reduced, the market would "consider" what the resulting highest and best use of the farm could be after these changes.

The market for dairy milking platforms that are no longer viable may change to them being viewed as a dairy run off or intensive finishing farms for dry stock. Both of these options would reduce their value on a per hectare basis. While the underlying value of the bare land may only experience a small decrease (say 5%) the value of the specialist dairy improvements (cowshed, effluent system, races) would be virtually nil under an alternative land use scenario.

In the case of farms that have used capital expenditure (e.g. cow housing) to meet Table 14.2, the market would factor in the added value of these new assets to a degree, but probably not enough to reflect the total capital cost of installing the infrastructure.

In the example in Table 5 it has been assumed that 70% of the cost to install the cow housing is reflected in changed capital value. This is reflective of how the market "prices" such infrastructure at present.

Table 5. Hypothetical examples of changes in farm capital value following mitigation

Self-Contained Farm			**125ha**		**Irrigated high Intensity farm**			**262ha**
Status Quo Value			**$3,000,000**		Status Quo Value			**$6,200,000**
Split as: -					Split as: -			
	Land Value		2,600,000			Land Value		5,000,000
	Cowshed		120000			Cowshed		600000
	Effluent System		50000			Effluent System		120000
	Races		25000			Races		50000
	Other Improvements		$205,000			Other Improvements		$430,000
Value After System Change			**$2,680,000**		Value After System Change			**$6,550,000**
Split as: -					Split as: -			
	Land Value		2,470,000			Land Value		5,000,000
	Cowshed		nil			Cowshed		600000
	Effluent System		nil			Effluent System		120000
	Races		5000			Races		50000
	Other Improvements		$205,000			Cow housing (70% of cost)		350000
						Other Improvements		$430,000

8. Costs Associated with the Consenting Process

The One Plan in Chapter five has objectives and policies regarding the management of water quality in sensitive catchments identified within the Manawatu and Wanganui region. The water quality values for each subzone within the catchments are shown in Table B2 of the One Plan and the water quality targets are shown in Table E2.

Under policies 14.5 and 14.6 of the One Plan the owners of all intensive farming operations must apply for a land use consent to continue operating. Rule 14.1 and Table 14.2 describe the conditions under which the Council can issue a controlled consent. The focus of this chapter in this report is on the costs for applicants of applying for a consent, with particular application to dairy farmers applying for a restricted discretionary consent.

There are expected to be four consent application pathways for farmers (Table 6):

- Where an existing farm is able to meet the nitrogen leaching caps in Table 14.2 of the One Plan and to mitigate any potential waterway contamination from phosphorus, sediment, and E.coli, their application will need to provide enough evidence from Overseer® to support the Council approving a controlled consent. The main costs will be for an agricultural consultant to describe the existing farm system and carry out a standard AEE. This should show that the farming business can operate within the effects anticipated by the One Plan with effects less than minor.

- Some existing farms may be able to meet the leaching caps in Table 14.2 of the One Plan and mitigate any potential waterway contamination from phosphorus, sediment, and E.coli but their mitigations cannot be calculated using Overseer. These will require extra preparation work to quantify the benefits of these mitigations. Such farms will need to apply for a restricted discretionary consent that shows calculations of the effectiveness of their mitigations. Generally the size of the benefits from these mitigations will be quite site specific and so information about the site as well as the mitigation will need to be provided. For example, the use of high carbon ditches to intercept nitrogen leaching will depend on the hydrology of the site. An agricultural consultant working with a farmer can provide the Council with this information with the support of industry scientists.

- Farms that can meet the nitrogen leaching caps in Table 14.2 within four years will need to address through their AEE the effects of the four year delay in meeting the Table. The additional costs for these farmers are generated from needing the advice of a professional ecologist and obtaining information from the Council about the cumulative effects for the catchment.

- The farms that are not anticipated to meet the nitrogen caps in Table 14.2 will need to apply for a restricted discretionary consent and prepare a very robust AEE. They will need to employ technical expertise to show that their effects on the environment are less than minor. It is probable that these applications could be publically notified and an additional deposit for this will need to be made to Horizons. The deposit may be around $8,000 in addition to the costs already shown in Table 4.

The costs shown in Table 6 could easily vary by 20% either up or down depending upon the complexity of the work involved.

Table 6. Detailed costing of consent application options (Horizon's costs in italics)

	Existing farm system meets Table 14.2 ($)	Existing farm system could meet Table 14.2 with mitigations ($)	Delayed farm system change to meet Table 14.2 with mitigations ($)	Restricted Discretionary consent outside Table 14.2 ($)
Site description with Farm system description	1000	1000	1000	1000
Maps from Horizons	500	500	500	500
Information from Horizons about cumulative catchment condition		400	400	400
Activity and proposal (Overseer)	4000		4500	
Activity and proposal (Overseer plus)		6000		6000
Information from the Rural Advice Team in Horizons	300	500	300	300
Assessment against One Plan rules	1000	1000	1000	1000
Assessment against NPSFM and One Plan policies (Planner)				1000
Assessment of environmental effects (ESHMAK)	2500	2500		
Information from catchment advice team in Horizons			600	800
Experts • Ecologist • Hydrogeological			4000	4000 4000
Consent application fee	1300	2000	1500	2000
Total	$10,600	13,900	13,800	21,000

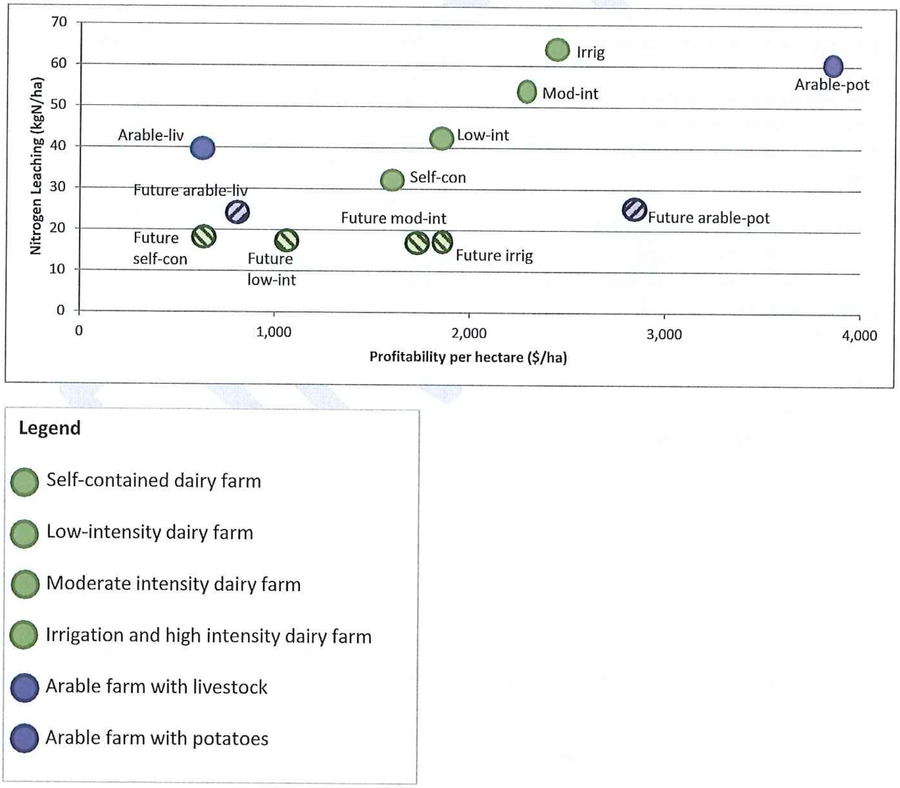
Farmers are annually required to provide information to Horizons so that the Council can monitor their consent conditions. If farm consultants provide this for their clients the cost could be about $1500 per farm.

The costs for individual farmers obtaining a consent may be able to be reduced if the fertiliser companies and milk processing companies provide the base farm information and annual monitoring services for their clients. It may be that the owners of the Overseer Company decide not to introduce charging, and it may be possible for all the farms in a subzone to share a single environmental assessment. Industry groups may be able to provide templates for completing an assessment of mitigations not included in Overseer.

9. Discussion and Conclusions

There were six farm models developed in this study. The summarised results are shown in Figure 3. The figure is a graph of profit ($/ha) related to nitrogen leaching (kgN/ha). In the graph the lowest leaching farm in its initial state is the self-contained dairy farm. That farm has a profit of $1,627/ha and nitrogen leaching of 32 kgN/ha. The highest leaching farm is an irrigated highly intensive dairy farm with a profit of $2,456/ha and nitrogen leaching of 64 kgN/ha.

Figure 3. A graphical representation of the model farms before and after they have been adjusted to meet the nitrogen caps in year 20 of Table 14.2 of the One Plan



The graph also displays in striped colours where each of the farms moves towards after they have been adjusted to meet the requirements of Table 14.2. In that case, all the dairy farms on soils in the Tararua District are below 18 kgN/ha. Both the arable farms on soils in the Rangitikei District are below 24 kgN/ha.

The significance of these changes can be determined from how much they might affect the adaptability, the sustainability, and the viability of farms like these in the region. Their adaptability could be influenced by how much change in management intensity these farms require. The more intensive the management, the less opportunity there is for farmers to explore new ways of doing things. In this report, any farms that have to reduce the amount of labour they can employ and that have to increase pasture utilisation can be considered to be becoming less adaptable. Diversifying their product range can also increase the adaptability of farming systems.

The sustainability of the farm systems can be related to the efficiency with which they utilise available natural resources. In this report farms that are able to increase their nitrogen efficiency can be considered to be becoming more sustainable in their use of natural resources.

The viability of the farm businesses will be related to their profitability and their ability to service their debt and achieve sufficient return on investment to provide financial security for their owners.

Self-Contained dairy farm

This farm model has all the heifers grazed off the farm for 12 months from 9 months of age. It assumes that there has already been some adjustment to reducing its environmental footprint by grazing half the dairy cows off the farm over winter. Regular soil tests are taken and maintenance phosphate fertiliser is applied. A summer forage crop of turnips is grown to manage a possible risk of a dry summer. On average 30kg N/ha is applied in early spring and autumn to extend pasture production in those seasons.

To meet Table 14.2 in the One Plan, the farm has to reduce the number of dairy cows from 270 to 140 animals. It can no longer apply nitrogen fertiliser and must stop all cropping. The farm is expected to no longer bring in feed supplements for the cows. Instead it harvests 288 tonnes of pasture DM and sells most of this off the farm. The sale of surplus feed is a very important part of pasture management on this farm because animal consumption has dropped to almost 6,000 kgDM/ha/yr. Without harvesting surplus feed, the quality of the pasture would fall and in a few years pasture composition would suffer.

The farm started with leaching 32 kgN/ha and was modified to be leaching only 18 kgN/ha, a reduction of 44%. These changes reduced the expected farm profit from $1,627/ha to $629/ha, a drop of over 60%. The return on assets dropped from 5.3% to 2.0%.

The self-contained farm model has had to reduce its labour but it has surplus pasture available for alternative landuses, and therefore its adaptability might increase overall. Nitrogen conversion efficiency has increased to 66% and so it can be expected to be more sustainable in its use of natural resources. However, its profitability is not enough to support the level of debt found on many farms in this region. The return on assets is insufficient to attract off-farm investment, should that be required for future improvements. Unless farms like this have less than half the amount of debt as the model farm, they will not survive the changes required to address Table 14.2 .

Low-intensity dairy farm

The low-intensity dairy farm is very common in the Tararua District and in the region generally. In this model there are more cows and they have greater production than the self-contained farm. On this farm there is more supplementary feed (260 tonnes DM) brought onto the farm and greater use is made of cropping in both winter and summer. Over the whole farm more than 100 kgN/ha is applied, mainly to lengthen the grass growing season in spring and autumn.

To meet Table 14.2 in the One Plan, the farm has to reduce the number of cows from 400 to 250 animals. They will also need to reduce nitrogen fertiliser applications toan average of 5 kgN/ha/yr and stop importing supplementary feed and growing a winter crop. The summer crop remains, and 443 tonnes of DM are conserved. Three quarters of the conserved feed is sold off the farm to maintain pasture quality.

The farm started with leaching 42 kgN/ha and was modified to be leaching only 17 kgN/ha, a drop of 60%. These changes reduced the expected farm profit from $1,848/ha to $1,064/ha, a drop of over 40%. The return on assets dropped from 6.4% to 3.7%.

The low intensity farm model has not reduced its labour and it has surplus pasture available for alternative landuses. It's adaptability might increase overall. Nitrogen conversion efficiency has increased to 56% and so it can be expected to be more sustainable in its use of natural resources. However, its profitability is not enough to pay tax and support the level of debt found on many farms in this region. The return on assets is insufficient to attract off-farm investment, should that be required for future improvements. Unless farms like this can reduce the amount of debt below that of the model farm they will not survive the changes required to address Table 14.2 .

Moderate-intensity dairy farm

This farm has 600 cows and achieves high production. The farm imports 757 tonnes DM, grows winter and summer crops and applies an annual application of over 150 kgN/ha.

To achieve Table 14.2 in the One Plan this farm has a covered barn installed for all the cows so that they can be housed all year. Although inside for much of the time, the cows are grazed outside for fixed periods throughout the year – 8 hours per day while lactating and 2 hours per day over winter. The farm imports the same amount of supplementary feed as it did previously and harvests another 38 tonne of supplements to maintain production. Dairy effluent is applied across the whole of the milking platform and nitrogen fertiliser applications reduced to 50 kgN/ha.

The farm started with leaching 54 kgN/ha and was modified to be leaching only 17 kgN/ha, a drop of almost 70%. These changes reduced the expected farm profit from $2,283 /ha to $1,745/ha, a drop of almost 25%. The return on assets dropped from 7.0% to 5.0%.

The moderate intensity farm model has not reduced its labour but it has had to increase its overall pasture utilisation. Its adaptability might therefore decrease overall. Nitrogen conversion efficiency only increases slightly to 27% and so there is not much improvement expected in the sustainable use of natural resources. However, the profitability of this farm is sufficient to support its expected level of debt and it has sufficient return on assets to provide financial security for its owners.

Irrigated high-intensity farm

The irrigated high intensity dairy farm in the base model has 640 cows and has a centre pivot irrigator and a feed pad. The farm imports 757 tones DM per year as a supplement or 1,180 kgDM/cow. It uses 187 kgN/ha of nitrogen a year.

To meet the requirements of Table 14.2 in the One Plan this farm has built housing for the cows so that they can be kept inside all year. The farm already had a feed pad and so the effluent system for housing the animals was already in place. While they are lactating, the cows are grazed outside for up to 8 hours per day. The amount of imported supplements on this farm is increased to 1,170 tonnes DM and 22 tonnes of supplements are made on the farm.

The farm started with leaching 64 kgN/ha and was modified to be leaching only 17 kgN/ha, a drop of over 70%. These changes reduced the expected farm profit from $2,456/ha to $1,850/ha, a drop of 25%. The return on assets dropped from 6.8% to 4.8%.

The irrigated high intensity farm model has not reduced its labour but it has had to increase its overall pasture utilisation. Its adaptability might therefore decrease overall. Nitrogen conversion efficiency only increases slightly to 28% and so there is not much improvement expected in the sustainable use of natural resources. However, the profitability of this farm is sufficient to support its expected level of debt and it has sufficient return on assets to provide financial security for its owners.

Arable farm with livestock

Both the arable farms are larger than the typical farms to be found in the Manawatu. Making them larger makes it easier to compare these farms with the dairy farms that have a similar size. This farm specialises in grain production over summer. It has been able to do that without irrigation. Half of the farm is used for growing barley and in winter it has been growing ryegrass for finishing livestock. The farm finishes lambs and heavy cattle over a 12 month period. Over the year 150 kgN/ha is applied to the cropping area or an average of 60 kgN/ha across the whole farm.

The changes required to meet Table 14.2 in the One Plan are to dispose of all the livestock and harvest as silage and hay the permanent pasture and ryegrass green crop. The area in barley had to be reduced from 100ha to 70 ha. Over a whole year 1,399 tonnes of pasture dry matter was made and exported from the farm.

The farm started with leaching 39 kgN/ha and was modified to be leaching only 24 kgN/ha, a drop of almost 40%. These changes decreased the expected farm profit from $915/ha to $477/ha, a decrease of 47%. The return on assets dropped from 2.6% to 1.3%.

The arable with livestock farm model has not reduced its labour but it has become dependent on the supplementary feed market. Its adaptability might therefore decrease overall. Nitrogen conversion efficiency has increased to 89% and so natural resource sustainability has also increased. The profitability of this arable farm is insufficient to support its expected level of debt and it has insufficient return on assets to provide much financial security for its owners.

Arable farm with potatoes

This model farm was again large for a cropping farm. This time there were no livestock and instead two different rotations were modelled. The second rotation of potatoes and brussels sprouts required a total application of 428 kgN/ha over a year. The other rotation of maize silage and winter oats for forage only needed 110 kgN/ha. Irrigation was used over summer on the potato crop and 500mm/yr was used.

The changes required for meeting Table 14.2 in the One Plan included reducing the amount of nitrogen fertiliser going on to the potato rotation (332 kgN/ha) and better timing fertiliser applications to align with crop requirements. A new rotation growing barley for grain was introduced to replace some of the area originally in a high nitrogen feeding crop (potatoes). To reduce drainage from excess irrigation a moisture probe was installed and a water budget put in place. This reduced the amount of water needed to 380mm/yr.

The farm started with leaching 60 kgN/ha and was modified to be leaching only 25 kgN/ha, a drop of almost 60%. These changes reduced the expected farm profit from $3,192/ha to $1,152/ha, a drop of over 64%. The return on assets dropped from 8.2% to 3.0%.

The arable with potato farm model has some reduction in casual labour and it has had to increase the range of crops being grown. Its adaptability might therefore increase overall. Nitrogen conversion efficiency has increased to 94%, a big improvement in the sustainable use of its natural resources. However, the profitability of this farm is insufficient to support its expected level of debt and it has insufficient return on assets to provide financial security for its owners.

Future farming systems

It is likely that the farming systems described here will be greatly modified after their first few years under consented conditions. It is likely that dairy farms with cows grazing outside all year will develop contracts for supplying surplus supplementary feed to other farmers with their cows housed indoors. The housed cow farmers are likely to expand the size of their operations until constrained by the efficiency of their effluent systems and the maximum loading of effluent that they are able to apply to land.

Some farmers may choose to winter some dairy cows on what would otherwise be arable farms growing grain. These farmers will need to use well designed stand-off pads to minimise the leaching of nitrogen over the winter months.

Consent Applications

The model farms above have been developed to show how these farms could be adapted to meet the nitrogen caps in Table 14.2 of the One Plan. They may need a number of years to put all the identified mitigations in place, in which case they will need to apply for a restricted consent to enable them to operate outside Table 14.2 over a transition period.

10. Assumptions, Limitations and Further Work

I have written this report in a style that is without references. The conclusions are evidenced based from a number of sources, using the information contained within the reported material, the client information held in company databases owned by KapAg Ltd, BakerAg Ltd and RD Consulting and the experience of the author. In addition, some of the costs used in this report were sourced from Dairy Base a national database of dairy farm physical and financial performance.

Further information about the author's experience is contained on the KaAg website listed under further reading.

At the time of preparing this report the costs of the consenting process were drawn from those associated with the processing of existing consents and estimates based on possible future requirements. A process for making an Assessment of Environmental Effects (AEE) had not been suggested by staff at Horizons. For this study it was assumed that the AEE could be carried out by a suitably qualified farm consultant that had received additional training from NIWA to be able to use the extended Stream Health Monitoring and Assessment Kit – ESHMAK. If there was a surface waterway available, the most significant of these on each property would be measured at two points along it. The results of the waterway assessment would be included in the AEE describing the effects of the farming activities on Table B1 values and Table E2 targets. These results in the AEE would be conveyed in narrative farm using numeric scores from the ESHMAK where these were available.

The nutrient budgeting software – Overseer, is currently available 'free' to registered users. In this report a cost is assumed. The Farmax ® charging policy has been used, that is: $200 per farm and unlimited scenarios per farm. If a farm system has significant changes made a new charge would be generated and three 'farms' have been used in the costing section of this report.

This report has not considered all the combinations of farm systems and nitrogen loss rates in the region but the results should still be indicative of the likely ranges of these. While the author has made full use of the information available at the time, this report can undoubtedly be enhanced by further input from industry experts.

11. Further Reading

Dairybase web site: https://www.dairynz.co.nz/business/dairybase/

DairyNZ 2010. Facts and Figures: For New Zealand dairy farmers

Denzin NK (Ed), 2009. Sociological Methods: A Sourcebook. Transaction Publishers, New Jersey.

Denzin NK and Giardina MD (Eds), 2008. Qualitative Inquiry and the Politics of Evidence. Left Coast Press Incorporated, California.

Farmax web site: http://www.farmax.co.nz/

KapAg Ltd web site: http://kapag.nz/

Overseer web site: https://www.overseer.org.nz/

Parminter TG, 2013. Of my own free will: voluntary approaches to environmental policy. LAP Lambert Academic Publishing, Germany.

Parminter TG and Grinter J 2016. Farm-scale Modelling Report: Ruamāhanga Whaitua Collaborative Modelling Project. Ministry for Primary Industries, Wellington, New Zealand.

Waikato Regional Council. Menus of practices to improve water quality: https://www.waikatoregion.govt.nz/community/your-community/for-farmers/healthy-farms/farm-menus

12. Appendix A. Glossary

Table 14.2 sets the nitrogen caps for farmers and growers operating in the Manawatu Wanganui Region.

Nitrogen caps for intensively farmed land, from Section 14.3 of the One Plan

Period (from the year that the rule has legal effect)	LUC I	LUC II	LUC III	LUC IV	LUC V	LUC VI	LUC VII	LUC VIII
Year 1	30	27	24	18	16	15	8	2
Year 5	27	25	21	16	13	10	6	2
Year 10	26	22	19	14	13	10	6	2
Year 20	25	21	18	13	12	10	6	2

Model Farm: Self-contained farm. The farm is described as self-contained although to start with there is some feed imported and some cows are grazed off the farm for two months over winter. Milk production in this model is not dependent on imported feed. Although clearly a system II farm, it approaches the type 1 system defined by the industry.

Model Farm: Low intensity. This farm is described as low intensity because it has a low level of imported feed. It fits a system II farm although it does support the lactation over summer and autumn with supplements and a summer crop.

Model Farm: Moderate intensity. This farm imports feed to support lactating cows and grazes dry cows off during the winter. The farm was considered to be a system IV farm.

Model Farm: High intensity. This farm feeds supplements to the cows through most of the year.

13. Appendix B. Project Brief

The following are abridged selections from the project brief supplied by email on the 6th June 2017. "Horizons Policy and Regulatory teams are undertaking a review of the policy and rule framework for nutrient management and intensive landuse provisions.

This work is required to address the need for applications to contain fuller assessments of environmental effects, including cumulative effects which consider impacts on the wider catchment. Consideration must also be given to all of the relevant objectives and policies in the One Plan, as well as, the capacity to maintain or enhance Schedule B values and Schedule E targets.

Additionally, the consent must contain an assessment against the objectives and policies of the National Policy Statement for Freshwater Management, ... section 105 of the RMA, and the National Environmental Standard for Sources of Human Drinking Water.

It is important for Council to understand all issues of cost and practicability in respect of consenting requirements for intensive land use activities. To this end, Council wishes to obtain advice through assessing the on-farm economic impacts on future consent applicants to compile, lodge and implement a land use consent for intensive agriculture or horticulture in the target catchments which fully address effects , and fully addresses the relevant objectives, policies, rules, schedules of the One Plan and the provisions of other relevant legislation.

The purpose of this study is to calculate the costs associated with applications for intensive farming land use activities and the economic impact of mitigations to reduce nitrogen leaching likely to be incurred as a result of the recommended improvements to the consenting process."

14. Appendix C. Farming practices introduced to the Livestock Farms

Remove winter applications of nitrogen (May to July inclusive)

Farmers apply nitrogen fertiliser in winter (typically May or late July) if they have insufficient feed and if conditions are suitable. Only the high intensity farm with irrigation applied nitrogen during this time and these applications have been removed as a mitigation.

Reduce nitrogen to a maximum of 100kg/ha/yr

Although the extra feed grown may be needed to support a farming system, reducing the amount of nitrogen fertiliser applied through a year reduces the amount of nitrogen leached. This was applied across all farms as a mitigation. As nitrogen fertiliser is decreased, so is the amount of pasture grown which requires either a decrease in stocking rate or a decrease in per cow performance.

Aggressive summer culling of cows

Removing cull cows in Autumn (around March) when the non-pregnant (empty cows) are known, reduces feed demand during a time when feed may be limiting. The reduced numbers also reduces nitrogen leaching. This was applied across all farms.

Replace high protein feed with a low protein feed

Replacing high protein feeds (nitrogen boosted pasture, high quality grass silage) with a low protein feed (starch based grains, maize silage) reduces urinary nitrogen and therefore decreases nitrogen leaching. The low protein feeds have to be 'imported' onto farms to replace the 'homegrown' feeds and they generally cost more to purchase. This change was applied to the moderate intensity and the high intensity with irrigation farms as a mitigation.

Spread effluent to reduce rates to 100kgN/ha

Reducing effluent nitrogen loadings from the consented 150 kgN/ha towards 100 kgN/ha application generally leads to a reduction to nitrogen leaching. This was applied to the self-contained farm and the low intensity farm. However, this was unable to be implemented on the other two farms because they had insufficient area available. This is due to the high effluent loading created with cows in a barn and higher rates of effluent nitrogen applied over the farms. On the two more intensive farms the effluent areas had to be increased to 85% of the farm to meet the consented 150kgN/ha N limit.

Remove all nitrogen fertiliser and export surplus feed

Reducing or eliminating nitrogen fertiliser reduces nitrogen leaching. However, as discussed, it also reduces grass growth and therefore stocking rate has to be reduced accordingly. This was applied as a mitigation to the self-contained and low intensity farms.

Export surplus feed

Where farms are forced to reduce stocking rate to meet nitrogen leaching limits, pasture demand is also reduced. Uneaten surplus pasture can lead to a decline in pasture quality and pasture species. To maintain pasture quality, silage or hay is made which can either be stored on farm, or sold off farm. In this report, unwanted surplus feed is sold off farm. This strategy was applied over the self-contained and low intensity farms.

Optimise Irrigation

Optimising water efficiency and therefore minimising drainage through the soil profile reduces nitrogen leaching. This mitigation was only applicable and applied to the high intensity farm with irrigation and the arable farm with potatoes.

Winter cows off the farm

Grazing dry cows off the farm during winter is a significant nitrogen mitigation, assuming that cows are grazed outside catchment. This mitigation was applied to the self-contained and low intensity farms.

Reduce cow numbers and bring grazed off heifer's home to replace cows

Reducing lactating cow numbers and replacing them with heifers reduces stocking rates and the cost of off-farm grazing. This is a nitrogen leaching mitigation was applied to the self-contained and low intensity farms.

Reduce Overall Stocking Rate

Reducing overall stocking rate is a significant nitrogen mitigation. This was implemented on the self-contained and low intensity farms to a major degree. Farmers with housed cows are able to adjust their effective stocking rate through controlling the duration of time that their cows are grazing outside. Because of this there was only a minor decrease required in stocking rate on the moderate intensity and high intensity with irrigation farms.

Use a standoff pad in wet winter weather

This mitigation enables cows to be held off paddocks for significant time during the winter and when it is wet. This prevents pugging and captures urinary nitrogen for treatment through a farm effluent system. This mitigation was applied to the moderate intensity and high intensity with irrigation farms.

Build a covered feed pad/ area

This mitigation enables supplementary feeds to be fed to cows when off paddocks. Feed pads are typically made of concrete. They are suitable to feed cows on, but are not suitable for stand cows on for long periods of time. This mitigation was applied to the rate on the moderate intensity and high intensity with irrigation farms.

Housed cows with duration controlled grazing

This mitigation allows cows to graze on pasture for short periods and then be kept in a barn with a soft litter area during the times of the year when the risks of urinary nitrogen leaching are high. During this time they may also have access to supplements fed on a concrete apron. In the modelled farm systems they grazed on pastures for eight hours per day in February, March, April and May, two hours in June and July and twelve hours in August. As a purpose-built barn it combines the "use a standoff pad in wet weather" and "a covered feed pad" during lactation.

Effluent from the housed cows is captured and along with bedding material is applied to paddocks during low risk periods of nitrogen leaching. This mitigation has been applied to the moderate intensity and high intensity with irrigation farms.

15. Appendix D. Farming Practices on Arable Farms

Minimal tillage

Minimal tillage and direct drilling are used to reduce the amount of cultivation applied between crops. The reduced cultivation reduces farm costs and nitrogen leaching from organic matter breakdown in the soil. In the arable models conventional tillage was used to cultivate pasture in both the base and modified models and minimal tillage between crops.

Minimal nitrogen applications

Nitrogen applications can be reduced to replace the amount of nitrogen being removed in produce and losses incurred during crop growing. There was limited ability to reduce applications in the model base farms although some reduction was applied to the arable with potatoes model.

Nitrogen fertiliser applied in side dressings

Nitrogen fertiliser can be applied to horticultural crops as side-dressings near the plant roots to improve uptake efficiency. This was not possible to model in Overseer but was assumed to be applicable on the arable farm with potatoes.

Spread nitrogen applications

Instead of applying nitrogen fertiliser in one dressing at heavy rates (over 45 kgN/ha) leaching will be reduced if the same amount of fertiliser is spread over a number of weeks or even months. There is limited ability to model this in Overseer, but both arable farms had large applications split over more than one month.

Bunding to capture runoff

There are advantages on bare ground of capturing stormwater to hold back sediment, nutrients and pathogens. On both arable farms bunds were assumed to be put in place, reducing the cultivatable area for cropping.

Active water management

To reduce annual water use on the modelled arable-with-potatoes farm a moisture probe was introduced to monitor soil moisture and establish a water budget. Using a water budget reduces water use to calculated deficits and reduces nutrient losses.

Reduce fallow

Fallow periods of bare soil increase nitrogen leaching. By using a cover crop, when the land is next cultivated, surplus nitrogen is captured and returned to the soil in organic matter.

Remove livestock

Livestock on arable farms concentrate nitrogen when they urinate in patches. Removing livestock reduces this source of nitrogen leaching.

Export green crops

Harvesting green crops captures the nitrogen they contain and enables surplus to be exported off the farm. It is better than grazing with livestock if the intention is to reduce nitrogen leaching.

Reduce the area of heavy nitrogen feeding crops

Crops that have a high proportion of their biomass harvested have a high requirement for nitrogen fertiliser and so increased nitrogen losses. Replacing heavy nitrogen feeders with grain crops reduces nitrogen requirements and nitrogen losses. The arable-with-potato farm had a proportion of potatoes replaced with barley.

16. Appendix E. A summary of Commodity and Service Prices

These are listed in no particular order

Dairy	Amount	Notes
Milk solids payout (kg MS)	$6.00	
Dividend	$0.40	Assumes fully shared up Fonterra suppliers
Management fee	$75,000 pa	Owners wage of management
Senior farm staff	$60 - $75,000 pa	2IC – farm manager
Farm hand	$50,000 pa	
Fertiliser Phosphate	$3.70 / kgP	High analysis fertiliser on arable farms used cost price
Fertiliser potash	$1.50 / kgK	As above
Fertiliser Nitrogen (Urea)	$700 / T incl spreading	As above
Off farm grazing - weaners	$5 / head / week	
Off farm grazing – Rising 1yr May to May	$8.50 / head / week	
Off farm grazing – winter mixed age cows	$27 / head / week incl transport	
Feed Prices – PKE	$280 / T delivered	
Pasture Silage Imported	$250 / TDM	
Maize Silage Imported	$320 / TDM	
Barley Grain	$400 / TDM	
Hay	$85 / bale delivered	
Sale Price of Exported Pasture Silage	$150 / TDM	
Arable Farms	Sale Price / T	Crop Cost $ / ha
Barley price	$333 / T	$1,344 / ha
Pasture silage	$150 / TDM	NA
Oat Silage	$150 / TDM	$500 / ha
Maize silage	$240 / TDM	$2,400 / ha
Potatoes	$300 / T	$9,519 / ha
Brussel Sprouts	$385.70	$3,456 / ha
	Sale Price	Purchase Price
Finished lambs (average)	$6.60 / kg cw	$2.87 kg lw
Store cattle (average)	$2.87 / kg LW	$3.71 / kg lw

KapAg

Finished cattle (average)	$5.73 / kg cw	$3.71 / kg lw
Other		
Farm consultants	$150/hr	
Technical specialists	$250/hr	
Council staff	$100/hr	
Interest rate on annuity for additional capital requirements	7%	