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Upper Waikato dairy support study

Environmental impact, mitigation effectiveness and associated cost

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EXECUTIVE SUMMARY

Dairy support is a significant land use in the Upper Waikato catchment ("the catchment") and is an essential component of both the dairy and drystock industries. However there has been little work carried out to understand the environmental footprint and how they impact of dairy support can be mitigated.

The Waikato Regional Council ("WRC") engaged Perrin Ag Consultants Ltd ("PAC") to undertake a study of real case study farms considered to be representative of businesses undertaking dairy support activity in the catchment in July 2014, with the finalised terms of reference requiring PAC to:

(i) To identify the base level of nitrogen leaching, phosphorus runoff and sediment and microorganism losses from dairy support farms/dairy support blocks in the Upper Waikato.

(ii) To identify mitigations that will reduce the environmental footprint from dairy support units – specifically nitrogen, phosphorus, sediment, and microbial impacts on water quality; and

(iii) To identify the possible on-farm mitigations to reduce nitrogen, phosphorus, sediment and microbe losses, and to quantify the financial cost of implementing those mitigations.

In total, eleven case studies, identified as A through K, were analysed, covering a matrix of two soil types, three dairy support activities, three feeding regimes and two ownership/operational models. Case studies A through F are on pumice soils, with G through K on allophanic soils. All of the participant farms had an initial field inspection and interview in September, at which time baseline data was obtained to develop representative status quo models of the farming systems in FarmaxPro and Overseer™ 6.1.3 and to obtain qualitative data on sediment and microbial losses. In the status quo models N leaching ranged from 17.6kg N/ha to 49.4kg N/ha with P loss ranging from 0.5kg P/ha to 3.6kg P/ha as assessed by Overseer™ 6.1.3.

Two nitrogen loss reduction scenarios (10% and 20%) and a single sediment/phosphorous loss minimisation scenario were modelled and analysed in Farmax and Overseer™.

A follow-up visit with each participant farm was then undertaken in early November to discuss the ease or difficulty of implementing the suggested mitigation scenarios.

Nitrogen loss mitigations were adopted sequentially until the target reductions were achieved. This was achieved by firstly reducing unprofitable N fertiliser use, then reducing/eliminating cropping activities where possible and finally lowering stocking rate.

Construction of wintering facilities were not modelled in this analysis due to the high capital outlay required and large reduction in EBIT per kg of N loss reduction achieved evident where wintering facilities have been modelled in similar studies. The 'Upper Waikato Drystock Nutrient Study, 2013' found that installing a wintering facility on a dairy support operation in the Taupo-Ohakuri catchment resulted in a reduction in EBIT of ($113)/ha which equated to a reduction in EBIT of ($48.18)/kg N loss reduction achieved. This reduction in EBIT/kg N loss reduced is far greater than any N loss mitigation modelled in this study therefore suggesting wintering facilities are predominantly inefficient mitigations for reducing N loss in dairy support systems.

For the 10% N loss reduction scenario, the average change in farm EBIT was a reduction in EBIT of ($7)/ha, which equates to an average loss in annual profitability of ($2.36)/kg N loss reduction achieved.

Under the 20% reduction scenario, the average change experienced per farm was an increase in EBIT of $6/ha. However, if the output from the singular outlying case study is removed, given the opportunity that it's atypical production system had in meeting the N reduction target with a significant increase in profitability, then the average change in EBIT in achieving a 20% reduction in N loss becomes a reduction of ($21)/ha. This is equivalent to an average loss in annual profitability of ($3.69)/kg N loss reduction achieved.

With regard to lowering P losses through normal mitigations, reductions in P losses to water, as estimated by Overseer™, were forecast to be achieved on five of the eleven case studies (when expressed on a per ha basis). The financial impact (Δ EBIT) of this on the business directly related to the size and productivity of the area retired (loss of feed offset by reduction in fertiliser, weed & pest and land maintenance costs), if any, and whether there was any potential to reduce P fertiliser without compromising pasture growth. Within the five case studies where reduction in P loss was assessed as achievable, the change in EBIT ranged from an increase of $89/ha to a reduction of ($44)/ha - an average reduction in profit across the five farms of ($0.6)/ha.

Risk of sediment and associated microbial losses to water within the studied farms would appear to be low based on visual soil assessment analysis, with all of the farms being assessed as being "good". However, based on the case study farms visited, it is likely that many farms will still have either riparian areas where direct stock exclusion is still required, or erosion prone areas adjacent to fenced riparian margins that would benefit from retirement

In conclusion it seems likely that reductions in current N losses from dairy support operations in the Upper Waikato in the order of 10% might be achieved with minimal economic disruption, given the tight range of financial outcomes and essentially nil average cost modelled in the case study farms in meeting this target. However, it appears that dairy support businesses will experience an overall loss in profitability in achieving N loss reduction targets in excess of 10% of current losses, although the impact on individual farm businesses will vary considerably.

Improvement in farm productivity may hold the key to many farms meeting potential N loss reduction targets without significant negative financial impact, but these improvements will not easily be achieved in the short-term and continued investment in on-farm research and extension activity will likely be required.

The financial impact of reducing P losses is less certain, with the case study analysis suggesting the greatest reductions in P losses will come from farms with excessive soil P reserves.

There appeared to still be a gap on many farms associated with best practice as regards minimising P, sediment and micro-organism losses. This was largely associated with the use of watercourses for stock water and grazing practices on steeper country.

In general, farmers appeared willing to make management changes to reduce N, P and sediment losses where the reduction in profitability was nil or minimal. However, where necessary mitigations required capital investment, such as riparian planting and fencing, participant farmers expressed hesitancy in making such investments without the prospect of co-funding [from the Regional Council].

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A NOTE REGARDING THE MODELLING OF PHOSPHORUS, SEDIMENT AND MICROBIAL ORGANISMS

In line with the provided terms of reference for this study, Overseer™ v6.1.3 was used to model both nitrogen losses and phosphorus loss risk associated with the case study farms, while the Visual Soil Assessment Tool (Second Edition) was used, along with Overseer™ P loss risk estimates, as a proxy for risk for losses of sediment and microbial organisms to water.

It is important to note the potential importance of hydrological connectivity as regards overland movement of soil particles in water and accordingly the limitations of the methodology utilised for assessing P, sediment and microbial losses to water.

Ballance Agri-Nutrients is developing a GIS-based water quality decision support tool that links with OVERSEER® to refine the latter models output known as 'MitAgator', It is intended that MitAgator will provide greater insight into the spatial variability of nutrients (as well as sediment and microbial) loss within a farm landscape (Stafford & Peyroux, 2013) and accordingly identify the critical source areas for these pollutants within the farm landscape.

Such a tool may have the potential to greatly improve the accuracy of estimating the risk of phosphorus, sediment and microbial loss to water and, more critically, how these can best be mitigated. However, this tool was not available for use in the current study.

A NOTE REGARDING CROPPING MODELS IN OVERSEER VERSION 6.1.3

The 'Best Practice Data Input Standards' guideline for Overseer 6 have been used in modelling the case study farms in Overseer 6.1.3. As specified in the guidelines the 'Fodder Crop' rotation has been used for all fodder cropping except where;

- The fodder crop is greater than 25% of the blocks or the blocks that it rotates through,
- The fodder crop rotations are not completed within a single assessment year,
- The same paddocks are used continuously for the fodder crop.
- In these instances a separate 'Crop' block is to be set up within the model.

The above guidelines have resulted in significant differences in nitrate leaching from maize cropping between case studies where a 'Fodder Crop' rotation has been used (Case study B) compared to where a separate 'Crop' block has been modelled (Case studies G and I). These differences are largely due to the assumed mineral N levels in the soil resulting from the previous year's activity i.e. maize coming out of perennial pasture results in high levels of mineralised N in the soil available for plant use or leaching.

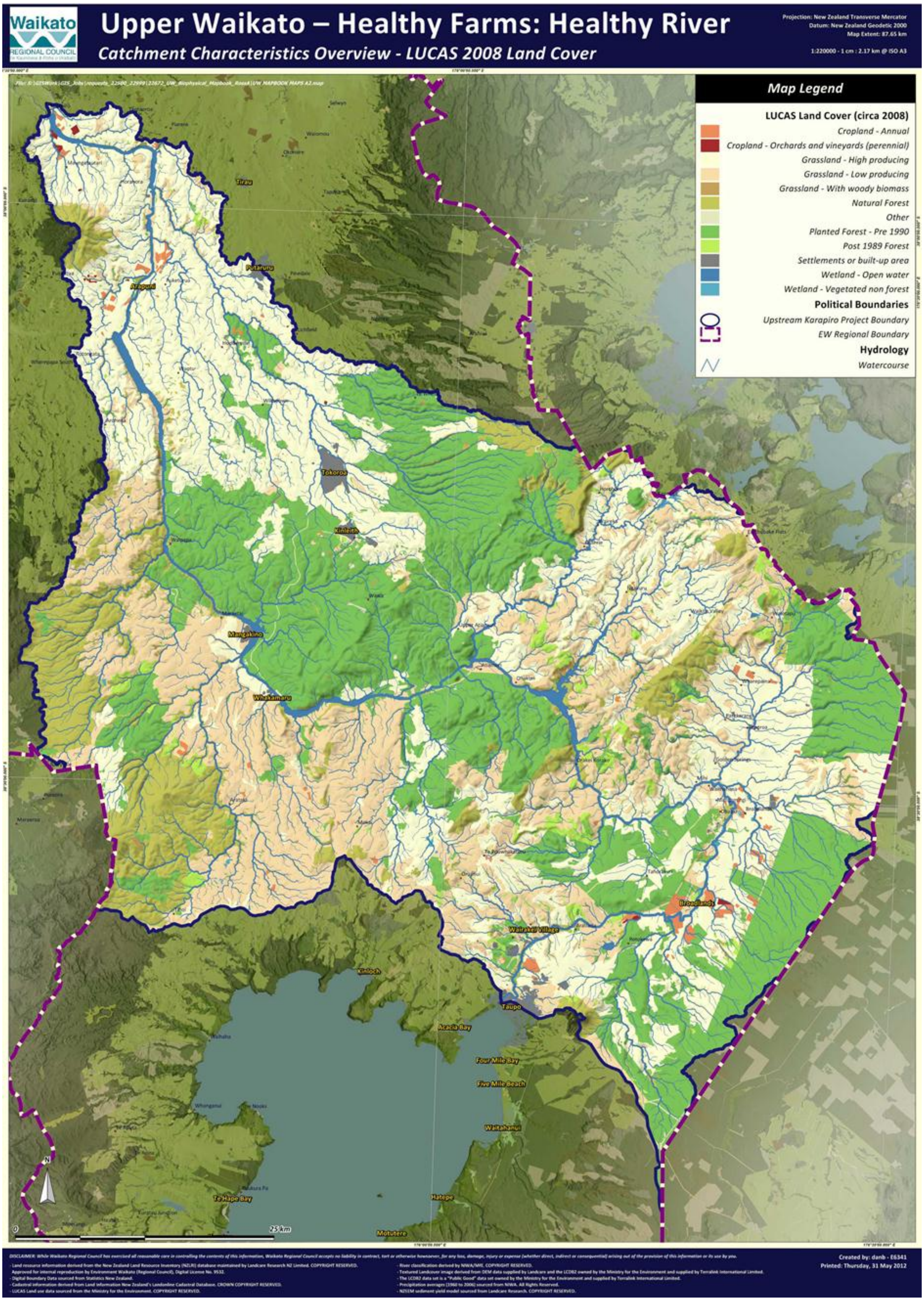

Figure 1: Map of the Upper Waikato catchment

1. Background and Terms of Reference

1.1. Dairy support is a significant land use in the Upper Waikato catchment ("the catchment") and is an essential component of both the dairy and drystock industries. The increase in dairying in New Zealand in recent years has resulted in greater interrelationship developing between dairying and traditional sheep & cattle (drystock) farming. The dairy industry is a significant source of both male and female cattle for beef finishing systems (Friesian and Friesian x cattle), while the drystock sector increasing relies on revenues derived from the dairy industry through the provision of bulls for mating, supplementary forages (grass and maize silage) and grazing both replacement dairy heifers from weaning through to entry into a dairy herd and non-lactating ("dry") dairy cows over the winter period as an alternative to these stock remaining on the milking area. The latter grazing activities comprise what most farmers would recognise as "dairy support".

1.2. However there has been little work carried out to understand the environmental footprint and how the impact of dairy support can be mitigated.

1.3. As a result, the Waikato Regional Council ("WRC") established an industry working group to provide input into the scope, design and structure of a study designed to:

(i) Gain a better understanding of the effects of dairy support in its various forms and the possible N and P reductions achievable;

(ii) Quantify sediment and microorganism losses from field observations and literature, and describe available mitigations;

(iii) Give both WRC staff and other stakeholders the tools and knowledge to advise farmers involved in dairy support on how to reduce their environmental footprint in the most economically viable way.

(iv) Advise the plan change project on practical mitigation options.

(v) Identify any other research and/or actions (including ongoing liaison work) that may be required as identified from the results of this study.

1.4. It was anticipated that the outcomes of the study could potentially be included in the MENUs as a future update – or be included in a new separate Dairy Support MENU.

1.5. The WRC was also keen to explore how resilient these dairy support systems are to adverse events or to farming within limits, and the effect of mitigations on the financial bottom line of dairy support.

1.6. The WRC engaged Perrin Ag Consultants Ltd ("PAC") to undertake the study in July 2014, with the finalised terms of reference requiring PAC to:

(i) To identify the base level of nitrogen leaching, phosphorus runoff and sediment and microorganism losses from dairy support farms/dairy support blocks in the Upper Waikato.

(ii) To identify mitigations that will reduce the environmental footprint from dairy support units – specifically nitrogen, phosphorus, sediment, and microbial impacts on water quality; and

(iii) To identify the possible on-farm mitigations to reduce nitrogen, phosphorus, sediment and microbe losses, and to quantify the financial cost of implementing those mitigations.

1.7. The analysis was to be derived from a range of real case study farms considered to be representative of businesses undertaking dairy support activity in the catchment

2. METHODOLOGY

2.1. The analysis was governed by methodology outlined by the WRC in the Request for Quote documents (“RFQ”).

2.2. Ten real pastoral dairy support systems were analysed to provide a broad cross-section of dairy support activity in the catchment. These were to comprise two types of dairy support activity (heifer grazing and wintering of dairy cows) with a mix of feeding regimes across the two main soil types found in the catchment.

2.3. In addition a further analysis of a cropping farm that grows maize from spring to autumn, sows an annual ryegrass for heifer grazing in winter and then puts the area back into maize the following spring was also completed.

2.4. In total, eleven case studies, identified as A through K, were analysed. These have been characterised by way of the case study parameters as presented in Table 1 below. In the end, a dairy cow wintering system on allophanic soils where cows were fed solely on silage and crop was not able to be identified, but two case studies where a maize silage cropping system as specified in the RFQ was in place were analysed.

Table 1: Allocation of case studies to representative system parameters

Dairy support system		Soil type: *Pumice*	Soil type: *Allophanic*
MA winter cow grazing			
	Predominantly pasture based feed	E	J
	Pasture / cropping based feed	A	H
	Predominantly supplements based feed	F	
Dairy heifer replacement grazing			
	Predominantly pasture based feed	C	K
	Pasture / cropping based feed	D	G
Maize cropping		B	I

2.5. Case studies were identified through the author's professional network, with some assistance from the WRC. All of the farm case studies were either fully or partially located within the Upper Waikato catchment.

2.6. All of the participant farms had an initial field inspection and interview in September, at which time baseline data was obtained to develop representative status quo models of the farming systems in FarmaxPro and Overseer™ 6.1.3 and to obtain qualitative data on sediment and microbial losses. Overseer™ data entry was completed in accordance with the prescribed Data Input Standards for Overseer™. The Visual Soil Assessment tool (Second Edition) was used as part of the qualitative assessment for sediment and microbial losses to water.

2.7. FarmaxPro was used to provide both physical and standardised financial outputs. The profit forecasting functionality within FarmaxPro was utilised to estimate the annual operating profit, as measured by earnings before interest and tax ("EBIT")[1], generated from each of these systems. The financial analysis was conducted on the basis of an "arm's length" basis to ensure that case study farms that may in reality be operated as a fully integrated component of a larger farming enterprise, could be accurately compared with stand-alone businesses. Medium term pricing expectations were used for used for forecasting income, while operating expenses were based on representative industry averages (Beef + Lamb New Zealand Economic Service 2013), moderated for locality specific variance and assuming a true market value for all labour and management.

2.8. Quantities of all key marginal inputs (feed, labour, N usage, freight, shearing, dairy expenses, animal health) were automatically varied appropriately according to the individual scenario, while maintenance fertiliser reflected the realistic levels of nutrients required to support the modelled stocking rate and/or pasture harvest, balanced for imported and exported nutrients in feed. Fixed costs and overheads were typically calculated on modelled farm area or stock numbers as appropriate.

2.9. In line with the RFQ, the analysis made no provision for the likely balance sheet/capital impacts that the system changes might incur, nor did it consider what changes in EBIT might mean as regards net profit after tax ("NPAT") and discretionary cashflow.

2.10. Overseer™ 6.1.3 outputs were able to be directly used to provide estimates of annual pastoral N & P losses from the farm systems.

[1] EBIT = revenue less operating expenses adjusted for changes in livestock numbers and values and depreciation

2.11. Once baseline farm models had been developed, a standardised sequential N loss mitigation protocol[2] specifically for dairy support operations was applied iteratively to each of the case studies until targeted reductions in annual N losses to water (as assessed in Overseer™ 6.1.3) of firstly 10 percent (Scenario 1) and then 20 percent (Scenario 2) from current/baseline losses were achieved. In the 10% reduction scenario, it was adjudged after preliminary modelling and farmer feedback that three of the eleven farms were configured such that it made practical sense to directly target a 20% reduction in annual N loss, so no 10% scenario was analysed.

2.12. For the purposes of modelling efficiency, N losses of +/- 3% were around the percentage target were accepted for individual case studies if ongoing iteration required to precisely achieve the target was considered to require impractical change on farm or add little value to the analysis. In the end an average per farm reduction of 11% and 20% were achieved through the modelling process for Scenarios 1 & 2 respectively.

2.13. The application of this basic mitigation protocol framework, which developed over the course of the study, ended up varying depending on whether the case study was either a run-off operated by a dairy farmer or a stand-alone enterprise, often mixed with other livestock classes, which relied on contracted dairy support activities as a revenue stream (see 5.13). The protocol is summarised in Table 2 below.

Table 2: N loss mitigation protocol for dairy support

Primary mitigation steps	On-farm implementation	
	Owned run-off	Stand-alone
1. Reduce unprofitable N fertiliser use	Replace N grown feed with imported supplements	Reduction of least “profitable” cattle enterprise
2. Eliminate cropping activity	Replace crop grown feed with imported supplements	Reduction of least “profitable” cattle enterprise
3. Lower stocking rate	Eliminate calf (4-10 months of age) grazing, sell surplus feed	Reduction of least “profitable” cattle enterprise, sell surplus feed
	Reduction in most “leaky” cattle enterprise, sell surplus feed	

2 This was adapted from an earlier drystock mitigation protocol developed by a Bay of Plenty Regional Council convened industry working group for the purposes of assessing N loss mitigation efficacy within the Rotorua catchment.

2.14. Construction of wintering facilities were not modelled in this analysis due to the high capital outlay required and large reduction in EBIT per kg of N loss reduction achieved evident where wintering facilities have been modelled in similar studies. The 'Upper Waikato Drystock Nutrient Study, 2013' found that installing a wintering facility on a dairy support operation in the Taupo-Ohakuri catchment resulted in a reduction in EBIT of ($113)/ha which equated to a reduction in EBIT of ($48.18)/kg N loss reduction achieved. This reduction in EBIT/kg N loss reduced is far greater than any N loss mitigation modelled in this study therefore suggesting wintering facilities are predominantly inefficient mitigations for reducing N loss in dairy support systems.

2.15. In all situations, the modelled scenarios provided for NO productivity gains or improvement in individual farm management ability. In general, this was managed in the modelling process through:

(i) Maintaining consistency in animal live weight profiles and levels of reproductive performance from baseline;

(ii) Consistency between scenarios in the shape of the pasture cover curve during the year, except where the adoption of different livestock policies with differing seasonal intake profiles would result in a change

2.16. A follow-up visit with each participant farm was then undertaken in early November to discuss the ease or difficulty of implementing the suggested mitigation scenarios. As a result of this feedback process, a final mitigation scenario for each stepwise reduction in N loss was confirmed with the farmer and used in the final analysis

2.17. The financial impact of suggested mitigations for reducing losses of P, sediment and microbes from the dairy support case studies was also developed.

2.18. Provisional findings were presented to dairy support working group in mid-November with subsequent feedback incorporated or addressed in the final report.

3. THE CASE STUDIES

3.1. The eleven case studies comprised six operations on pumice soils (A through F) and five operating on allophanic soils (G through K). The base physical and financial indicators for the properties are summarised in **Table** 3 below.

3.2. While case studies indicators have been presented on a per ha or % basis only to protect the anonymity of participants, the average effective area of the case study farms was 277ha, ranging from 21ha to 902ha in size.

3.3. Six of the case studies were owned/leased run-offs directly associated with dairy farm enterprises in the Upper Waikato, while the remaining 5 farms were operated as stand-alone dry stock enterprises.

3.4. Six of the operations incorporated livestock classes other than grazing dairy cattle within their existing policy mix. On average, 77% of all livestock carried[3] represented dairy support classes (heifer calves, yearling heifers and winter grazed cows). This varied from as little as 5%, in Case Study H, to 100%, in Case Studies C, D, F, I & J.

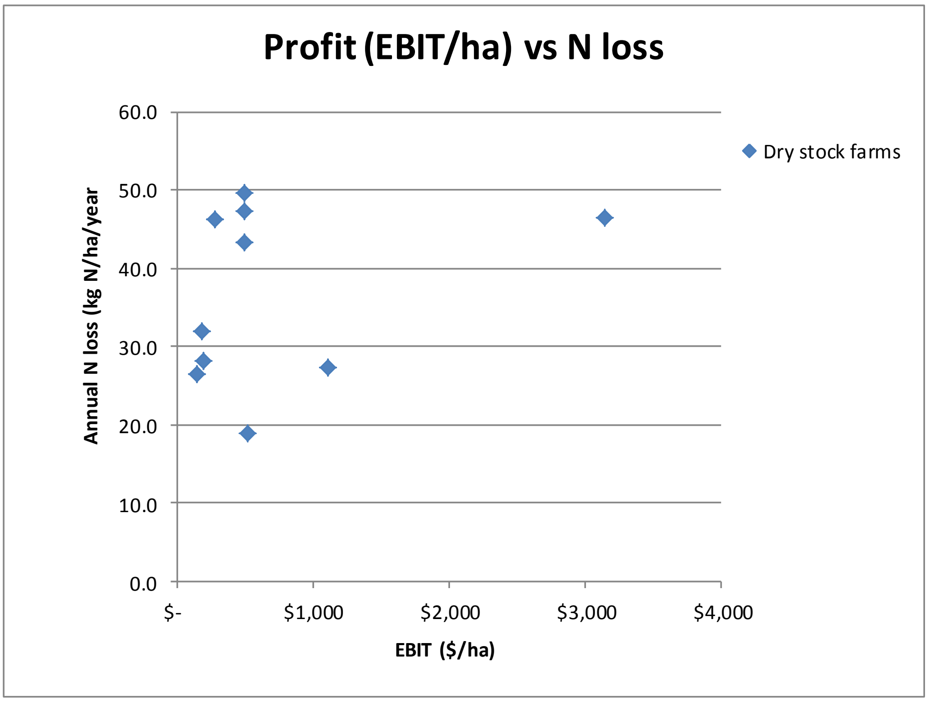

Figure 2: Relationship between status quo annual N losses (kg N/ha) and EBIT ($/ha) in the case study group

[3] Based on annual feed intake

3.5. All but two of the enterprises utilised a winter crop (representing an average of 7% of effective farm area where used), while N fertiliser applied to pasture ranged from 0kg N/ha/year to 77kg N/ha/year, averaging 45kg N/ha/year where applied.

3.6. Assessed baseline profitability of the dairy support systems ranged from EBIT of $183/ha to $3,147/ha. Weighted for farm size within the case study group, average EBIT was $374/ha. Baseline N losses to water ranged from 17.6kg N/ha/year to 49.4kg N/ha/year. Phosphate losses were assessed as ranging from 0.5k P/ha/year to 3.1kg P/ha/year.

3.7. All of the case studies had visual soil assessment scores sufficiently high in both soil and plant categories to qualify as "good", indicating no significant general risks from soil sediment perspective. Plant and soils scores were largely consistent with one another.

3.8. While the sample size is too small to draw definitive conclusions from any statistical analysis, as can be seen in Figure 2 above, there appears to be no relationship between farm profitability and annual N leaching levels.

3.9. Full details of each of the case study farms are presented in the Appendices.

Table 3: Summary of case study physical and financial indicators

Status quo	Pumice						Allophanic				
	A	B	C	D	E	F	G	H	I	J	K
Pasture harvested (kg DM/ha)	8,796	6,997	11,224	9,832	7,629	8,026	10,180	6,294	11,740	10,594	7,246
Stocking rate (SU/ha) [1]	16.2	12.8	19.9	17.5	14.8	14.6	15.2	12.1	14.2	17.1	13.2
Dairy heifers	79.1%	56.1%	100.0%	100.0%	59.5%	57.8%	63.9%	0.0%	100.0%	77.4%	36.3%
Carryover dairy cows	8.3%	9.2%	0.0%	0.0%	0.0%	14.3%	0.0%	0.0%	0.0%	0.0%	0.0%
Winter dairy cows	6.0%	2.5%	0.0%	0.0%	15.4%	27.9%	1.7%	5.0%	0.0%	22.6%	0.0%
Dairy support sub-total	**93.4%**	**67.8%**	**100.0%**	**100.0%**	**74.9%**	**100.0%**	**65.6%**	**5.0%**	**100.0%**	**100.0%**	**36.3%**
Sheep	0.5%	17.0%	0.0%	0.0%	24.7%	0.0%	4.1%	45.3%	0.0%	0.0%	55.0%
Beef	6.1%	15.2%	0.0%	0.0%	0.4%	0.0%	30.3%	23.5%	0.0%	0.0%	8.7%
Deer	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	26.2%	0.0%	0.0%	0.0%
Net product excl cash crop (kg/ha)	409	301	524	449	346	341	302	252	266	403	293
Liveweight wintered (kg/ha)	974	669	911	716	1266	1839	934	898	1067	1102	925
Winter crop used (% farm area)	8.3%	3.3%	4.6%	10%	3%	22%	3%	5%	0%	0%	2%
Cash crop used (% of farm area)	0.0%	5.5%	0.0%	0%	0%	0%	29%	0%	62%	0%	0%
N applied to pasture (kg/ha/year)	54	0	74	19	65	77	0	7	0	20	0
Supplement purchased (kg DM/ha)	245	0	0	0	98	568	0	0	0	83	0
Supplement harvested (% farm area)	39%	23%	51%	29%	34%	53%	27%	6%	33%	76%	8%
EBIT ($/ha)	$ 496	$ 183	$ 494	$ 497	$ 144	$ 283	$ 1,106	$ 193	$ 3,147	$ 520	$ 334
($/SU)	$ 31	$ 14	$ 25	$ 28	$ 10	$ 19	$ 73	$ 16	$ 222	$ 30	$ 25
($/kg N leached)	$ 10	$ 6	$ 11	$ 11	$ 5	$ 6	$ 41	$ 7	$ 68	$ 28	$ 19
Net product/kg lwt wintered	42%	45%	58%	63%	27%	19%	32%	28%	25%	37%	32%
N conversion efficiency	8%	34%	24%	22%	20%	39%	78%	14%	64%	26%	27%
N loss (kg N/ha/year) [2]	49.4	32.0	43.2	47.3	26.4	45.7	27.2	28.2	46.3	18.8	17.6
% N loss coming from all crops	41%	40%	13%	39%	18%	72%	31%	61%	69%	0%	27%
% N loss coming from winter forage crop	41%	19%	0%	18%	0%	72%	3%	54%	0%	0%	27%
P loss (kg N/ha/year) [2]	3.5	1.2	1.6	1.6	2.7	1.7	1.1	2.3	0.7	0.5	3.6
VSA score SOIL (% of maximum)	79%	77%	95%	76%	79%	80%	74%	83%	80%	100%	78%
VSA score PLANT (% of maximum)	93%	76%	90%	89%	86%	82%	100%	84%	83%	100%	90%

[1] Annualised stock units (6,000 MJ ME pasture intake/annum)

[2] Overseer 6.1.3

4. RESULTS

4.1. Nitrogen

4.1.1. All of the case studies were assessed as being able to achieve both the targeted reductions in annual N losses and continue to operate a dairy support activity.

4.1.2. While the financial impact of the proposed mitigations varied between individual case studies, the majority of case studies were forecast to experience a reduction in operating profitability in achieving the reduction targets. The relationship between changes in profitability and N loss reduction under the 10% and 20% N loss reduction scenarios is summarised in **Figure 3** below.

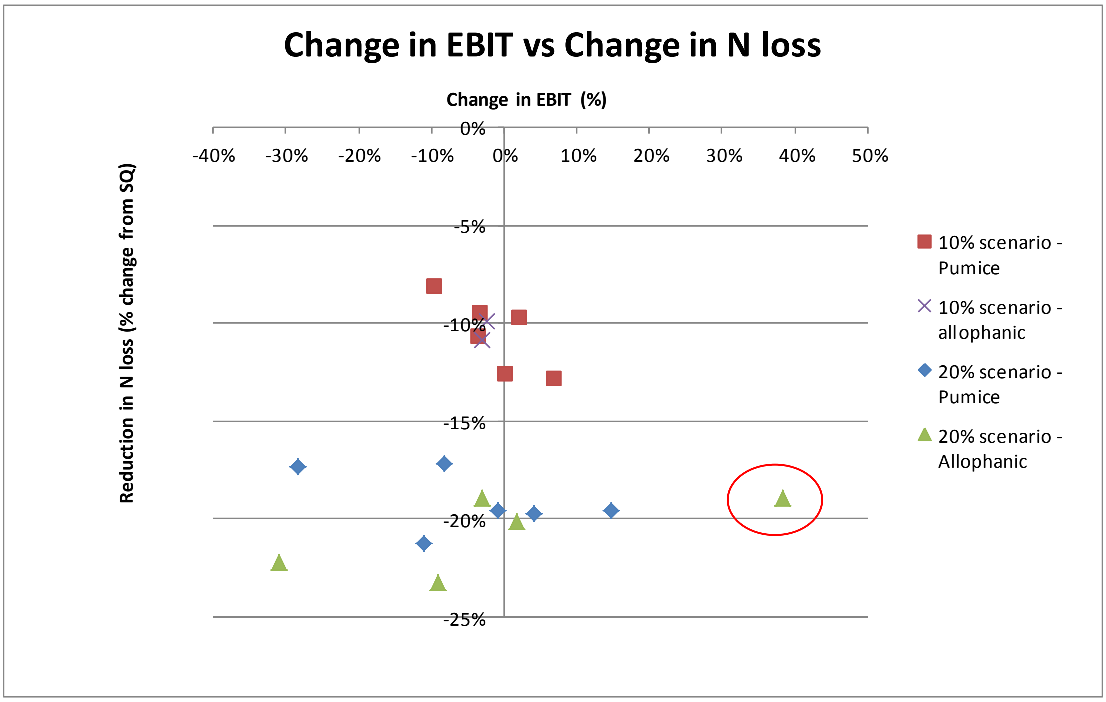

Figure 3: Relationship between change in EBIT and reduction in N losses for 10% and 20% reduction targets

4.1.3. Under the 10% reduction scenario, the change in farm operating profits ranged from a reduction in EBIT of ($27)/ha to a net gain in EBIT of $10/ha. The average change in farm EBIT across the eight case studies where a 10% N loss reduction was modelled was a reduction in EBIT of ($7)/ha. Only three of the eight case studies (25%) were forecast to increase EBIT under this scenario.

4.1.4. This equates to an average loss in annual profitability of ($2.36)/kg N loss reduction achieved.

4.1.5. In meeting this threshold, the area planted in winter crop reduced by an average of 56% across the eight case studies, while total stock numbers reduced by only 1% and fertiliser N applications to pasture reduced by 8%. As a result imported feed use increased by 64% across the 8 case study farms to achieve this threshold. Four of the eleven farms increased the amount of purchased supplement with three case studies increasing PKE and one case study increasing maize silage.

4.1.6. A summary of individual case study output is presented in **Table 4** below.

4.1.7. Under the 20% reduction scenario, the range widened to a loss in EBIT of ($161)/ha to an increase of $423/ha, with the average change per farm an increase in EBIT of $6/ha. Four of the eleven case studies (36%) were forecast to have an increase in EBIT under this scenario.

4.1.8. If the output from Case Study G is removed as an outlier, given the opportunity that it's atypical production system had in meeting the N reduction target with a significant increase in profitability, then the average change in EBIT in achieving a 20% reduction in N loss becomes a reduction of ($21)/ha.

4.1.9. This is equivalent to an average loss in annual profitability of ($3.69)/kg N loss reduction achieved. This higher average "cost" of mitigation in the 20% scenario suggests that more cost-effective mitigations were employed initially, which the mitigation protocol was designed to do.

4.1.10. In meeting the 20% reduction target, the area planted in winter crop reduced further to an average reduction of 65% from current area. Total stock numbers reduced by 10% compared to current levels and where fertiliser N was being applied to pasture, applications to pasture reduced by 35%. As a result imported feed increased by 90%. Four of the eleven farms increased the amount of purchased supplement with 2 case studies increasing PKE, one case study increasing Maize silage and one case study increasing pasture silage bales.

4.1.11. A summary of individual case study output is presented in **Table 5** below.

4.1.12. It is not possible to assess from the limited data set whether there is any difference between the financial impacts of reducing N losses between dairy support properties operating on the different soil types.

4.1.13. As a general rule, across both of the reduction scenarios, the proportion of dairy livestock classes out of the total stock carried remained virtually static, with only two case studies (Case Studies B & G) actually increasing the relative dairy support proportion of their livestock (by 2% and 6% respectively) and one case study (E) reducing the proportion of dairy support livestock on their farm (-3%).

4.1.14. Given no productivity changes were modelled, increases in profitability as a result of mitigation implementation resulted in situations where the case studies had the opportunity to exchange either a less profitable, higher N loss enterprise for a more profitable, more N efficient one, or replace a more expensive, "leakier" feed with a cheaper, "less leaky" feed. Examples of this include:

(i) baling and selling annual ryegrass at a net margin of $0.175/kg harvested in place of maintaining a breeding cow herd at $0.03/kg DM eaten (Case Study G);

(ii) replacing winter forage crops with harvested silage where the crop isn't delivering a net annual DM yield advantage over pasture (Case Studies B, E & I)

4.1.15. We note that with the exception of Case Study G and to a lesser extent Case Study I, such changes delivered only small increases in profitability. These might easily be reduced or eliminated by subtle changes in the assumptions used in the modelling process, such as the cost of baleage harvested and/or the price realised when it's sold, the relative feed quality and utilisation of the crops versus harvested silage or the relativity of labour costs to stock numbers. The converse also applies to those scenarios only forecast to experience small losses in profitability.

Table 4: Summary of case study KPIs under a 10% N loss reduction scenario

10% reduction in N loss	Pumice						Allophanic				
	A	B	C	D	E	F	G	H	I	J	K
Pasture growth (kg DM/ha) incl. N	9,996	8,432	12,620	11,644	8,790	9,822		7,268			8,516
Stocking rate (SU/ha) [1]	15.8	12.7	19.9	17.9	14.6	14.9		12.0			13
Dairy heifers	78.4%	56.2%	100.0%	100.0%	58.6%	57.8%		0.0%			36.3%
Carryover dairy cows	8.6%	9.0%	0.0%	0.0%	0.0%	14.3%		0.0%			0.0%
Winter dairy cows	6.2%	2.5%	0.0%	0.0%	15.8%	27.9%		5.0%			0.0%
Dairy support sub-total	**93.2%**	**67.7%**	**100.0%**	**100.0%**	**74.4%**	**100.0%**		**5.0%**			**36.3%**
Sheep	0.5%	17.1%	0.0%	0.0%	25.2%	0.0%		46.1%			55.0%
Beef	6.3%	15.2%	0.0%	0.0%	0.4%	0.0%		22.3%			8.7%
Deer	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%		26.6%			0.0%
Net product (kg/SQha)	377	304	524	459	324	348		250			294
Liveweight wintered (kg/ha)	938	669	911	732	1260	1876		890			928
Δ winter crop area from Base	-38%	-67%	-100%	-43%	-100%	-24%		-23%			-50%
Cash crop used (% of farm area)	0%	5.5%	0%	0%	0%	0%		0%			0%
N applied to pasture (kg/ha/year)	53	0	70	19	64	54		7			0
Supplement purchased (kg DM/ha)	264	0	200	97	98	843		0			0
Retired area (% farm area)	0.9%	0.1%	0.0%	2.2%	0.5%	1.9%		1%			0%
Supplement harvested (% farm area)	39%	26%	51%	29%	34%	53%		9%			15%
EBIT ($/SQha)	$ 479	$ 187	$ 478	$ 498	$ 154	$ 256		$ 187			$ 326
Δ EBIT from Base	-$ 17	$ 4	-$ 16	$ 1	$ 10	-$ 27		-$ 6			-$ 8
%	-3%	2%	-3%	0%	7%	-10%		-3%			-2%
Weighted average Δ EBIT from Base	-$ 7.2										
N loss (kg N/ha/year)	44.1	28.9	39	41	23	42		25			15.8
Δ N loss from Base	-5	-3	-4	-6	-3	-4		-3			-2
%	-11%	-10%	-10%	-13%	-13%	-8%		-11%			-10%
Weighted average Δ N loss from Base	-3 kg N/ha/year										
Δ EBIT/kg N reduced	-$ 3.22	$ 1.28	-$ 3.88	$ 0.17	$ 2.9	-$ 7.2		-$ 1.96			-$ 4.59
Weighted average Δ EBIT/kg N reduced	-$ 2.36										

[1] Annualised stock units (6,000 MJ ME pasture intake/annum)

[2] Overseer 6.1.3

Table 5: Summary of case study KPIs under a 20% N loss reduction scenario

20% reduction in N loss	**Pumice**						**Allophanic**				
	A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**
Pasture growth (kg DM/ha) incl. N	9,916	8,444	12,058	11,640	8,790	9,809	11,692	7,257	14,018	12,825	8,488
Stocking rate (SU/ha) [1]	15.4	12.3	19.4	17.9	13.2	14.9	13.8	11.9	6.0	16.3	13.3
Dairy heifers	77.9%	58.1%	100.0%	100.0%	54.3%	57.8%	70.1%	0.0%	100.0%	81.1%	36.3%
Carryover dairy cows	8.8%	9.3%	0.0%	0.0%	0.0%	14.3%	0.0%	0.0%	0.0%	0.0%	0.0%
Winter dairy cows	6.4%	2.6%	0.0%	0.0%	17.4%	27.9%	1.9%	5.1%	0.0%	18.9%	0.0%
Dairy support sub-total	**93.1%**	**70.0%**	**100.0%**	**100.0%**	**71.7%**	**100.0%**	**72.0%**	**5.1%**	**100.0%**	**100.0%**	**36.3%**
Sheep	0.5%	17.7%	0.0%	0.0%	27.9%	0.0%	11.0%	46.4%	0.0%	0.0%	55.0%
Beef	6.4%	12.3%	0.0%	0.0%	0.4%	0.0%	17.0%	21.7%	0.0%	0.0%	8.7%
Deer	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	26.8%	0.0%	0.0%	0.0%
Net product (kg/SQha)	377	293	510	459	287	348	314	248	47	348	294
Liveweight wintered (kg/ha)	903	637	884	732	1210	1876	809	883	1067	419	928
Δ winter crop area from Base	-58%	-100%	-100%	-64%	-100%	-24%	0%	-40%	0%	0%	-100%
Cash crop used (% of farm area)	0%	4.9%	0%	0%	0%	0%	29%	0%	62%	0%	0%
N applied to pasture (kg/ha/year)	52	0	0	18	64	54	0	7	0	0	0
Supplement purchased (kg DM/ha)	292	0	0	317	98	1071	0	0	0	83	19
Retired area (% farm area)	1%	0%	0%	2%	1%	1.9%	0%	1%	0%	0%	0%
Supplement harvested (% farm area)	39%	26%	51%	29%	34%	53%	61%	11%	151%	76%	21%
EBIT ($/SQha)	$ 455	$ 210	$ 490	$ 442	$ 150	$ 203	$ 1,529	$ 187	$ 3,199	$ 359	$ 304
Δ EBIT from Base	-$ 41	$ 27	-$ 4	-$ 55	$ 6	-$ 80	$ 423	-$ 6	$ 52	-$ 161	-$ 30
%	-8%	15%	-1%	-11%	4%	-28%	38%	-3%	2%	-31%	-9%
Weighted average Δ EBIT from Base	$ 5.72										
N loss (kg N/ha/year)	40.9	25.7	34.8	37.2	21.2	37.8	22.1	22.8	37.0	14.6	13.5
Δ N loss from Base	-8	-6	-8	-10	-5	-8	-5	-5	-9	-4	-4
%	-17%	-20%	-20%	-21%	-20%	-17%	-19%	-19%	-20%	-22%	-23%
Weighted average Δ N loss from Base	-6 kg N/ha/year										
Δ EBIT/kg N reduced	-$ 4.83	$ 4.31	-$ 0.47	-$ 5.48	$ 1.2	-$10.09	$ 81.94	-$ 1.12	$ 5.57	-$ 38.64	-$ 7.34
Weighted average Δ EBIT/kg N reduced	$ 1.49										

[1] Annualised stock units (6,000 MJ ME pasture intake/annum)

[2] Overseer 6.1.3

4.2. **Phosphorus, sediment and microbes**

4.2.1. While the VSA assessment process indicated low levels of inherent risk of sediment losses from the farms as a result of poor soil structure, management of overland flows were adjudged to have potential for improvement on seven of the eleven case study farms.

4.2.2. The fencing off and subsequent retirement from grazing of riparian margins equivalent to an average of 1% of farm area (range 0.1% to 2.2%) were identified on these seven farm properties to improve sediment capture and associated phosphate and microbe entry into water courses.

4.2.3. One off the eleven farms (Case Study A) was found to have soil Olsen P levels above levels considered suitable for optimising pasture growth and was in a position to lower their "maintenance" phosphate applications.

4.2.4. Eight of the eleven farms also had potential to optimise the application rates and timing of P fertiliser applications, reducing the risks of direct losses to water.

4.2.5. In total, reductions in P losses to water, as estimated by Overseer™, were forecast to be achieved on five of the eleven case studies (when expressed on a per ha basis).

4.2.6. The financial impact (Δ EBIT) of this on the business directly related to the size and productivity of the area retired (loss of feed offset by reduction in fertiliser, weed & pest and land maintenance costs), if any, and whether there was any potential to reduce P fertiliser without compromising pasture growth.

4.2.7. Within the six case studies where reduction in P loss was assessed as achievable, the change in EBIT ranged from an increase of $89/ha to a reduction of ($44)/ha - an average reduction in profit across the six farms of ($0.6)/ha – essentially no impact.

4.2.8. These outputs are summarised in **Table 6** below.

Table 6: Summary of case study KPIs under a the proposed P loss minimiation scenario

Minimise P loss	Pumice						Allophanic				
	A	B	C	D	E	F	G	H	I	J	K
Pasture harvested (kg DM/ha)	8,796	6,997	11,224	9,832	7,629	8,026	10,180	6,294	11,740	10,594	7,246
Stocking rate (SU/ha) [1]	16.2	12.8	19.9	17.5	14.8	14.6	15.2	12.1	14.2	17.1	13.2
Dairy heifers	79%	56%	100%	100%	60%	58%	64%	0%	100%	77%	36%
Carryover dairy cows	8%	9%	0%	0%	0%	14%	0%	0%	0%	0%	0%
Winter dairy cows	6%	3%	0%	0%	15%	28%	2%	5%	0%	23%	0%
Dairy support sub-total	**93%**	**68%**	**100%**	**100%**	**75%**	**100%**	**66%**	**5%**	**100%**	**100%**	**36%**
Sheep	0%	17%	0%	0%	25%	0%	4%	45%	0%	0%	55%
Beef	6%	15%	0%	0%	0%	0%	30%	24%	0%	0%	9%
Deer	0%	0%	0%	0%	0%	0%	0%	26%	0%	0%	0%
Net product (kg/SQha)	409	301	524	449	346	341	302	252	266	403	293
Liveweight wintered (kg/ha)	974	669	911	716	1266	1839	934	898	1067	1102	925
Winter crop used (% farm area)	8.3%	3.3%	4.6%	10.1%	3%	22%	3%	5%	0%	0%	2%
Cash crop used (% of farm area)	0.0%	5.5%	0.0%	0.0%	0%	0%	29%	0%	62%	0%	0%
N applied to pasture (kg/ha/year)	54	0	74	19	65	77	0	7	0	20	0
Retired area (% farm area)	0.9%	0.1%		2.2%	0.5%	1.9%		0.6%			0.3%
Supplement purchased (kg DM/ha)	310	0	0	145	137	714	0	30	0	83	17
Supplement harvested (% farm area)	39%	23%	51%	29%	34%	53%	27%	6%	33%	76%	8%
EBIT ($/SQha)	$ 585	$ 183	$ 494	$ 454	$ 132	$ 239	$ 1,106	$ 184	$ 3,147	$ 520	$ 329
Δ EBIT from Base	$ 89			-$ 43	-$ 12	-$ 44		-$ 9			-$ 5
%	17.9%	0.0%	0.0%	-8.6%	-8.1%	-15.5%	0.0%	-4.6%	0.0%	0.0%	-1.5%
Weighted average Δ EBIT from Base	-$ 0.6										
P loss (kg P/ha/year)	2.5	1.2	1.6	1.6	2.7	1.6	0.9	2.1	0.7	0.5	3.1
Δ P loss from Base	-1.0				-0.1	-0.1	-0.2	-0.2			-0.5
%	-28%	0%	0%	0%	-2%	-6%	-15%	-10%	0%	-8%	-14%
Weighted average Δ P loss from Base	-0.3 kg P/ha/year										
Δ EBIT/kg P reduced	$ 92				-$ 205	-$ 463	$ -	-$ 40			-$ 10

[1] Annualised stock units (6,000 MJ ME pasture intake/annum)

[2] Overseer 6.1.3

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5. DISCUSSION

5.1. The results of the scenario analysis completed for this study are largely consistent with the findings in a number of other studies[4] looking at pastoral N (and to a lesser extent P) losses on pumice and allophanic soils in the wider regions in that there is likely to be a wide range of financial outcomes on individual farm systems when targeting N loss reductions.

5.2. In this analysis, a majority of the case studies analysed were forecast to experience a loss of profitability in meeting these N loss targets.

5.3. Where either small increases or small decreases in profitability associated with mitigations have been forecasted for properties (≈ +/- $10 EBIT/ha), we suggest this is more appropriately interpreted as indicting that such N loss reductions might be implemented with little impact on these operations' individual farm financial performance, rather than suggesting an inherently more or less profitable farm system will result.

5.4. On this basis, it would still appear reasonable to suggest that dairy support operations will experience an overall loss in profitability in achieving the 20% N reduction targets modelled, but the financial impact on achieving a 10% reduction will be negligible.

5.5. Reducing the use of grazed winter forage cropping appears to have the greatest impact on N losses from the analysed dairy support systems. After removing the potentially confounding effect on N losses from farms in the sample group that grow maize silage, there appears to be a strong relationship between the amount of grazed winter cropping undertaken and whole farm N losses to water (**Figure** 4). This is supported by analysis presented in **Table** 3**: Summary of case study physical and financial indicators** above, with winter forage crop activity responsible for an average of 32% of total farm system N losses, across the sample group of farms.

5.6. Research by Lucci *et al* (2013) assessed that the major risk of N losses associated with winter forage crops was associated with the risk of redistribution of N in the crop via the urine returned to the soil via grazing animals. Their research on crop establishment on pumice soils demonstrated no loss of yields associated with direct drilling compared with conventional cultivation (which would typically be expected to lead to greater mineralisation) and the potential for forage brassicas to remove high levels of mineral N

[4] Upper Waikato Nutrient Efficiency Study (AgFirst 2009), Farmer Solutions Project (Perrin Ag 2012), Upper Waikato Drystock Nutrient Study (Perrin Ag 2013), NDA Impact Analysis (Perrin Ag 2014)

from the soil during growth. Their research also suggested that total DM yields did not increase with fertiliser N applications in excess of 200kg N/ha.

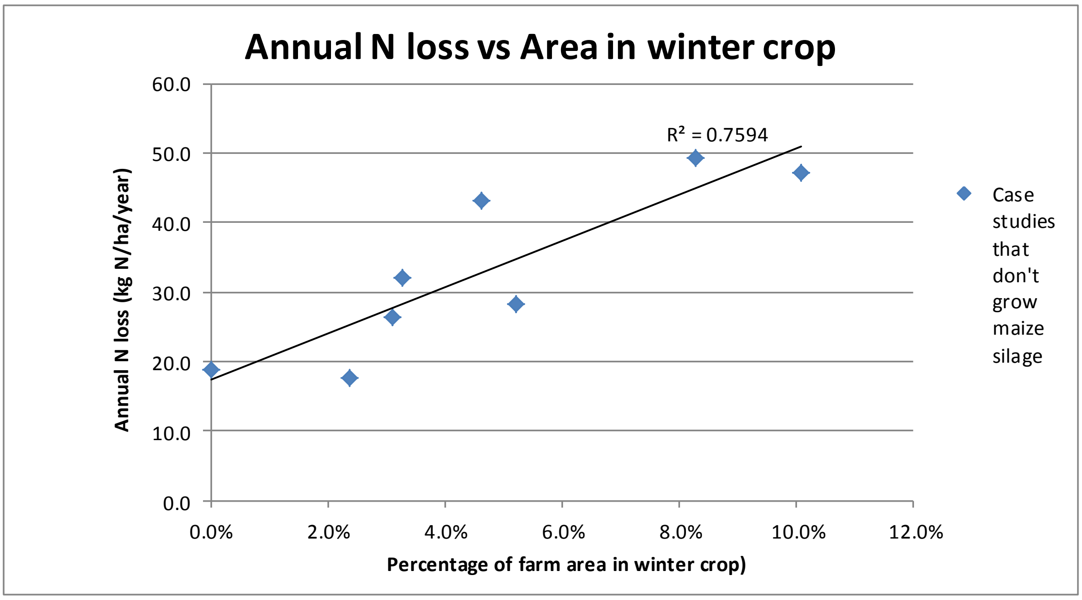

Figure 4: Relationship between annual N losses and grazed winter forage cropping

5.7. On this basis, techniques for harvesting winter forage brassica without the need for grazing *in situ* would likely have a significant impact on reducing the nitrogen losses associated with traditional winter forage brassica management techniques. However, the economic and management implications for the cut & carry of forage brassica has not been significantly investigated in a NZ context. The lifting of fodder beet for winter feed is occurring to a limited extent in some areas of NZ, but the cost of this activity appears to be significant, with the authors understanding lifting beet adds in the vicinity of $0.10/kg DM to the cost of the forage.

5.8. Additional research by Carlson *et al* (2013) also indicated the N losses from grazed winter forage brassicas might be reduced through later season (i.e. late July), rather than earlier season grazing (June), further complemented by ensuring the subsequent crop had the potential to uptake significant amounts of mineral N still in the soil.

5.9. Where cropping of areas previously in developed ryegrass pastures has been removed from a system, the equivalent area of re-grassing (grass to grass) is assumed to continue in the 10% and 20% scenario models.

5.10. Where cropping has also been utilised as a method of eliminating browntop and native grasses, any reduction in these cropping areas not only result in the scenario models continuing with the same re-grassing area (grass to grass) but also results in a lower pasture production curve in the scenario models due to a faster reversion back to native grasses without the cropping rotation.

5.11. The use of dicyandiamide (DCD) as a means to limit N losses from grazed winter forage crops was demonstrated by Shepherd *et al* (2012), but due to the presence of DCD found in milk products in 2013, this product is not currently available for use in NZ farming systems.

5.12. Given the overall productivity of many of the farms in the case study, the reduction or removal of grazed winter crop areas, as modelled, appeared to be possible in many cases with only limited negative financial cost. Participant farmers tended to respond less negatively to the apparent need to reduce winter cropping area than was expected. However, the fact that winter cropping was so widely utilised within the sample group, predominantly for grazing wintered R2 heifers or mixed-aged dairy cows, suggests that its perceived importance to these farm systems is inadequately captured by the scenario modelling. In situations where the financial benefit from cropping appears to be low or non-existent, we suggest some of the following reasons for its continued use within the farm system:

(i) Risk management: the use of winter crop to shift feed supply into winter deficit periods is likely to be perceived as less risky than relying on (a) "normal" spring and early summer weather conditions to deliver sufficient surplus for harvest and subsequent feeding out and (b) "normal" autumn climate to provide the flush necessary to build sufficient grass covers for wintering on.

(ii) Convenience: having bulk winter feed in a concentrated area of the farm tends to improve the ease of farm management (as regards stock movement, grazing rotations etc) in autumn, compared with challenges of creating large banks of autumn saved pasture.

(iii) Regrassing: while we have separated post-harvest regrassing costs from the financial impact of winter cropping on the basis that most famers would/should regrass irrespective, the reality is that in many areas, cropping is seen as a way of extracting greater value from the need to cultivate and/or undertake multiple desiccations as part of the regrassing program. In areas of browntop dominant pasture, cropping is seen as a necessary component of any regrassing strategy as a means to destroy browntop thatch, exhaust/minimise the seed bank and improve contour to facilitate silage harvest.

5.13. The long-term impact of reducing winter forage cropping areas on pasture renewal is uncertain. Given that it is the redistribution of N in grazed forage through urine deposition that is responsible for the high N losses from winter forage cropping, rather than the cropping activity in of itself, alternative cropping strategies may be possible to facilitate pasture renewal in where grass to grass renewal is not deemed feasible. Cereal crops sown in late winter with high potential for mineral N uptake and subsequent harvest for silage in mid-summer could help provide the desired break between older pastures and new sowings, as could alternative multi-graze deep-rooted pastoral forages such as plantain or chicory. Fodder beet subsequently lifted for winter feed may also be a viable option where dairy cows could be successfully wintered at home whilst successfully capturing winter urine i.e. in housing or on wintering pads.

5.14. N leaching from grazed winter forage crops in Overseer™ 6.1.3 is highly sensitive to N applications, with reductions in fertiliser N having a significant impact on crop-related N losses. Reviews of the N pool graphs[5] for grazed forage crops in Overseer™ demonstrate that the model simply assumes that sufficient mineral N is present in the soil to meet a crop yield as input, so applications of fertiliser N will lead to increased N losses from any subsequent grazing of the crop relative to one of similar yield that received no fertiliser N. However, given forage brassicas are highly responsive to N fertiliser application (de Ruiter *et al* 2009), the significant withholding of N applications may lead to reductions in yield if mineral N in the soil is insufficient to meet crop demands and is unlikely to be a practical reality. Given the cost of establishing forage brassicas is relatively high, farmers may be unwilling to sacrifice yield and increase the average c/kg DM cost of feed in order to reduce N loss. However, it makes sense for farmers to optimise fertiliser N usage, applying only as little is as necessary to achieve optimal yields and looking to take advantage of any existing soil mineral N first.

5.15. Where winter forage crop activity is deemed necessary in the farm system, the following measures are likely to lead to reduced N losses from their continued use, albeit these may not all be fully reflective in current Overseer™ modelling:

(i) crop establishment via direct drilling versus conventional cultivation;

(ii) restrict N applications to ≤200kg N/ha for forage brassicas and apply in a single application

(iii) delaying grazing of winter forage to later in the winter period;

(iv) use of “cut & carry” (if possible) in lieu of grazing; and

[5] Located in Forage Crop block reports in Overseer™ 6.1.3

(v) following crop with a subsequent crop or pasture capable of high rates of mineral N uptake.

5.16. As a result of the follow-up meetings with farmers after the initial mitigation modelling had been completed, a clear distinction emerged between those farms that were operating as a dairy farm run-off and those that weren't, as regards adjusting the farm system in response to implementing N loss mitigations.

5.17. Where grazing dairy stock were owned by the land owner (i.e. in a run-off situation) there was a clear preference to replace any reductions in feed supply associated with removing forage crop or nitrogen fertiliser with imported feed, rather than destocking and contract grazing the stock elsewhere. This is despite the fact that contacted grazing would have been both a more cost-effective means to manage the feed deficit and would have lowered N losses further. In the event that access to this imported feed was unavailable, we expect farmers would initially look to destock and bring stock back to the milking platform, despite the increased financial impact of doing so.

5.18. Such a position is understandable given the high value that many dairy farmers place on the capacity to retain control of their heifer replacements after variable and often negative experiences with contract grazing – we would suggest that such experiences will often be a significant contributing factor to any decision to buy or lease a run-off. However, this outcome potentially overstates the potential marginal cost of N reduction in these systems, but reflects farmer reality.

5.19. Where destocking appeared to be an absolute necessity to meet N loss targets, run-off case studies were prepared to consider reducing numbers of dairy heifer calves (those aged between 4 and 10 months). This decision potentially reflects a view that if required such animals could be managed back on the milking platform or on third-party properties. Of course, this eventuality would simply see an effective transfer of N losses back to dairy farms from drystock properties, rather than achieve a net reduction in N loss from within the catchment.

5.20. In contrast, farmers grazing contracted heifers were more willing to destock in relation to reductions in feed supply associated with mitigating N losses, although where other less profitable stock classes existed there was a clear preference to prioritise stock reductions from these animals.

5.21. While the majority of case studies analysed were assessed as delivering a reduction profitability in achieving a 20% reduction in N loss based on their pre-existing level of management skill and productivity levels, it is likely than within many farming systems, there exists potential for productivity gains to offset financial losses from mitigation activity.

5.22. A subsequent scenario was developed for Case Study K, a mixed enterprise dairy support property on allophanic soils, to demonstrate this. While the initial modelling forecast a 9% loss in profitability of ($30)/ha in achieving the 20% reduction in N loss, "optimising" farm performance actually resulted in a 24% reduction in N loss while actually improving baseline profitability of $334/ha by 14% to $381/ha.

5.23. This improvement in both operating performance and N loss reduction was essentially achieved through improved system productivity – in this case improving ewe reproductive performance, reducing ewe numbers and improved grass utilisation through an increased silage harvest. While we have assessed achieving the proposed management changes as being challenging for the case study farmer concerned, the levels of productivity proposed (135% lambing, mating ewe hoggets) would not be unrealistic in the context of the industry. The impact of productivity improvements in underperforming solely dairy cattle grazing businesses have not been assessed in this study, but positive financial benefits in the face of necessity to reduce N losses might be possible where heifer grazing revenue was based on live weight gain ("LWG") rather than simply a time-based grazing fee.

5.24. However, as the author has previously observed (Perrin Ag, 2014), the level of farming efficiency and/or profitability can be expected to follow a normal distribution. Hence there will always be below-average and above-average farmers. The notion that below-average farmers can somehow become average or above-average farmers is therefore somewhat simplistic.

5.25. While the example above, along with previous analysis by the author and others (AgFirst 2009, Dewes 2012), clearly demonstrate the potential that improving productivity can have on minimising or eliminating the negative financial implications of lowering N losses from pastoral farming systems in New Zealand, the level of farming performance is influenced by a range of drivers including business and personal goals, as well as management skills. Whilst the former might be influenced by regulation, it is not a simple task to lift inherent farm management skills, even with a significant incentive such as a likely loss of profitability in the event no positive improvement is achieved.

5.26. Lifting farm performance has been the focus of extension activity in New Zealand's primary industries for most of its history. Given the increasing importance of lowering farm environmental footprint and the typical accompanying negative impact on farm profitability, prioritising research into identifying profitable farm system changes associated with lowered environmental impact will be critical for the pastoral sector if it is to continue to underpin the NZ economy.

5.27. As regards the assessed risk of losses of phosphorus, sediment and micro-organisms from the case study farms, qualitative assessment conducted out on farm suggested there is still some way to go as regards attainment of best practice actions amongst farmers.

5.28. While many of the farms concerned had taken significant steps to retire land from grazing in conjunction with WRC or its predecessor organisations and all of the farms scored highly in the VSA analysis, over half of the eleven case study properties were identified as still being able to further improve on-farm actions to reduce the risk of soil loss and those associated pollutants to the watershed. These improvements primarily related to:

(i) restricting stock access to water courses still used for stock water;

(ii) restricting cattle grazing on steeper sidlings;

5.29. It is important to note that half of the case study farms had soil Olsen P levels that were actually declining in the face of decisions to limit fertiliser phosphorus application. None of the farms had soil P levels that we would consider to be substantially below those levels, if at all, considered as the agronomic optimum given their enterprise mix[6]. However, were financial returns to significantly increase and increasing Olsen P levels was deemed to be cost effective, the risks of P loss as assessed in Overseer™ would be expected to increase as soil P levels lifted.

[6] Journeaux *et al* (2013) suggests soil Olsen P levels around 18ppm on hill country properties to be optimal given current cost:price relationships. Given that the case study farms had a higher average EBIT/ha ($374/ha) than the B+LNZ Economic service data for hill country properties used by Journeaux *et al*, optimal Olsen P levels will likely be higher than this level for the case study farms.

6. CONCLUSIONS AND RECOMMENDATIONS

6.1. It seems likely that reductions in current N losses from dairy support operations in the Upper Waikato in the order of 10% might be achieved with minimal economic disruption, given the tight range of financial outcomes and essentially nil average cost modelled in the case study farms in meeting this target.

6.2. However, it appears likely that dairy support operations in the Upper Waikato will experience an overall loss in profitability in achieving N loss reduction targets in excess of 10% of current losses , as captured in the 20% N loss reduction scenario, although the impact on individual farm businesses will vary considerably. Improvement in farm productivity may hold the key to many farms meeting potential N loss reduction targets without significant negative financial impact, but these improvements will not easily be achieved in the short-term and continued investment in on-farm research and extension activity will likely be required.

6.3. It is important to note this analysis has been completed at an individual farmer level and any cumulative effects on the catchment would require further catchment level analysis.

6.4. The financial impact of reducing P losses is less certain, with the case study analysis suggesting the greatest reductions in P losses will come from farms with excessive soil P reserves.

6.5. Sediment and associated microbial losses to water within the studied farms would appear to be low based on visual soil assessment analysis, but seven of the farm properties had either riparian areas identified where direct stock exclusion was still required, or erosion prone areas adjacent to fenced riparian margins that would benefit from retirement.

6.6. In general, farmers appeared willing to make management changes to reduce N, P and sediment losses where the reduction in profitability was nil or minimal. However, where necessary mitigations required capital investment, such as riparian planting and fencing, participant farmers expressed hesitancy in making such investments without the prospect of co-funding [from the Regional Council].

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APPENDIX 1: CASE STUDY A - PUMICE DAIRY HEIFER GRAZING

1.1 Base Model for Case Study A

1.1.1 Description of operation

- Case study A has a mixture of owned plus external dairy heifer replacements and dairy winter cow grazers. There is also a small flock of sheep and a few beef animals run on the property.
- Heifer calves arrive on the support block as 100kg weaners in mid-December. Owned heifers are taken through to 23 months of age before leaving the support block at the end of the June. External heifers are returned from March through to May as in calf rising 2 year heifers.
- A total of 8% of the effective farm area is used for winter cropping with a further 39% of the effective area harvested for pasture silage.
- Bought in supplement (PKE) totals 245kg DM/ha which equates to 15.1kg DM/stock unit.
- Nitrogen fertiliser is applied at 15kg N/ha over the effective area, predominantly in August. A further 30kg N/ha is applied to the majority of the farm in March/April.
- Phosphate fertiliser is applied at 53kg P/ha over the effective area in August and October.

1.1.2 Climate and contour

- The rainfall average for this property is 1,605mm per annum.
- This farm is predominantly rolling contour with a small amount of steeper area composed of ignimbrite, so not heavily vegetated, or grazed.
- Approximately 60ha of steeper area has already been retired. This protects a significant water way and many of its tributaries.
- There appear to be no major erosion concerns.
- There are some significant spring heads and damp depressions that the farmer is willing to fence off to exclude stock. The retired area will total 2.5ha with approximately 2.3km of 7 wire post and batten fencing.

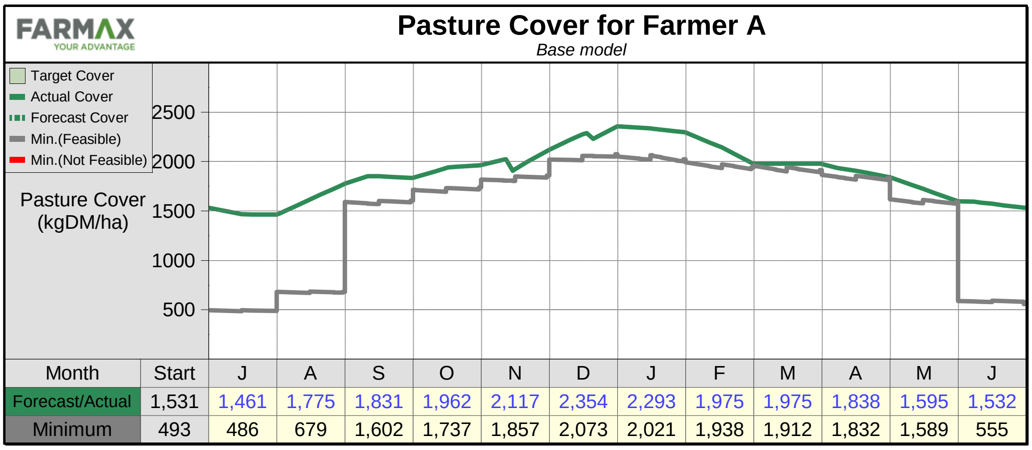
1.1.3 Soil

- Soils on the property are predominantly Taupo sandy loam. Its soil description from the S-Map data is Taupo_23a.1, and recommendation is to use ‘Sandy Loam’ for the soil texture in Overseer™ inputs.
- Average Olsen P levels over the farm are estimated at 41. The farm nutrient budget indicates an increase in inorganic P levels in the soil of between 23kg P/ha/yr which equates to an increase in Olsen P of approximately 3 units per year.
- Visual soil assessments (VSA) were completed on a recently regrassed paddock and another that had been set-stocked through the winter period. Soil quality was rated either poor (<10), moderate (10-20) or good (>20).
- Results for the soil indicators totalled 22/28 for both areas. The plant indicators totalled 28/30 and 29/30 for the set-stocked and regrassed areas respectively.
- With all indicators rating ‘good’ in the VSA assessments this suggests that there is a minimal sediment runoff risk over the majority of the effective area.

Size	250-300ha	**Soil Type**	61% Pumice
Ave Rainfall	1605	**Ave PET**	715
Ave Olsen P	41	**Area already retired**	60ha
Pasture	70% developed rye/clover, 30% Browntop		
VSA		**Soil score**	**Plant score**
	Set-Stock	22/28	28/30
	Re-grassed	22/28	29/30

1.1.4 Pasture

- Pastures predominantly consist of ryegrass and white clover species with pasture renovation evident in recent years. Approximately 30% of the farm area remains in native species such as Browntop. This is being addressed through a cropping regime which has more opportunity for destruction of the Browntop, thus allowing less reversion to Browntop over time.



1.1.5 Limitations to N reductions

- This case study is an owned runoff therefore needs to support same number of winter dairy cows.
- Pasture quality limits the potential to cut and sell silage.
- Autumn N is viewed by Farmer A as crucial to ensure feed quality and quantity through winter.

1.1.6 Overseer™ outputs from effective area

- Modelling of the base scenario in Overseer™ version 6.1.3 estimated annual losses of 49.4kg N/ha 3.5kg P/ha over the effective area. These losses did not take into account any loses from domestic dwellings on the property nor any areas already retired.

Block	N leaching		P Losses		
	kg N/ha	AWC	P kg/ha	Soil	Fert
Grazing P	33	<13.6mm	4.2	High	Extreme
Grazing A	34	<25mm	1.2	Medium	High
Grazing O	16	<68mm	13.8	Extreme	Extreme
Kale	212		1.7	N/A	N/A
Swede/Kale	263		1.7	N/A	N/A
Total/Ave	**49.4**		**3.5**		

1.2 Scenario 1: Reduce nitrogen leaching (10%)

1.2.1 The following iterative changes were made to the base model in order to achieve an N loss reduction of 11.2% from the base model.

a) Reduce winter crop by 37.5%.
b) Reduce replacement dairy heifers by 3.6% from base.
c) Purchase an additional 21kg DM/ha (1.3kg DM/SU) of PKE.

Block	N leaching kg N/ha	Drinking Water N	P Losses P kg/ha	Soil	Fert
Grazing P	33		4.2	High	Extreme
Grazing A	34		1.2	Medium	High
Grazing O	16		13.8	Extreme	Extreme
Kale (0ha)	0		0	N/A	N/A
Swede Kale	264	24.3ppm	1.7	N/A	N/A
Total/Ave	**44.1**		**3.5**		

1.2.2 Scenario 1 resulted in an 10.7% reduction in N loss from base while only requiring minor destocking therefore was deemed acceptable by the farmer.

1.2.3 The above changes resulted in a reduction in EBIT of $17/ha to $479/ha over the original effective area.

1.2.4 This is equivalent to an annual loss in profitability of ($3.22)/kg N loss reduction achieved.

1.3 Scenario 2: Reduce nitrogen leaching (20%)

1.3.1 Further changes were made to Scenario 1 in order to achieve an N loss reduction of 17.2% from the base model.

d) Reduce winter crop an additional by 20.5% (total reduction of 58% from base winter crop area).
e) Reduce replacement dairy heifers by an additional 2.7%.
f) Purchase an additional 31kg DM/ha (2.0kg DM/SU) of PKE.

Block	N leaching kg N/ha	Drinking Water N	P Losses P kg/ha	Soil	Fert
Grazing P	33		4.2	High	Extreme
Grazing A	34		1.2	Medium	High
Grazing O	16		13.8	Extreme	Extreme
Kale (0ha)	0		0	N/A	N/A
Swede Kale	288	24.3ppm	1.7	N/A	N/A
Total/Ave	**40.9**		**3.5**		

1.3.2 Scenario 2 resulted in a 17.6% reduction in N from the base model.

1.3.3 The extent of the destocking and the increase in PKE being fed was deemed acceptable by the farmer.

1.3.4 These changes resulted in a reduction in EBIT of $41/ha to $455/ha from the base model.

1.3.5 This is equivalent to an annual loss in profitability of ($4.83)/kg N loss reduction achieved.

Financial comparison of N loss changes

	Base	Scenario 1	Scenario 2
Pasture harvested (kg DM/ha)	8,796	8,585	8,384
Stocking rate (SU/ha) [1]	16.2	15.8	15.4
Dairy heifers	79%	78%	78%
Carryover dairy cows	8%	9%	9%
Winter dairy cows	6%	6%	6%
Dairy support sub-total	93%	93%	93%
Sheep	0%	1%	1%
Beef	6%	6%	7%
Deer	0%	0%	0%
Net product (kg/SQha)	409	377	377
Liveweight wintered (kg/ha)	974	938	903
Winter crop used (% farm area)	8%	5%	3%
Cash crop used (% of farm area)	0%	0%	0%
N applied to pasture (kg/ha/year)	54	53	52
Supplement purchased (kg DM/ha)	245	264	292
Supplement harvested (% farm area)	39%	39%	39%
EBIT	$ 496	$ 479	$ 455
Δ EBIT from Base		-$ 17	-$ 41
%		-3%	-8%
N loss (kg N/ha/year)	49.4	44.1	40.9
Δ N loss from Base		-5	-8
%		-11%	-17%
Δ EBIT/kg N reduced		-$ 3.22	-$ 4.83

1.4 Scenario 3: Minimise P, sediment and microorganism losses

1.4.1 Given Olsen P levels are currently at optimum, P fertiliser applied to pasture has been reduced in Scenario 3 by an average of 23kg P/ha over the effective farm area to eliminate the increase in Olsen P levels in the soil. The balance of the late winter/early spring P inputs have been shifted to November to keep them outside of the high risk months.

1.4.2 With the VSA results suggesting the grazing area has a low sediment runoff risk the primary area of concern are the critical source areas.

1.4.3 There was no visible erosion evident upon inspection of the property.

1.4.4 It is estimated 2.5ha will need to be retired to exclude the wet spring area and waterways from the grazing area. Approximately 2,300m of 7 wire post and batten fencing required to exclude sheep and cattle from this area.

Block	N leaching kg N/ha	AWC	P Losses P kg/ha	Soil	Fert
Grazing P	33	<13.6mm	3	High	High
Grazing A	34	<25mm	0.8	Medium	Low
Grazing O	16	<68mm	9.4	Extreme	Extreme
Kale (0ha)	212		0	0	0
Swede Kale	263		1.7	N/A	N/A
New Riparian	3		0.1	N/A	N/A
Total/Ave	**49.4**		**2.5**		

1.4.5 The reduction in P loss as modelled by Overseer™ 6.1.3 is estimated to decrease by 1.0kg P/ha given the above mitigations.

1.4.6 With the balance of the farming operation remaining unchanged from the base model, Scenario 3 is projected to increase EBIT by $89/ha from the base model to $585/ha primarily due to a reduction in fertiliser costs of $108/ha.

1.4.7 However interest costs are expected to increase by $8/ha due to the costs of capital fencing assuming the cost of borrowing at 8%pa.

1.5 Farmer commentary on N and P reductions

1.5.1 The reduction in cropping necessary to reduce nitrogen leaching will lead to a perpetual decline in pastoral productivity. Improvement of pasture to remove Browntop is just one element. Significant issues with consecutive droughts, plus grass grub and other pasture pests are leading to a decline in production of the newer pasture species. Cropping is the most effective way of ensuring a good establishment base for the required re-grassing programmes

1.5.2 PKE was not required in the initial modelling however after reduction of winter cropping in each scenario was explained to the farmer it became evident there would be a decrease in pasture production of 3t DM/ha over the cropping area reduced from the base file due to faster reversion to browntop species and reduced weed and pest control. Hence the requirement for PKE purchases in Scenario 1 and 2.

1.5.3 The farmer was happy to retire the wet areas however was concerned about the cost of the fencing.

APPENDIX 2: CASE STUDY B: PUMICE MAIZE CROPPING

2.1 Base Model for Farmer B

2.1.1 Description of operation

- Farmer B runs a maize cropping operation in conjunction with dairy heifer support and a sheep breeding and beef finishing operation.
- Dairy heifer grazers, arriving at 4 months and leaving, in–calf, the following June, make up over 56% of the pastoral grazing operation. This is supplemented by a small number of dry dairy cows, which are grazed for the entire year.
- The remainder of the operation comprises of a mob of yearling steers, finished to the works at about 24 months, and a sheep breeding and finishing operation.
- A total of 3.3% of the effective farm area is used for winter cropping with a further 23% of the effective area harvested for pasture silage, 3% of which is sold off farm.
- 5.5% of the overall area is used for a maize silage cash crop.
- No supplements are currently bought into the system.
- There is no Nitrogen fertiliser applied to the pastoral area. Phosphate fertiliser is applied to the rolling block in April at 22kg P/ha/yr. The easy hill block receives no fertiliser.
- The Maize crop receives 75kg N/ha as Sulphate of Ammonia and DAP at sowing, followed by a further 138kg N as Urea in December. The Maize crop is exported off farm and yields 18t DM/ha.
- The Kale crop receives 14kg N and12kg P from Cropzeal Brassica Base at sowing, followed by 69kg N as SustaiN in January. The Kale crop is grazed in situ and yields 11t DM/ha.

2.1.2 Climate and contour

- The rainfall average for this property is 1,587mm per annum.
- Winters are hard and can be long, with frosts possible late into the spring. It is not unusual for this area to suffer from autumn droughts, and indeed, there have been three in the last four years.
- This farm is predominantly rolling contour with just over 25% in easy hill country. All cropping is carried out on the rolling block
- Approximately 38ha of the farm has already been retired in conservation block, protecting waterways coming up on the property and on its boundary.

- There appear to be no major erosion concerns.

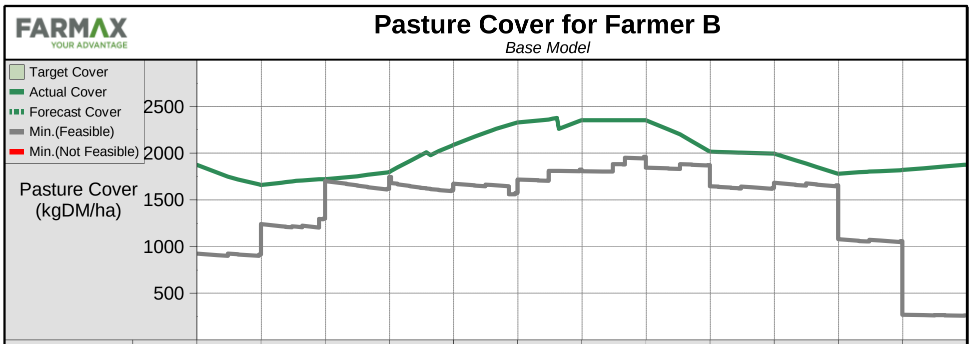
2.1.3 Soil

- Soils on the property are predominantly Kaingaroa pumice. Its soil description from the S-Map data is Kaing_10a.1, and recommendation is to use 'Loamy Sand' for the soil texture in Overseer™ inputs.
- Average Olsen P levels over the farm are estimated at 16-17 across the pastoral areas. The farm nutrient budget indicates a decrease in inorganic P levels in the soil of 1 unit per year for the rolling country and 2 units per year on the easy hill.
- Visual soil assessments (VSA) were completed on a flatter paddock and a recently regrassed one. Soil quality was rated either poor (<10), moderate (10-20) or good (>20).
- Results for the soil indicators totalled 30.5/40 for both areas. The plant indicators totalled 20/28 for both areas.
- With all indicators rating 'good' in the VSA assessments this suggests that there is a minimal sediment runoff risk over the majority of the effective area.

<table>
<tr><td>Size</td><td>150-200ha</td><td>Soil Type</td><td>74% Pumice</td></tr>
<tr><td>Ave Rainfall</td><td>1587</td><td>Ave PET</td><td>720</td></tr>
<tr><td>Ave Olsen P</td><td>41</td><td>Area already retired</td><td>60ha</td></tr>
<tr><td>Pasture</td><td colspan="3">74% developed rye/clover, 26% Browntop</td></tr>
<tr><td rowspan="3">VSA</td><td></td><td>Soil score</td><td>Plant score</td></tr>
<tr><td>Set-Stock</td><td>30.5/40</td><td>30.5/40</td></tr>
<tr><td>Re-grassed</td><td>20/28</td><td>20/28</td></tr>
</table>

2.1.4 Pasture

- Pastures predominantly consist of ryegrass and white clover species with pasture renovation evident in recent years. Approximately 26% of the farm area remains in native species such as Browntop. The areas in Browntop pasture are steeper hill contour and is likely to remain so.



Month	Start	J	A	S	O	N	D	J	F	M	A	M	J
Forecast/Actual	1,874	1,659	1,719	1,795	2,086	2,326	2,353	2,351	2,015	1,993	1,779	1,818	1,875
Minimum	925	912	1,296	1,616	1,603	1,571	1,824	1,959	1,870	1,629	1,656	1,057	262

2.1.5 Limitations to N reductions

- Profitability is the main limitation to N reductions as the business cannot afford to decrease profitability due to the ownership structure of the business.

2.1.6 Overseer™ outputs from effective area

- Modelling of the base scenario in Overseer™ version 6.1.3 estimated annual losses of 32.0kg N/ha 1.2kg P/ha over the effective area. These losses did not take into account any loses from domestic dwellings on the property nor any areas already retired.

Block	N leaching	AWC	P Losses		
	kg N/ha		P kg/ha	Soil	Fert
Rolling Block	21	57.9mm	1.5	Medium	Medium
Easy Hill	23	29.0mm	0.6	Low	N/A
Maize	121	56.9mm	1.2	N/A	N/A
Kale	187	56.9mm	1.3	N/A	N/A
Total/Ave	**32.0**		**1.2**		

2.2 Scenario 1: Reduce nitrogen leaching (10%)

2.2.1 The following iterative changes were made to the base model in order to achieve an N loss reduction of 10.9% from the base model.

a) Reduce Kale crop by 66%

b) Cut and feed an extra 18t DM of baleage.

Block	N leaching kg N/ha	Drinking Water N
Rolling Block	21	2.4ppm
Easy Hill	23	N/A
Maize	121	**11.4ppm**
Kale	188	**17.6ppm**
Total/Ave	**28.9**	

2.2.2 Scenario 1 resulted in a 9.7% reduction in N loss from base with no destocking, which was deemed acceptable by the farmer.

2.2.3 The above changes resulted in an increase in EBIT of $4/ha to $187/ha over the original effective area.

2.2.4 This is equivalent to an annual gain in profitability of $1.28/kg N loss reduction achieved.

2.3 Scenario 2: Reduce nitrogen leaching (20%)

2.3.1 Further changes were made to Scenario 2 in order to achieve an N loss reduction of 19.6% from the base model.

c) Remove Kale crop
d) Reduce beef steers by 22%
e) Reduce Maize crop by 20%

Block	N leaching kg N/ha	Drinking Water N
Rolling	21	2.3ppm
Easy Hill	23	N/A
Maize	121	**11.4ppm**
Kale (0ha)	0	**---**
Total/Ave	**25.7**	

2.3.2 Scenario 2 resulted in an 19.6% reduction in N from the base model.

2.3.3 The extent of the destocking and the increase in PKE being fed was deemed acceptable by the farmer.

2.3.4 These changes resulted in an increase in EBIT of $27/ha to $210/ha.

2.3.5 This is equivalent to an annual increase in profitability of $4.31/kg N loss reduction achieved.

Financial comparison of N loss changes

Farmer B

	Base	Scenario 1	Scenario 2
Pasture harvested (kg DM/ha)	6,997	7,035	6,884
Stocking rate (SU/ha) [1]	12.8	12.7	12.3
Dairy heifers	56%	56%	58%
Carryover dairy cows	9%	9%	9%
Winter dairy cows	3%	3%	3%
Dairy support sub-total	68%	68%	70%
Sheep	17%	17%	18%
Beef	15%	15%	12%
Deer	0%	0%	0%
Net product (kg/SQha)	301	304	293
Liveweight wintered (kg/ha)	669	669	637
Winter crop used (% farm area)	3%	1%	0%
Cash crop used (% of farm area)	5%	5%	5%
N applied to pasture (kg/ha/year)	0	0	0
Supplement purchased (kg DM/ha)	0	0	0
Supplement harvested (% farm area)	23%	26%	26%
EBIT	$ 183	$ 187	$ 210
Δ EBIT from Base		$ 4	$ 27
%		2%	15%
N loss (kg N/ha/year)	32.0	28.9	25.7
Δ N loss from Base		-3	-6
%		-10%	-20%
Δ EBIT/kg N reduced		$ 1.28	$ 4.31

2.4 Scenario 3: Minimise P, sediment and microorganism losses

2.4.1 Given the currently low inputs of Olsen P, and the suitable timings of them, there is little opportunity to mitigate for P loss from this property.

2.4.2 There are no additional areas requiring retirement however there were 2 springs which did require 150m of 7 wire fencing to exclude stock. However this area only equated to 0.1% of the farm area and had no impact on operating profitability. The only cost to the business was in the form of debt servicing assuming the total cost of $1,800 was borrowed at 8% interest.

2.4.3 With the VSA results suggesting the grazing area has a low sediment runoff risk the primary area of concern was a small amount of erosion where cattle had been grazing a steep sidling. The farmer suggested he could graze this area with sheep to minimise the erosion instead at no detriment to the system or profitability.

2.5 Farmer commentary on N and P reductions

2.5.1 The farmer was happy with the suggested changes given the small increase in overall profitability.

2.5.2 The farmer was particularly happy to reduce cropping this was viewed as an eyesore from the road.

APPENDIX 3: FARMER C: PUMICE DAIRY HEIFER GRAZING – PREDOMINANTLY PASTURE

3.1 Base Model for Farmer C

3.1.1 Description of operation

- Farmer C operates a commercial dairy heifer operation, owning no animals on the property and having no direct ties to any one dairy operation. The majority of the farm is owned by the operation with 25% of the effective area leased.
- Heifer calves arrive on the support block as 100kg weaners from late-November, these will make up 30% of the R2 heifers the following year. In May the remaining 70% of yearling heifers arrive on the property. These animals are all grazed through to February of the following year when a small proportion leave the property as in calf rising 2 year heifers. The remainder of the rising 2 year heifers leave the property by the end of April.
- A total of 4.6% of the effective farm area is used for winter cropping with a further 51% of the effective area harvested for pasture silage, all of which is fed out on farm.
- There is no additional supplement purchased.
- Nitrogen fertiliser is applied at a total of 74kg N/ha over the effective area, predominantly in December and March. Nitrogen fertiliser is also used when the paddocks are closed up for silage in September.
- Phosphate fertiliser is applied at an average of 19kg P/ha over the effective area in March.
- 50kg N/ha is applied at sowing to the Summer Rape crop, as well as a side dressing of 75kg N/ha. This crop is grazed in situ and yields 10t DM/ha

3.1.2 Climate and contour

- The rainfall average for this property is 1,312mm per annum.
- Winters are hard and can be long, with frosts possible late into the spring. It is not unusual for this area to suffer from autumn droughts, and indeed, there have been three in the last four years.
- The farm ranges from flat to easy hill, with a fewer steeper sides to some of the hilly contour.
- There is a very small amount of erosion visible on the steeper hills, but this looks to be relatively stable, and more aligned with animals seeking minerals, shade and shelter, than land on the move.

- Approximately 1.8ha of land has already been retired from pastoral operations and comprises the steepest, erosion prone gullies. These have been planted in various exotic trees to assist with soil stabilisation.

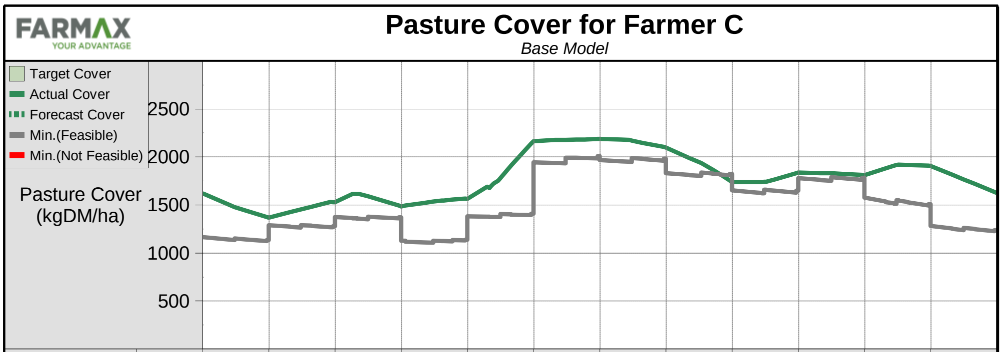
3.1.3 Soil

- Soils on the property are predominantly a mixture of Oruanui loamy sand and Atiamuri Sand. The soil descriptions from the S-Map data are Orua_13a.1 and Kaing_10a.1 respectively, and recommendation is to use 'Sandy Loam' for the soil texture in Overseer™ inputs for both.
- Average Olsen P levels over the farm, from soil tests are 58. The farm nutrient budget indicates a reduction in inorganic P levels in the soil of an average of 38kg P/ha/yr which equates to a decrease in Olsen P of approximately 6-7 units per year.
- Visual soil assessments (VSA) were completed on a recently regrassed flat paddock and a hill paddock which was in older brown top pasture . Soil quality was rated either poor (<10), moderate (10-20) or good (>20).
- Results for the soil indicators totalled 28/28 for the flat paddock and 25/28 for the hill paddock. The plant indicators totalled 26/30 and 28/30 for the flat and hill paddocks respectively.
- With all indicators rating 'good' in the VSA assessments this suggests that there is a minimal sediment runoff risk over the majority of the effective area.

Size	250-300ha	**Soil Type**	58% Pumice
Ave Rainfall	1312	**Ave PET**	795
Ave Olsen P	58	**Area already retired**	1.8ha
Pasture	43% developed rye/clover, 57% Browntop		
VSA		**Soil score**	**Plant score**
	Flat	28/28	26/30
	Rolling Hill	25/28	28/30

3.1.4 Pasture

- Developed pastures predominantly consist of ryegrass and white clover species with pasture renovation evident in recent years. A large area of the farm is still in brown-top pasture due to the steeper hill contour. Most of the land which can be developed has been put into ryegrass and white clover mixes.



Month	Start	J	A	S	O	N	D	J	F	M	A	M	J
Forecast/Actual	1,621	1,365	1,526	1,484	1,561	2,162	2,188	2,098	1,736	1,837	1,809	1,906	1,625
Minimum	1,165	1,132	1,278	1,371	1,135	1,408	2,010	1,979	1,824	1,646	1,782	1,508	1,235

3.1.5 Limitations to N reductions

- Farmer not keen to reduce nitrogen fertiliser as it is viewed as an essential part of the silage harvesting process.
- Very free draining pumice soils on some parts of the property.
- Although all of the animals are grazed, the farmer did not want to reduce the number of animals on farm as this was viewed as a decrease in farm income and therefore profitability.

3.1.6 Overseer™ outputs from effective area

- Modelling of the base scenario in Overseer™ version 6.1.3 estimated annual losses of 43.2kg N/ha 1.6kg P/ha over the effective area. These losses did not take into account any loses from domestic dwellings on the property nor any areas already retired.

Block	**N leaching kg N/ha**	**AWC**	**P Losses P kg/ha**	**Soil**	**Fert**
RP	32	<10mm	2.6	High	Medium
PHP	35	<10mm	4	Extreme	Medium
PHA	33	29.0mm	1.1	Medium	Low
LP	57	57.9mm	0.8	Medium	Low
Summer Rape	122	<10mm	1.2	N/A	N/A
Ave	**43.2**		**1.6**		

3.2 Scenario 1: Reduce nitrogen leaching (10%)

3.2.1 The following iterative changes were made to the base model in order to achieve an N loss reduction of 9.5% from the base model.

a) Summer rape crop removed
b) Purchase 60t PKE to balance reduction in feed.

Block	N leaching kg N/ha	Drinking Water N
RP	33	5.8ppm
PHP	34	N/A
PHA	33	N/A
LP	57	9.8ppm
Total/Ave	**39.1**	

3.2.2 Scenario 1 resulted in a 9.5% reduction in N loss from base without reducing the number of heifer grazers.

3.2.3 The above changes resulted in a reduction in EBIT of $16/ha to $478/ha over the original effective area.

3.2.4 This is equivalent to an annual loss in profitability of ($3.88)/kg N loss reduction achieved.

3.3 Scenario 2: Reduce nitrogen leaching (20%)

3.3.1 Further changes were made to Scenario 2 in order to achieve an N loss reduction of 19.6% from the base model.

c) Reduce the number of weaners coming on in December by 7.5%, and reduce May yearling heifer arrivals by 3%.
d) Eliminate PKE purchased in b) above.

Block	N leaching kg N/ha	Drinking Water N
RP	29	5.1ppm
PHP	31	N/A
PHA	30	N/A
LP	51	7.0ppm
Total/Ave	**34.8**	

3.3.2 Scenario 2 resulted in a 19.6% reduction in N from the base model.

3.3.3 The extent of the destocking and the removal of PKE being fed was deemed acceptable by the farmer.

3.3.4 These changes resulted in a decrease in EBIT of $4/ha to $490/ha. The increase in profitability from the 10% reduction scenario was due to a reduction in labour costs and the removal of bought in feed.

3.3.5 This is equivalent to an annual loss in profitability of ($0.47)/kg N loss reduction achieved.

Financial comparison of N loss changes

Farmer C

	Base	Scenario 1	Scenario 2
Pasture harvested (kg DM/ha)	11,224	11,189	10,762
Stocking rate (SU/ha) [1]	19.9	19.9	19.4
Dairy heifers	100%	100%	100%
Carryover dairy cows	0%	0%	0%
Winter dairy cows	0%	0%	0%
Dairy support sub-total	100%	100%	100%
Sheep	0%	0%	0%
Beef	0%	0%	0%
Deer	0%	0%	0%
Net product (kg/SQha)	524	524	510
Liveweight wintered (kg/ha)	911	911	884
Winter crop used (% farm area)	5%	0%	0%
Cash crop used (% of farm area)	0%	0%	0%
N applied to pasture (kg/ha/year)	74	70	0
Supplement purchased (kg DM/ha)	0	200	0
Supplement harvested (% farm area)	51%	51%	51%
EBIT	$ 494	$ 478	$ 490
Δ EBIT from Base		-$ 16	-$ 4
%		-3%	-1%
N loss (kg N/ha/year)	43.2	39.1	34.8
Δ N loss from Base		-4	-8
%		-10%	-20%
Δ EBIT/kg N reduced		-$ 3.88	-$ 0.47

3.4 Scenario 3: Minimise P, sediment and microorganism losses

3.4.1 Olsen P levels are currently well above optimum across the whole farm but are reducing, on average, by about 6-7 units of Olsen P per year.

3.4.2 P inputs are medium to low across the whole farm, and current levels are needed to prevent any decrease in Olsen P tests.

3.4.3 With the VSA results suggesting the grazing area has a low sediment runoff risk the primary area of concern are the critical source areas.

3.4.4 Fencing is already under way to finish stock exclusion from a stream running through the property. This had limited access, due to its depth and fast flowing nature, so there had been very little stock access.

3.4.5 There is an area of pugging on the lower ground near to the stream where water does remain in the depressions, but the farmer has no intention of fencing it off, as it would create some very small, awkward to access paddocks. This is potentially an area for micro-organism losses but there is minimal flow from this area of pugging into the stream, it is more of a stagnant low-lying area.

3.5 Farmer commentary on N and P reductions

3.5.1 The farmer was happy with the proposal to reduce stocking rate as long as profitability wasn't dramatically affected.

3.5.2 The farmer was concerned that decreasing the numbers of heifers grazed on the property may mean the stock owner would look elsewhere for a grazier who could take the entire line.

3.6 Best Management Practices

3.6.1 This was the first time this farmer had really looked at his operation in terms of nutrient use and management, although he had received basic nutrient management plans from his fertiliser representative.

3.6.2 There are some small areas of the farm where there is water laying in the paddock in proximity to streams due to an altered water table. Ideally this area would be fenced off but doing so would leave several small inaccessible paddocks around the periphery. This small area does not represent the overall presentation of the farm.

3.6.3 This farmer is conscious of items such as the location of his silage pit and the lack of risk of waterway contamination from any leakage.

APPENDIX 4: CASE STUDY D: PUMICE DAIRY HEIFER GRAZING

4.1 Base Model for Case Study D

4.1.1 Description of operation

- Case study D is an exclusive dairy heifer support block which also rears breeding bulls used to service the heifers.
- Heifer calves arrive on the support block as 100kg weaners in October, are taken through to 23 months of age before leaving the support block at the end of the June.
- A total of 10% of the effective farm area is used for winter cropping with a further 34% of the effective area harvested for pasture silage.
- No supplement is bought in off farm.
- Nitrogen fertiliser is applied at 19kg N/ha over the effective area in April.
- Phosphate fertiliser is applied at 26kg P/ha over the effective area in April.

4.1.2 Climate and contour

- The rainfall average for this property is 1,570mm per annum.
- This farm is predominantly rolling country with some steeper areas that are stable but still in brown-top, due to their contour.
- Approximately 10ha is retired in a steeper gully which is fenced. Additionally an exclusion zone is fenced off around a swampy 'duck pond'.
- The only critical source point requiring attention was erosion of the steeper banks along the waterway passing through the property. This erosion was exaggerated by treading damage from stock.
- There is approximately 3.1ha which requires fencing to remove stock from waterways. This water is fairly fast flowing and the stream bed ranges from steeply banked to easily accessible.

4.1.3 Soil

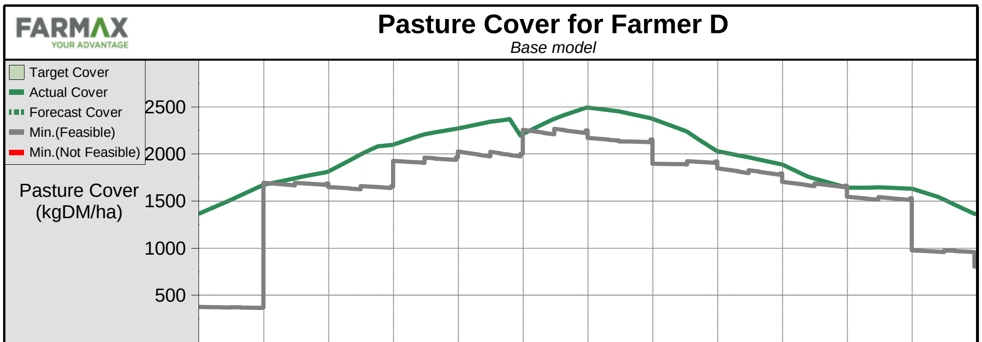
- Soils on the property are a Taupo pumice which is described as pumice with a profile of loamy sand. Its soil description from the S-Map data is Taupo_23a.2.
- Average Olsen P levels over the farm are estimated at 17. The farm nutrient budget indicates an increase in inorganic P levels in the soil of 3kg P/ha/yr which equates to an increase in Olsen P of approximately 0.5 units per year on the pumice soil.

- Visual soil assessments (VSA) were completed on the property on both of the predominant contour categories; 'Rolling' and 'Hill'. Soil quality was rated either poor (<10), moderate (10-20) or good (>20).
- Results for the soil indicators totalled 20.5/28 and 22/28 for the rolling and hill areas respectively. The plant indicators totalled 29/30 and 24.5/30 for the rolling and the hill areas respectively.
- With all indicators rating 'good' in the VSA assessments suggests that there is a minimal sediment runoff risk over the majority of the effective area.

Size	100-150ha	**Soil Type**	100% Pumice
Ave Rainfall	1570	**Ave PET**	730
Ave Olsen P	17	**Area already retired**	10ha
Pasture	80% developed rye/clover, 20% Browntop		
VSA		**Soil score**	**Plant score**
	Rolling	20.5/28	29/30
	Hill	22/28	24.5/30

4.1.4 Pasture

- Pastures predominantly consist of ryegrass and white clover species with pasture renovation in recent years evident. Approximately 20% of the farm area remains in native species such as Browntop on the steeper areas.



Month	Start	J	A	S	O	N	D	J	F	M	A	M	J
Forecast/Actual	1,363	1,671	1,811	2,098	2,267	2,211	2,494	2,374	2,028	1,887	1,641	1,630	1,363
Minimum	376	367	1,684	1,655	1,963	2,000	2,249	2,152	1,917	1,792	1,661	1,526	805

4.1.5 Limitations to N reductions

- Low inputs of N fertiliser and supplementary feed.

- This property runs all of the young stock for the farmer's dairy unit.
- A natural mating programme for the owners dairy unit means that all service bulls, from weaning to 3 years of age, are also required to be run on the block except over mating.

4.1.6 Overseer™ outputs from effective area

- Modelling of the base scenario for Farmer D in Overseer™ version 6.1.3 estimated annual losses of 47.3kg N/ha over the effective area and 1.6kg P/ha over the effective area. These losses did not take into account any loses from domestic dwellings on the property nor any areas already retired.

Block	N leaching		P Losses		
	kg N/ha	AWC	P kg/ha	Soil	Fert
Rolling	28	<10mm	1.5	Medium	Medium
Hill	31	<10mm	2.3	High	Medium
Swede+Kale	293	<10mm	1.7	N/A	N/A
Autumn Rape	141	<10mm	1.2	N/A	N/A
Total/Ave	**47.3**		**1.6**		

4.2 Scenario 1: Minimise P loss and reduce nitrogen leaching (10%)

4.2.1 The following iterative changes were made to the base model in order to achieve an N loss reduction of 13% from the base model.

a) Reduce winter crop area by 43%.
b) Purchase 97kg DM/ha (5.4kg DM/SU) of PKE to feed through winter to account for reduction in winter crop.

Block	N leaching	Drinking	P Losses		
	kg N/ha	Water N	P kg/ha	Soil	Fert
Rolling	30		1.5	Medium	Medium
Hill	33		2.3	High	Medium
Swede+Kale	223	27.2ppm	1.7	N/A	N/A
Autumn Rape	71	12.7ppm	1.2	N/A	N/A
Total/Ave	**41.3**		**1.6**		

4.2.2 Scenario 1 resulted in a 13.0% reduction in N loss and did not require destocking therefore was deemed acceptable by the farmer.

4.2.3 The above changes resulted in an increase of $1/ha to $498/ha.

4.2.4 This is equivalent to an annual increase in profitability of $0.17/kg N loss reduction achieved.

4.3 Scenario 2: Minimise P loss and reduce nitrogen leaching (20%)

4.3.1 Further changes were made to Scenario 1 in order to achieve an N loss reduction of 21.3% from the base model.

c) Eliminate winter crop completely.

d) Purchase an additional 317kg DM/ha (17.7kg DM/SU) of PKE to replace winter crop.

Block	N leaching kg N/ha	Drinking Water N	P Losses		
			P kg/ha	Soil	Fert
Rolling	32		1.5	Medium	Medium
Hill	34		2.3	High	Medium
Swede+Kale	0		0	N/A	N/A
Autumn Rape	19	14.1ppm	1.2	N/A	N/A
Total/Ave	**37.2**		**1.6**		

4.3.2 Scenario 3 resulted in a 21.3% reduction in N from the base model but required the purchase of a total of 557kg DM/ha of PKE.

4.3.3 These changes resulted in a reduction in EBIT of $55/ha to $442/ha.

4.3.4 This is equivalent to an annual decrease in profitability of ($5.48)/kg N loss reduction achieved.

Financial comparison of N loss changes

	Base	Scenario 1	Scenario 2
Pasture harvested (kg DM/ha)	9,832	9,789	9,737
Stocking rate (SU/ha) [1]	17.5	17.9	17.9
Dairy heifers	100%	100%	100%
Carryover dairy cows	0%	0%	0%
Winter dairy cows	0%	0%	0%
Dairy support sub-total	100%	100%	100%
Sheep	0%	0%	0%
Beef	0%	0%	0%
Deer	0%	0%	0%
Net product (kg/SQha)	449	459	459
Liveweight wintered (kg/ha)	716	732	732
Winter crop used (% farm area)	10%	6%	4%
Cash crop used (% of farm area)	0%	0%	0%
N applied to pasture (kg/ha/year)	19	19	18
Supplement purchased (kg DM/ha)	0	97	317
Supplement harvested (% farm area)	29%	29%	29%
EBIT	$ 497	$ 498	$ 442
Δ EBIT from Base		$ 1.0	-$ 55
%		0%	-11%
N loss (kg N/ha/year)	47.3	41.3	37.2
Δ N loss from Base		-6	-10
%		-13%	-21%
Δ EBIT/kg N reduced		$ 0.17	-$ 5.48

4.4 Scenario 3: Minimise P, sediment and microorganism losses

4.4.1 Autumn application of phosphate fertiliser at a rate of 25kg P/ha over the effective area in the base model is sufficient to meet maintenance P requirements with a minimal increase to Olsen P levels. Under the base model Olsen P levels are expected to increase by approximately 0.5 units per year. Given the current average Olsen P levels are below optimum this relatively slow increase in Olsen P is required to optimise the farming system. However when Olsen P levels near optimum it is recommended phosphate fertiliser is reduced so that inorganic P levels in the soil are balanced annually. Therefore there are no immediate changes required to timing or quantity of phosphate fertiliser applications to minimise P loss.

4.4.2 With the VSA results suggesting the grazing area has a low sediment runoff risk the primary area of concern are the critical source areas.

4.4.3 Given the steep valley and the wet duck pond area have already been fenced the only remaining critical source area is along the banks of the waterway running through the property. This area will require fencing and planting where appropriate to exclude stock and minimise water erosion from the banks of the waterway which is currently exaggerated by treading damage.

4.4.4 It is estimated 3.1ha of effective grazing area will need to be retired given the lay of the land with 4,500m of 4 wire electric fencing required to exclude cattle.

4.4.5

Block	N leaching kg N/ha	Drinking Water N	P kg/ha	P Losses Soil	Fert
Rolling	28		1.5	Medium	Medium
Hill	31		2.3	High	Medium
Swede+Kale	293		1.7	N/A	N/A
Autumn Rape	141	14.1ppm	1.2	N/A	N/A
New ripairian	3		0.1		
Total/Ave	**47.3**		**1.6**		

4.4.6 With no significant changes to P inputs, Overseer™ estimates an unchanged average P loss of 1.6kg P/ha.

4.4.7 With the balance of the farming operation remaining unchanged, Scenario 1 is projected to decrease EBIT by $43/ha to $454/ha primarily due to increased supplementary feed costs due to a reduction in effective grazing area.

4.4.8 Additionally interest costs are expected to increase by $10/ha due to the costs of capital fencing and planting assuming the cost of borrowing at 8%pa.

4.5 Farmer commentary on N and P reductions

4.5.1 Reductions in profitability is the greatest concern for the business.

4.5.2 The farmer was happy with the N reduction mitigations as they didn't include destocking which would not have been acceptable.

4.5.3 The use of PKE to account for reduction in winter crop was viewed as acceptable as the infrastructure was available to make this transition cost effectively.

4.5.4 The farmer was concerned over the cost to retire the river bank area and did not know how he would fund this if it was enforced.

APPENDIX 5: CASE STUDY E: PUMICE MA WINTER COW GRAZING – PREDOMINANTLY PASTURE

5.1 Base Model for Farmer E

5.1.1 Description of operation

- This farm is an owned support block for a local dairy farm but also runs some external heifer grazers as well. The farm runs a mixture of dairy heifers and MA winter dairy cows, complemented by a breeding ewe flock comprising 25% of the operation.
- Heifer calves arrive on the support block as 130kg weaners in December, are taken through to 21 months of age before leaving the support block at the end of April.
- Only 3% of the effective farm area is used for winter cropping, which is a winter oats to new grass regrassing regime. A further 34% of the effective area harvested for pasture silage which is fed out on farm.
- 98kg DM/ha is purchased, equating to 6.6kg DM/Su.
- Nitrogen fertiliser is applied at 65kg N/ha over the effective area in spring and autumn. Additionally 10kg N/ha is applied post-silage to the harvested area.
- Phosphate fertiliser is applied at 14kg P/ha over the effective pastoral area in March.
- The farm also runs a 6ha plantain block which receives the same fertiliser applications as the grass blocks.

5.1.2 Climate and contour

- The rainfall average for this property is 1,502mm per annum.
- This farm is predominantly rolling country with around 45% of the block being identified as easy contour.
- Approximately 32.6ha is retired and fenced off.
- There is approximately 1ha of wetlands which requires fencing to exclude stock.

5.1.3 Soil

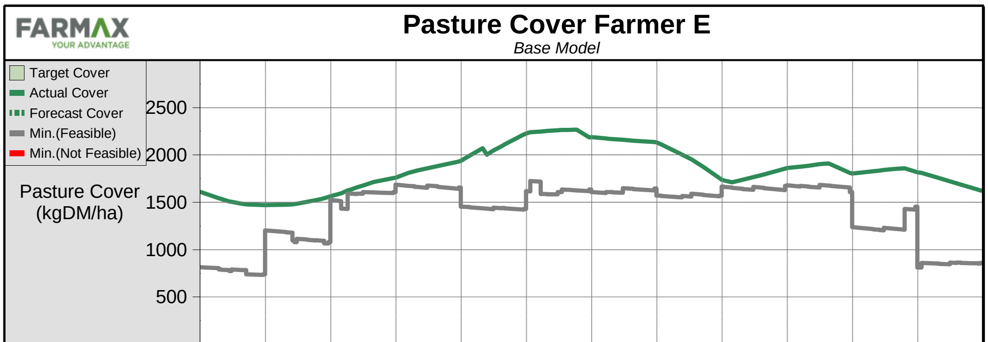
- Soils on the property are a Kinleith pumice which is described as pumice with a profile of loamy silt (using loamy sand for Overseer™ inputs). Its soil description from the S-Map data is Kinle_1a.1.

- Average Olsen P levels over the farm are estimated at 28. The nutrient budget for the Plantain block indicates an increase in inorganic P levels in the soil of approximately 1 unit Olsen P per year. The nutrient budget for both the rolling and hill blocks indicates a decrease in inorganic P levels in the soil of approximately 3 units Olsen P per year.
- Visual soil assessments (VSA) were completed on the property on both of the predominant contour categories; 'Rolling' and 'Hill'. Soil quality was rated either poor (<10), moderate (10-20) or good (>20).
- Results for the soil indicators totalled 33/40 and 29.5/40 for the rolling and hill areas respectively. The plant indicators totalled 21.5/28 and 25/28 for the rolling and the hill areas respectively.
- With all indicators rating 'good' in the VSA assessments suggests that there is a minimal sediment runoff risk over the majority of the effective area.

Size	150-200ha	**Soil Type**	100% Pumice
Ave Rainfall	1502	**Ave PET**	820
Ave Olsen P	17	**Area already retired**	32.6ha
Pasture	52% developed rye/clover, 44% Browntop, 3% Plantain		
VSA		**Soil score**	**Plant score**
	Rolling	33/40	21.5/28
	Hill	29.5/40	25/28

5.1.4 Pasture

- Pastures predominantly consist of ryegrass and white clover species with pasture renovation in recent years evident. Approximately 44% of the farm area remains in native species such as Browntop on the steeper areas.
- Plantain has been introduced as a new pasture species to increase production on some of the easier country.



Month	Start	J	A	S	O	N	D	J	F	M	A	M	J
Forecast/Actual	1,610	1,468	1,563	1,759	1,935	2,225	2,188	2,132	1,738	1,860	1,803	1,814	1,619
Minimum	812	738	1,078	1,608	1,653	1,427	1,636	1,643	1,569	1,673	1,607	1,452	858

5.1.5 Limitations to N reductions

- Contour and soil type are major limiting factors for this property. Much of the property is not able to be harvested for silage (82%), and requires grazing.
- This unit supports 3 other dairy farms owned by the same farmer and therefore are limited in terms of reducing stock numbers.

5.1.6 Overseer™ outputs from effective area

- Modelling of the base scenario for Farmer E in Overseer™ version 6.1.3 estimated annual losses of 26.4kg N/ha over the effective area and 2.7kg P/ha over the effective area. These losses did not take into account any loses from domestic dwellings on the property nor any areas already retired.

Block	N leaching kg N/ha	AWC	P Losses P kg/ha	Soil	Fert
Rolling	22	15.4mm	2.3	High	High
Hill	23	15.4mm	3.3	High	High
Oats-New Grass	152	14.4mm	1.0	N/A	N/A
Plantain	35	15.4mm	2.6	High	Extreme
Total/Ave	**26.4**		**2.7**		

5.2 Scenario 1: Reduce nitrogen leaching (10%)

5.2.1 The following iterative changes were made to the base model in order to achieve an N loss reduction of 12.9% from the base model.

a) Remove Oats to New Grass programme from system.
b) Reduce external dairy heifer grazers by 9%
c) Sell 4% of the pasture silage already cut on farm.

Block	N leaching kg N/ha	Drinking Water N
Rolling	22	3.1ppm
Hill	23	N/A
Plantain	36	5.1ppm
Total/Ave	**23.0**	

5.2.2 Scenario 1 resulted in a 12.9% reduction in N loss and did not require destocking of the owned dairy heifers, therefore was deemed acceptable by the farmer.

5.2.3 However, the farmer did raise concerns about the long term viability of the scenario due to the fact that it removed his ability to re-grass and improve productivity.

5.2.4 The above changes resulted in an increase in EBIT of $10/ha to $154/ha.

5.2.5 This is equivalent to an annual increase in profitability of $2.93/kg N loss reduction achieved.

5.3 Scenario 2: Reduce nitrogen leaching (20%)

5.3.1 Further changes were made to Scenario 1 in order to achieve an N loss reduction of 19.7% from the base model.

d) Further reduce external grazing heifers by 41%.

e) Sell a total of 35% of the harvested silage off farm.

Block	N leaching kg N/ha	Drinking Water N
Rolling	20	2.8ppm
Hill	21	N/A
Plantain	35	4.8ppm
Total/Ave	**21.2**	

5.3.2 Scenario 3 resulted in a 19.8% reduction in N from the base model and required the removal of half of the initial number of external heifer grazers, plus further silage sold off farm.

5.3.3 These changes resulted in an increase in EBIT of $6/ha to $150/ha.

5.3.4 This is equivalent to an annual increase in profitability of $1.15/kg N loss reduction achieved.

Financial comparison of N loss changes

Farmer E

	Base	Scenario 1	Scenario 2
Pasture harvested (kg DM/ha)	7,629	7,565	7,081
Stocking rate (SU/ha) [1]	14.8	14.6	13.2
Dairy heifers	60%	59%	54%
Carryover dairy cows	0%	0%	0%
Winter dairy cows	15%	16%	17%
Dairy support sub-total	75%	74%	72%
Sheep	25%	25%	28%
Beef	0%	0%	0%
Deer	0%	0%	0%
Net product (kg/SQha)	346	324	287
Liveweight wintered (kg/ha)	1266	1260	1210
Winter crop used (% farm area)	3%	0%	0%
Cash crop used (% of farm area)	0%	0%	0%
N applied to pasture (kg/ha/year)	65	64	64
Supplement purchased (kg DM/ha)	98	98	98
Supplement harvested (% farm area)	34%	34%	34%
EBIT	$ 144	$ 154	$ 150
Δ EBIT from Base		$ 10.0	$ 6
%		7%	4%
N loss (kg N/ha/year)	26.4	23.0	21.2
Δ N loss from Base		-3	-5
%		-13%	-20%
Δ EBIT/kg N reduced		$ 2.93	$ 1.15

5.4 Scenario 3: Minimise P, sediment and microorganism losses

5.4.1 Move P components of fertiliser in September and October to November to avoid the High Risk months of application.

5.4.2 With the VSA results suggesting the grazing area has a low sediment runoff risk the primary areas of concern are the critical source areas.

5.4.3 The only visible sediment erosion present upon inspection was where cows had been grazing steep sidling areas. The farmer was willing to not use cows to graze these sidlings with the alternative being sheep only through these areas. It was both the writers and the farmer's view that this change in grazing was both manageable and the unlikely to have a substantial effect on EBIT.

5.4.4 The swampy area showed evidence of pugging after grazing which will be increasing sediment and the associated P and microorganism loses to water. The area was not flowing with water upon inspection however it was evident the water flows over this area in wetter months.

5.4.5 It is estimated 1.0ha of effective grazing area will need to be retired given the lay of the land with 900m of 4 wire electric fencing required to exclude cattle.

5.4.6 With the balance of the farming operation remaining unchanged, Scenario 3 is projected to decrease EBIT by $12/ha to $132/ha primarily due to increased supplementary feed costs due to a reduction in effective grazing area.

5.4.7 Additionally interest costs are expected to increase by $4.48/ha due to the costs of capital fencing and planting assuming the cost of borrowing at 8%pa.

Block	**P Losses**		
	P kg/ha	**Soil**	**Fert**
Rolling	2.2	High	High
Hill	3.3	High	High
Oats-New Grass	1.0	N/A	N/A
Plantain	2.3	High	High
New Riparian	0.1	N/A	N/A
Total/Ave	**2.7**		

5.5 Farmer commentary on N and P reductions

5.5.1 The farmer was happy to make all suggested changes to reduce N loss however expressed concern that if he could not graze all of the external heifers the heifer owner would pull out all together.

5.5.2 There was consensus that the grazing regime would need to be altered to push more pasture into the winter with the reduction of oats however this was made possible due to the reduction in dairy heifer numbers.

5.5.3 The mitigations to minimise P and sediment loss were viewed as acceptable and manageable by the farmer. However the farmers view was a subsidy should be provided by the WRC for the capital fencing.

APPENDIX 6: CASE STUDY F: PUMICE MA WINTER COW GRAZING – PREDOMINANTLY SUPPLEMENTS

6.1 Base Model for Case study F

6.1.1 Description of operation

- This farm is a complete support block for the family dairy farm, 10km away. The entire milking herd is wintered on the property, as well as all replacement heifers. Heifer calves arrive on the support block as weaners from August onwards; they are mated and stay on the property until just prior to calving. A small number of Jersey bulls for mating duty are also brought on as weaners and remain on the property until the following December
- A total of 22% of the effective farm area is used for winter cropping with a further 53% of the effective area harvested for pasture silage.
- 568kg DM/ha PKE is purchased on an annual basis, equating to 39kg DM/SU.
- Nitrogen fertiliser is applied 102kg/ha average, across both the silage and truckable blocks, this includes post-silage dressing on harvested country. No Nitrogen fertiliser is used on the areas of the farm that need fertiliser applied by plane.
- DAP Sulphur Super is used to input phosphate into the farming system. There are applications in March and September, but only across the truckable country. The silage country receives a total of 15kg P/ha/yr and the truckable country 24kg P/ha/yr.
- Two applications of 92kg N/ha are applied to all of the Swede Kale crops. These crops are grazed in situ, with a yield of 10t DM/ha.
- Winter Oats are planted with 41kg N/ha and yield 6t DM/ha

6.1.2 Climate and contour

- The rainfall average for this property is 1,411mm per annum.
- The pumice country on this property is strong rolling country, with some steeper contour on the ash country
- Approximately 5.5ha is in areas which are already fenced off, planted and stock excluded. These protect small waterways running through the farm and are well maintained.
- There appear to be no major erosion concerns.

- There is still approximately 12ha of stream head which stock have access to which is not fenced. This is the only source for water in this paddock and is only used 2-3 times per year for younger stock to graze. Due to contour and accessibility, the farmer is not planning on fencing off this area as it would entail quite a large area.

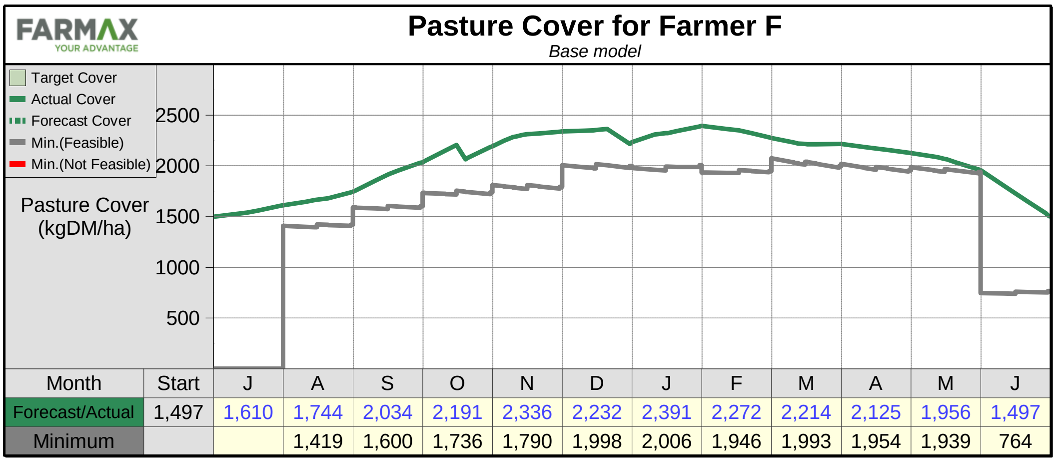
6.1.3 Soil

- Soils on the property are predominantly Oruanui Sand which is described as pumice with a profile of loamy sand. Its soil description from the S-Map data would be Orua_12a.1.
- Average Olsen P levels over the farm are 40 for all of the truckable country and 25 for the plane country. The farm nutrient budget indicates a loss in Olsen P of 31 for the silage country, 25 for the plane country and 4 for the non-silaged truckable country (due to no harvesting). Decreases of 5 units Olsen P/ha are predicted on the silage block, 3 units on the plane country and only 1 unit on the non-silage truckable country.
- Visual soil assessments (VSA) were completed on the property on a recently regrassed paddock and an older pasture paddock. Soil quality was rated either poor (<10), moderate (10-20) or good (>20).
- Results for the soil indicators totalled 22/28 and 23/28 for recently regrassed and older pasture areas respectively. The plant indicators totalled 28/30 and 21/30 for recently regrassed and older pasture areas respectively.
- With all indicators rating ‘good’ in the VSA assessments suggests that there is a minimal sediment runoff risk over the majority of the effective area.
- The lower score on the older pasture was due to poor pasture composition, lack of drought tolerance and issues with ponding in very wet weather.

Size	150-200ha	**Soil Type**	79% Pumice
Ave Rainfall	1411	**Ave PET**	729
Ave Olsen P	37	**Area already**	5.5ha
Pasture	85% developed rye/clover, 15% browntop		
VSA		**Soil score**	**Plant score**
	New Regrass	28/28	28/30
	Older Pasture	23/28	21/28

6.1.4 Pasture

- Pastures predominantly consist of ryegrass and white clover species with pasture renovation evident in recent years. Approximately 15% of the farm area remains in native species such as Browntop. The areas of the farm still in Browntop are likely to remain so due to steeper contour.



6.1.5 Limitations to N reductions

- Predominant pumice soil type and rainfall are major drivers for N loss.
- Runoff needs to support 600 dairy cows for 8 weeks through winter.
- Very high feed requirements on farm during winter months.
- Ensuring changes to the system do not just transfer any nutrient loss to the dairy platform.

6.1.6 Overseer™ outputs from effective area

- Modelling of the base scenario for Farmer F in Overseer™ version 6.1.3 estimated annual losses of 45.7kg N/ha over the effective area and 1.7kg P/ha over the effective area. These losses did not take into account any loses from domestic dwellings on the property nor any areas already retired.

Block	N Leaching kg/ha	AWC Diff	P Losses P kg/ha	Soil	Fert
Silage	12	<10mm	2.4	High	High
Truckable	21	<10mm	2.4	High	High
Plane	18	29.0mm	0.6	Low	N/A
Swede Kale JJ	186	<10mm	1.0	N/A	N/A
Winter Oats	52	190.2mm	0.9	N/A	N/A
Swede Kale May	194	<10mm	1.0	N/A	N/A
Ave	**45.7**		**1.7**		

- Due to the high variance in stock numbers over the period of cropping, the Swede Kale crop had to be split in two to enable Overseer™ to model the farm. The two crop blocks in the Overseer™ model are in fact one crop, grazed through May, June & July.

6.2 Scenario 1: Reduce nitrogen leaching (10%)

6.2.1 The following iterative changes were made to the base model in order to achieve an N loss reduction of 8.2% from the base model **:**

a) Remove 14% of Swede Kale crop (all of May grazed for ease of calculation)
b) Purchase an additional 275kg DM/ha of maize silage
c) Remove spring Nitrogen **f**ertiliser from Silage & Truckable

Block	**N Leaching kg/ha**	**Drinking Water N**
Silage	12	1.7ppm
Truckable	20	2.8ppm
Plane	19	N/A
Swede Kale JJ	186	**20.5ppm**
Winter Oats	51	6.2ppm
Ave	**42.0**	

6.2.2 Scenario 1 resulted in an 8.2% reduction in N loss. There are no reductions to stock numbers to the farmer was relatively happy with this solution. However, the main purpose for buying a run-off to support the main dairy block was to get away from the need to purchase in supplements, such as maize silage.

6.2.3 The above changes resulted in a reduction in EBIT of $27/ha to $256/ha over the original effective area.

6.2.4 This is equivalent to an annual loss in profitability of ($7.25)/kg N loss reduction achieved.

6.3 Scenario 2: Reduce nitrogen leaching (20%)

6.3.1 Further changes were made to Scenario 1 in order to achieve an N loss reduction of 17.4% from the base model.

d) Reduce remaining Swede Kale crop to 50% of original total.
e) Purchase a further 228kg DM/ha of maize silage.

Block	N Leaching kg/ha	Drinking Water N
Silage	13	1.7ppm
Truckable	19	2.6ppm
Plane	18	N/A
Swede Kale JJ	201	**22.1ppm**
Winter Oats	50	6.1ppm
Ave	**37.8**	

6.3.2 Scenario 2 resulted in a 17.4% reduction in N loss. The over-riding goal of not reducing stock numbers was again achieved, but with further purchases of maize silage and a further drop in EBIT, the farmer was not that comfortable with the solution.

6.3.3 The above changes resulted in a reduction in EBIT of $80/ha to $203/ha over the effective area.

6.3.4 This is equivalent to an annual loss in profitability of ($10.09)/kg N loss reduction achieved.

Financial comparison of N loss changes

Farmer F

	Base	Scenario 1	Scenario 2
Pasture harvested (kg DM/ha)	8,026	7,966	7,805
Stocking rate (SU/ha) [1]	14.6	14.9	14.9
Dairy heifers	58%	58%	58%
Carryover dairy cows	14%	14%	14%
Winter dairy cows	28%	28%	28%
Dairy support sub-total	100%	100%	100%
Sheep	0%	0%	0%
Beef	0%	0%	0%
Deer	0%	0%	0%
Net product (kg/SQha)	341	348	348
Liveweight wintered (kg/ha)	1839	1876	1876
Winter crop used (% farm area)	22%	17%	17%
Cash crop used (% of farm area)	0%	0%	0%
N applied to pasture (kg/ha/year)	77	54	54
Supplement purchased (kg DM/ha)	568	843	1071
Supplement harvested (% farm area)	53%	53%	53%
EBIT	$ 283	$ 256	$ 203
Δ EBIT from Base		-$ 27.0	-$ 80
%		-10%	-28%
N loss (kg N/ha/year)	45.7	42.0	37.8
Δ N loss from Base		-4	-8
%		-8%	-17%
Δ EBIT/kg N reduced		-$ 7.25	-$ 10.09

6.4 Scenario 3: Minimise P, sediment and microorganism losses

6.4.1 Spring applications of P fertiliser are in September in the form of DAP Sulphur Super. This has been amended to a straight application of P fertiliser in November, with the other elements of the P fertiliser being applied in October.

6.4.2 With the VSA results suggesting the grazing area has a low sediment runoff risk, the primary areas of concern are the critical source areas.

6.4.3 A further 3.7ha of the Plane country has been retired to protect the head of a stream that springs up on the farm. This has required fencing off all around, and water being reticulated to the two new paddocks that are created.

6.4.5 Scenario 3 resulted in a 5.5% reduction in P from the base model.

6.4.6 With the balance of the farming operation remaining unchanged from the base model, Scenario 3 is projected to decrease EBIT by $44/ha from the base model to 239/ha primarily due to increased feed costs from the retirement of 3.7ha of grazing area.

6.4.7 However interest costs are also expected to increase by $23.24/ha due to the costs of capital fencing assuming the cost of borrowing at 8%pa.

Block	P Losses		
	P kg/ha	Soil	Fert
Silage	2.2	High	Medium
Truckable	2.3	High	Medium
Plane	0.7	Low	N/A
Swede Kale JJ	1.0	N/A	N/A
Winter Oats	0.9	N/A	N/A
Swede Kale May	1.0	N/A	N/A
New Riparian	0.1	N/A	N/A
Ave	**1.6**		

6.5 Farmer commentary on N reductions

6.5.1 As stated above, the farmer is not happy with the requirements for increased Maize silage purchases. This was something the operation was trying to avoid when they purchased the runoff block.

6.5.2 The need to retire further land to exclude stock from the head of a waterway that is only grazed a couple of times a year, is not very palatable. The rest of the farm is well fenced and this area will require a large area of fencing and land retired, to protect a relatively small area of stream. In addition, reticulated water will need to be put into the two small paddocks created by this retirement.

6.5.3 Reduction in cropping can be mitigated by purchase of supplementary feed but this has been shown to have a negative impact on the EBIT.

6.6 Best Management Practice

6.6.1 This is a drystock operation with newly metalled races in many places due to external contractor work, so there is almost no scouring of tracks and very little soil visible on the tracks.

6.6.2 The farmer has been using Nutrient budgets in conjunction with his fertiliser applications for many years, but has not used this information to look deeper at his farming operation. However he is conscious of the environment and the farm's impact on it.

6.6.3 There is one large ephemeral waterway that flows across the middle of the farm in very wet winter weather, but this is impossible to fence and although it is a large body of water in wet weather, it is definitely not a permanent feature.

6.6.4 There was evidence of some sedimentary runoff from the crop establishment the previous year. However, in this region of the country heavy, isolated downpours are not uncommon and can be very localised, making them hard to predict or mitigate against.

Appendix 7: Case Study G: Allophanic Dairy Heifer Grazing – Pasture/Cropping

7.1 Base Model for Case Study G

7.1.1 Description of operation

- This farm is a drystock trading property with a 66% dairy support component. This comprises a mixture of dairy replacements and some winter dairy cows. Numbers and types of dairy animals can vary from year to year depending on climatic conditions and trading values
- The main line of heifer calves arrives on May 1 for one year and left in-calf. A smaller line of heifer calves also came on in December and also left in-calf in May. There are a small number of winter grazing dairy cows as well
- Only 3% of the effective farm area is used for winter cropping with a further 27% of the effective area harvested for pasture silage.
- 29% of the property is flat country which is used for maize, under which the 3% of cropping takes place.
- No supplements are imported into this operation.
- No Nitrogen fertiliser is applied to the pastoral operation.
- Superten 7k is applied across all of the pastoral areas of the farm at 30kg P/ha in October.
- On the Maize block, Serpentine Super 25K is applied at maize planting (22kg P/ha) along with DAP (28kg N/ha and 32kg P/ha), a side dressing of Urea is applied in December (115kg N/ha). When the new grass is planted in April DAP is also applied (28kg N/ha and 30kg P/ha).
- Kale is planted under a small part of the maize crop, as a low yielding winter crop, using 118kg N/ha.

7.1.2 Climate and contour

- The rainfall average for this property is 1,501mm per annum.
- This property is predominantly Ash across the hill country with only the flat maize block being of pumice.
- Approximately 68ha is in areas which are already fenced off and stock excluded. These protect small waterways running through the farm and some of the steeper more erosion prone country.

- There are some areas of erosion showing in the steeper country but the farmer is very conscious of these and undertakes best management practice of maintaining higher covers on this country and grazing with lambs where possible.
- The majority of the fencing off on this property has been undertaken, and all waterways leaving the property are stock excluded and run through the maize block which is predominantly cropped and grazed infrequently.

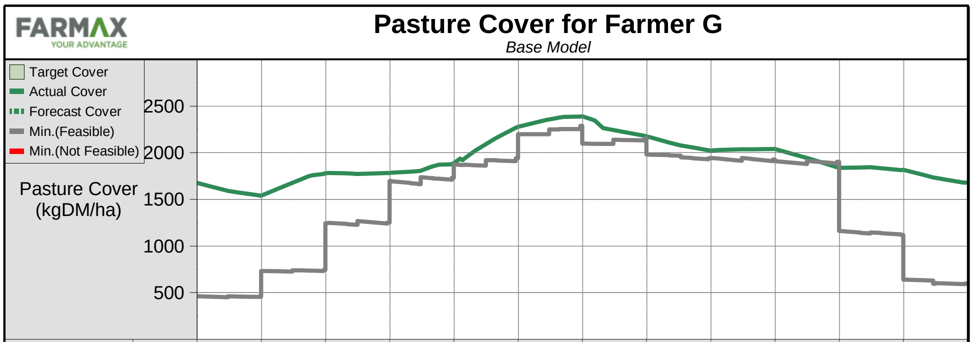
7.1.3 Soil

- Soils on the property are predominantly of the Otorohanga class of Allophanic soils which is described as Allophanic with a profile of sandy loam or loamy silt, both of which use sandy loam as their Top Soil Texture description for Overseer™. The soil descriptions from the S-Map data would be Otor_28a.1, Otoro_19a.1 and Otoro_33a.2.
- Average Olsen P levels over the farm are 24-28 for the pastoral blocks and 17 for the maize block. The farm nutrient budget indicates a loss in inorganic P levels of 33 for the rolling country, 9 for the easy country, 4 for the steep country and an increase of 2 for the maize block. Decreases of 5 units Olsen P/ha are predicted on the rolling block, 2 units on the easy and steep country and no change on the maize block.
- Visual soil assessments (VSA) were completed on the property on the maize block, planted in grass and on a paddock in the steep block. Soil quality was rated either poor (<10), moderate (10-20) or good (>20).
- Results for the soil indicators totalled 21/28 and 20.5/28 for the maize/grass and steep paddock respectively. The plant indicators totalled 30/30 for both blocks.
- With all indicators rating 'good' in the VSA assessments suggests that there is a minimal sediment runoff risk over the majority of the effective area.
- The lower soil scores on both blocks were predominantly attributed to very low earthworm counts and some minor soil porosity and compaction issues.

Size	150-200ha	**Soil Type**	74% Allophanic
Ave Rainfall	1501	**Ave PET**	781
Ave Olsen P	24	**Area already**	68ha
Pasture (exlc Maize)	5% developed rye/clover, 95% browntop		
VSA		**Soil score**	**Plant score**
	Maize/Grass	21/28	20.5/28
	Steep	30/30	30/30

7.1.4 Pasture

- Pastures predominantly consist of Browntop combined with some low grade clover plants in the mixture on the permanent pasture blocks on the farm. The contour of this farm is not conducive to cropping or re-grassing, so much of the farm is in low producing pastures and is unlikely to be changed.



Month	Start	J	A	S	O	N	D	J	F	M	A	M	J
Forecast/Actual	1,676	1,539	1,777	1,782	1,887	2,275	2,390	2,174	2,021	2,038	1,837	1,815	1,676
Minimum	459	458	740	1,248	1,730	1,938	2,287	2,155	1,940	1,924	1,902	1,117	596

7.1.5 Limitations to N reductions

- Contour is the biggest limiting factor. This farmer is focussed on profit and ease of operation, as he is the only labour unit. However, with a flexible system, he is able and willing to make changes to maximise nutrient retention, as long as they are financially viable.

7.1.6 Overseer™ outputs from effective area

- Modelling of the base scenario for Farmer G in Overseer™ version 6.1.3 estimated annual losses of 27.2kg N/ha over the effective area and 1.1kg P/ha over the effective area. These losses did not take into account any loses from domestic dwellings on the property nor any areas already retired.

Block	N Leaching	AWC	P Losses		
	kg/ha	Difference	P kg/ha	Soil	Fert
Rolling	22	15.4mm	2.5	High	Extreme
Easy Hill	31	15.7mm	1.0	Medium	High
Steep Hill	19	18.4mm	1.4	Medium	High
Maize	29	147.4mm	0.5	N/A	N/A
Autumn Kale	32	147.4mm	2.2	N/A	N/A
Total/Ave	**27.2**		**1.1**		

7.2 Scenario 2: Reduce nitrogen leaching (20%)

7.2.1 The following iterative changes were made to the base model in order to achieve an N loss reduction of 19.0% from the base model. Due to the contour of this property, it was very hard to make changes to the system that were significant, so the modelling stage of 10% reduction was omitted and a 20% solution was modelled:

a) Remove the mob of 40 young breeding cows from the operation
b) Reduce winter dairy grazers by 53
c) Increase trade winter lambs to 1140 from 500.
d) Cut an additional 34% of the farm for baleage, predominantly from annual ryegrass planted following the annual maize crops, rather than grazing it.

Block	N Leaching kg/Ha	Drinking Water N
Rolling	20	2.7ppm
Easy Hill	28	N/A
Steep Hill	18	N/A
Maize + c/c grass	8	0.9ppm
Autumn Kale	31	3.2ppm
Maize & Graze	28	3.2ppm
Total/Ave	**22.1**	

7.2.2 Scenario 1 resulted in a 19.0% reduction in N loss. The farmer has no permanent capital stock, so he was happy to consider these changes to his management regime.
7.2.3 The above changes resulted in an increase in EBIT of $423/ha to $1,529/ha over the effective area.
7.2.4 This is equivalent to an increase in profitability of $81.94/kg N loss reduction achieved.

Financial comparison of N loss changes

Farmer G

	Base	Scenario 1	Scenario 2
Pasture harvested (kg DM/ha)	10,180		9,842
Stocking rate (SU/ha) [1]	15.2		13.8
Dairy heifers	64%		70%
Carryover dairy cows	0%		0%
Winter dairy cows	2%		2%
Dairy support sub-total	66%		72%
Sheep	4%		11%
Beef	30%		17%
Deer	0%		0%
Net product (kg/SQha)	302		314
Liveweight wintered (kg/ha)	934		809
Winter crop used (% farm area)	3%		3%
Cash crop used (% of farm area)	29%		29%
N applied to pasture (kg/ha/year)	0		0
Supplement purchased (kg DM/ha)	0		0
Supplement harvested (% farm area)	27%		61%
EBIT	$ 1,106		$ 1,529
Δ EBIT from Base			$ 423
%			38%
N loss (kg N/ha/year)	27.2		22.1
Δ N loss from Base			-5
%			-19%
Δ EBIT/kg N reduced			$ 81.94

7.3 Scenario 3: Minimise P, sediment and microorganism losses

7.3.1 Spring applications of Superten fertiliser are in October, moving this to November is the only major amendment to this system.

7.3.2 With already low P losses across the farm and well-fenced areas of stock exclusion from waterways, there is very little additional work that could be done to decrease sediment run off.

7.3.3 With stock excluded from waterways there is little opportunity for micro-organisms to enter the waterways.

7.3.4 After some historical erosion issues on the steeper hill country, under different management, the current management is focussed on maintaining covers on the steeper land and grazing with lambs, wherever possible.

7.3.5 At current application rates of P fertiliser, the farm is losing an average of 5 units of Olsen P/ha/yr across the pastoral operation, from an average soil test of 24 units. This will need addressing in the near future, at which point P losses will naturally increase.

7.3.6 The change in timing of fertiliser application should have no effect on the EBIT for this operation, but the reduction in P loss is 15% from the base.

Block	P Losses		
	P kg/ha	Soil	Fert
Rolling	2.1	High	Medium
Easy Hill	0.8	Medium	Low
Steep Hill	1.1	Medium	Medium
Maize + c/c grass	0.5	N/A	N/A
Autumn Kale	2.2	N/A	N/A
Total/Ave	0.9		

7.4 Farmer commentary on N & P reductions

7.4.1 Due to the trading nature of the operation, and in light of the fact that the proposed changes would make the farmer more money, he is very keen to consider these changes.

7.4.2 Amending P fertiliser applications to November is feasible, especially with his own airstrip on the property.

7.5 Best Management Practice

7.5.1 This is a drystock operation with mostly grass and ash races, so there is some risk of runoff along the tracks in high rainfall but there is not much evidence of scouring issues.

7.5.2 The farmer is very aware of looking after his steeper country to maintain soil and reduce the risk of erosion.

7.5.3 For personal reasons, this property is not farmed to its maximum potential, so there is good opportunity to maintain pasture covers and therefore soil health and retention.

APPENDIX 8: CASE STUDY H: ALLOPHANIC MA WINTER COW GRAZING – PASTURE AND CROPPING

8.1 Base Model for Case Study H

8.1.1 Description of operation

- This is a large station with a 5% winter MA dairy cow grazing operation for a neighbouring dairy farm.
- The property runs breeding operations of cattle, sheep and deer.
- Winter MA dairy grazers are on the property from late May to late July. There are no dairy heifer replacements grazed on the property.
- 5% of the effective area of the farm is used for winter cropping, 83% of which is predominantly used for the dairy grazing operation.
- 6% of the effective area of the farm is used to harvest supplement.
- No supplement is bought in off farm.
- Nitrogen fertiliser is applied at 7kg N/ha over the effective area predominantly in the mid to late spring period.
- Phosphate fertiliser is applied at 20kg P/ha over the effective area from August to November.

8.1.2 Climate and contour

- The rainfall average for this property is 1,544mm per annum.
- This farm has a small proportion of flats with the main contour being a mixture of relatively intensive rolling country and extensive easy hill country blocks.
- Approximately 330ha is already retired, fenced off and stock excluded. This area comprises a mixture of swampy areas, riparian streams and steeper sidlings.
- There was a small amount of erosion evident where cattle had been grazing steeper sidlings.
- There is approximately an additional 5ha within the sheep and beef block which requires fencing to remove stock from spring heads within paddock areas.

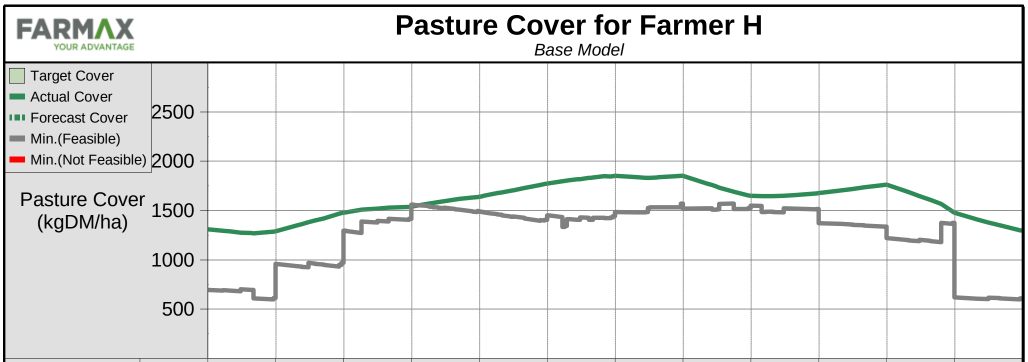
8.1.3 Soil

- On a property of this size there is a mixture of soils, but the predominant ones are a Haparangi Ash which is described as Allophanic with a profile of loamy sand. Its soil description from the S-Map data is Hapa_3a.2.
- Olsen P levels across the farm are estimated are 21 for the steeper hill country, increasing to 27 on the rolling blocks and 45 on the flat country. The farm nutrient budget indicates a decrease in inorganic P levels in the soil of between 5-9kg P/ha/yr on the Allophanic country. This equates to a decrease in Olsen P of approximately 1-2 units per year on these soils.
- Visual soil assessments (VSA) were completed on the property on both of the predominant contour categories; 'Rolling' and 'Hill'. Soil quality was rated either poor (<10), moderate (10-20) or good (>20).
- Results for the soil indicators totalled 32/40 and 34/40 for the rolling and hill areas respectively. The plant indicators totalled 22.5/28 and 24.5/28 for the rolling and the hill areas respectively.
- With all indicators rating 'good' in the VSA assessments suggests that there is a minimal sediment runoff risk over the majority of the effective area.

Size	+300Ha	**Soil Type**	51% Allophanic
Ave Rainfall	1544	**Ave PET**	832
Olsen P	21-45	**Area already retired**	330ha
Pasture	28% developed rye/clover, 72% Browntop		
VSA		**Soil score**	**Plant score**
	Rolling	32/40	22.5/28
	Hill	34/40	24.5/28

8.1.4 Pasture

- Pastures predominantly consist of Browntop due to the contour of much of the area and the scale of the property. Approximately 28% of the farm has undergone a pasture renovation programme and is in a ryegrass/clover mix.



Month	Start	J	A	S	O	N	D	J	F	M	A	M	J
Forecast/Actual	1,309	1,287	1,477	1,537	1,636	1,772	1,850	1,851	1,646	1,673	1,762	1,475	1,293
Minimum	694	610	970	1,413	1,492	1,403	1,440	1,570	1,522	1,514	1,334	1,374	609

8.1.5 Limitations to N reductions

- Due to the small percentage of dairy support on this large scale property any N loss will have to be from the whole operation, not focussed on the MA winter dairy grazers.
- Reducing cropping is the most obvious way to reduce N loss but this is the most profitable enterprise on the farm.

8.1.6 Overseer™ outputs from effective area

- Modelling of the base scenario for Farmer H in Overseer™ version 6.1.3 estimated annual losses of 28.2kg N/ha over the effective area and 2.3kg P/ha over the effective area. These losses did not take into account any loses from domestic dwellings on the property nor any areas already retired.
- Due to largely varying numbers of animals grazing the winter crop over the three month period, the crop had to be modelled in two blocks Jun/July and August. Where the crop has been reduced to mitigate N loss, this has been proportionately split between these two nominal blocks.

Block	N leaching kg N/ha	AWC	P Losses P kg/ha	Soil	Fert
Down	11	10.2mm	3.5	High	Extreme
Hill	9	13.8mm	1.1	Medium	Medium
Mowable	13	10.2mm	2.4	High	High
Deer Flats	17	10.2mm	0.9	Medium	Low
Deer Hill	14	13.8mm	1.0	Medium	Medium
Winter Swede Deer	294	<10mm	1.5	N/A	N/A
Spring Oats	73	<10mm	1.1	N/A	N/A
Winter Swede Cows JJ	296	<10mm	1.5	N/A	N/A
Winter Swede Cows Aug	286	<10mm	1.5	N/A	N/A
Total/Ave	**28.2**		**2.3**		

8.2 Scenario 1: Reduce nitrogen leaching (10%)

8.2.1 The following iterative changes were made to the base model in order to achieve an N loss reduction of 10.9% from the base model:

a) Reduce winter crop area by 23%.
b) Reduce breeding cows by 13%, along with associated offspring
c) An additional 3% of the effective area is harvested to silage, which is fed out on farm.

Block	N leaching kg N/ha	Drinking Water N
Down	12	N/A
Hill	9	N/A
Mowable	13	1.7
Deer Flats	17	2.1
Deer Hill	14	N/A
Winter Swede Deer	294	**29.9**
Spring Oats	72	7.5
Winter Swede Cows JJ	304	**30.6**
Winter Swede Cows Aug	293	**29.8**
Total/Ave	**25.1**	

8.2.2 Scenario 1 resulted in a 10.9% reduction in N loss and did not require major destocking therefore was deemed acceptable by the farmer.

8.2.3 These changes resulted in a reduction of $6/ha from the original EBIT to $187/ha.

8.2.4 This is equivalent to an annual decrease in profitability of ($1.96)/kg N loss reduction achieved.

8.3 Scenario 2: Reduce nitrogen leaching (20%)

8.3.1 Further changes were made to Scenario 1 in order to achieve an N loss reduction of 19.0% from the base model.

d) Further reduce winter crop by 22%, to 60% of the original area.
e) Further reduce breeding cows and associated progeny by 9%, to 80% of the original total.
f) An additional 2% of the effective area is harvested to silage, which is fed out on farm.

Block	**N leaching kg N/ha**	**Drinking Water N**
Down	12	N/A
Hill	9	N/A
Mowable	13	1.7
Deer Flats	17	2.1
Deer Hill	14	N/A
Winter Swede Deer	294	**29.9**
Spring Oats	72	7.5
Winter Swede Cows JJ	310	**31.2**
Winter Swede Cows Aug	297	**30.2**
Total/Ave	**22.8**	

8.3.2 Scenario 2 resulted in a 19.0% reduction in N from the base model but required further destocking of capital breeding cows.

8.3.3 These changes resulted in a reduction of $6/ha from the original EBIT to $187/ha.

8.3.4 This is equivalent to an annual decrease in profitability of ($1.12)/kg N loss reduction achieved.

Financial comparison of N loss changes

Farmer H

	Base	Scenario 1	Scenario 2
Pasture harvested (kg DM/ha)	6,294	6,279	6,242
Stocking rate (SU/ha) [1]	12.1	12.0	11.9
Dairy heifers	0%	0%	0%
Carryover dairy cows	0%	0%	0%
Winter dairy cows	5%	5%	5%
Dairy support sub-total	5%	5%	5%
Sheep	45%	46%	46%
Beef	24%	22%	22%
Deer	26%	27%	27%
Net product (kg/SQha)	252	250	248
Liveweight wintered (kg/ha)	898	890	883
Winter crop used (% farm area)	5%	4%	3%
Cash crop used (% of farm area)	0%	0%	0%
N applied to pasture (kg/ha/year)	7	7	7
Supplement purchased (kg DM/ha)	0	0	0
Supplement harvested (% farm area)	6%	9%	11%
EBIT	$ 193	$ 187	$ 187
Δ EBIT from Base		-$ 6.0	-$ 6
%		-3%	-3%
N loss (kg N/ha/year)	28.2	25.1	22.8
Δ N loss from Base		-3	-5
%		-11%	-19%
Δ EBIT/kg N reduced		-$ 1.96	-$ 1.12

8.4 Scenario 3: Minimise P, sediment and microorganism losses

8.4.1 Current applications of P are not sufficient to maintain Olsen P levels in the soil, so a capital fertiliser programme for phosphate will need to be implemented at some point, which will increase P losses from this system.

8.4.2 Current timings of P vary from August to November. Those applications of P in the high-risk months (pre November) have, for the main part, been amended to November. However, the application of Pasturemag 7K in September has been left in place, due to the timing requirements to meet animal health needs.

8.4.3 With the VSA results suggesting the grazing area has a low sediment runoff risk the primary area of concern are the critical source areas.

8.4.4 It is estimated 5ha of effective grazing area will need to be retired from the sheep and cattle block given the lay of the land with 6,100m of 4 wire electric fencing required to exclude cattle and sheep.

8.4.5 With the balance of the farming operation remaining unchanged, Scenario 1 is projected to decrease EBIT by $8.79/ha to $184/ha primarily due to increased supplementary feed costs due to a reduction in effective grazing area.

8.4.6 Additionally interest costs are expected to increase by $6.49/ha due to the costs of capital fencing and planting assuming the cost of borrowing at 8%pa.

Block	**P Losses**		
	P kg/ha	**Soil**	**Fert**
Down	3.1	High	Medium
Hill	1.1	Medium	Medium
Mowable	2.1	High	Medium
Deer Flats	0.9	Medium	Low
Deer Hill	0.9	Medium	Low
Winter Swede Deer	1.5	N/A	N/A
Spring Oats	1.1	N/A	N/A
Winter Swede Cows JJ	1.5	N/A	N/A
Winter Swede Cows Aug	1.5	N/A	N/A
New Retired	0	N/A	N/A
Total/Ave	**2.1**		

8.5 Farmer commentary on N and P reductions

8.5.1 The farmer was happy to implement all suggestions relating to N and P loss however was concerned that reducing his breeding cow numbers any further would limit his ability to maintain pasture quality.

Appendix 9: Farmer I: Allophanic – Maize Cropping

9.1 Base Model for Farmer I

9.1.1 Description of operation

- Farmer I runs a small block, in close proximity to his main dairy unit. A large portion of this block is cropped annually for maize and the rest is used for grazing replacement heifers.
- Heifer calves arrive on the support block as 90kg weaners in September and are carried through to the end of April. At the same time a small line of weaner beef steers are also on the block. From May replacement rising two year heifers are carried on the block until they leave for mating at the end of September.
- There is no winter cropping undertaken on the property but 62% of the property is in a permanent maize crop cycle. An additional 33% of the farm is cut for silage and fed out on the block.
- No Nitrogen fertiliser is applied to the pastoral block, which receives 19kg P/ha as Superten in the autumn.
- Due to the continual cropping of the maize block and consequent low mineral N reserves in the soil, the area planted receives around 540kg N/ha/yr, over half of this is in chook manure and dry feedpad scrapings, and the rest is split between N-Rich Urea and Sustain.

9.1.2 Climate and contour

- The rainfall average for this property is 1,350mm per annum.
- This farm is classified as rolling contour. However there are some smaller areas of river flats on the heifer block which are prone to winter flooding.
- There is a fast flowing stream on one of the boundaries, this is stock excluded for the majority of its length[1] and the farmer has one grass buffer paddock between the maize crop and the stream.
- There are no erosion concerns.

9.1.3 Soil

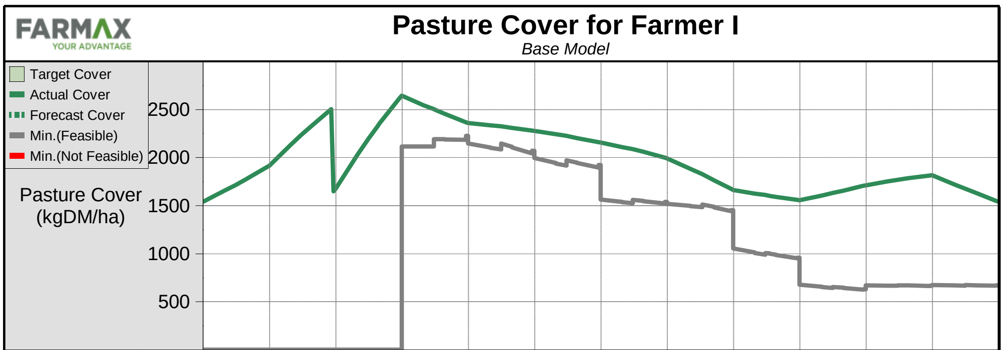
- Soils on the property are Horotiu which is an Allophanic soil. Its soil description from the S-Map data is Otor_19a.1, and recommendation is to use 'Loamy Silt' for the soil texture in Overseer™ inputs.

- Average Olsen P levels from soil tests, are 24 for the pastoral area. The farm nutrient budget indicates an annual decrease of 3 units of Olsen P levels in the inorganic soil pool.
- Two visual soil assessments (VSA) were completed, both on the pastoral area, one on the river flats and the other on the more ‘average’ rolling terrain. Soil quality was rated either poor (<10), moderate (10-20) or good (>20).
- Results for the soil indicators totalled were 20/28 and 25/28 for the river flats and rolling terrain respectively. Results for the plant indicators totalled 26/30 and 24/30 for the river flats and rolling terrain respectively.
- With all indicators rating ‘good’ in the VSA assessments this suggests that there is a minimal sediment runoff risk over the majority of the effective area.
- The limiting factors on river flats block were some signs of issues with soil structure and capacity, caused by flooding, plus very low earthworm counts.

Size	0-50ha	**Soil Type**	100% Allophanic
Ave Rainfall	1350	**Ave PET**	849
Ave Olsen P	24	**Area already retired**	0 ha
Pasture	100% developed rye/clover		
VSA		**Soil score**	**Plant score**
	River Flats	20/28	26/30
	Rolling	25/28	24/30

9.1.4 Pasture

- Pastures predominantly consist of ryegrass and white clover species with pasture renovation evident in recent years. There is some evidence of damage to pastures on the lower lying, flood-prone areas.



Month	Start	J	A	S	O	N	D	J	F	M	A	M	J
Forecast/Actual	1,538	1,914	1,671	2,642	2,357	2,274	2,154	1,991	1,660	1,556	1,710	1,815	1,540
Minimum					2,225	2,069	1,921	1,537	1,450	957	629	667	669

9.1.5 Limitations to N reductions

- The maize silage crop is an integral part of the owned dairy unit. With relatively low rates of mineralisation in the soil due to continual cropping, high inputs of Nitrogen are required to maintain the high yielding crops. However by using slow release inputs such as chook manure, the farmer is looking after the soil on this block at the same time as ensuring the yield remains viable.
- This is a very small block and not all of it can be harvested for silage, so there will always be a requirement for some animals to eat pasture.

9.1.6 Overseer™ outputs from effective area

- Modelling of the base scenario in Overseer™ version 6.1.3 estimated annual losses of 46.3kg N/ha 0.7kg P/ha over the effective area. These losses did not take into account any loses from domestic dwellings on the property nor any areas already retired.

Block	N Leaching kg/ha	AWC Diff	P Losses		
			P kg/ha	Soil	Fert
Heifer Block	37	16.6mm	0.4	Low	Low
Maize Block	52	147.4mm	0.8	N/A	N/A
Total/Ave	**46.3**		**0.7**		

9.2 Scenario 2: Reduce nitrogen leaching (20%)

9.2.1 Due to the fact this is a small block with over 60% of it in maize silage, options for mitigation were limited. To get to a realistic scenario that left reasonable sized mobs of animals on the pastoral area, only a 20% scenario was modelled.

a) Retain R2 dairy heifers for five months and R1 steers for 7 months
b) Eliminate all weaner dairy heifers
c) Cut and sell 130t DM of baleage from annual grass planted post-maize harvest.

Block	N leaching kg/ha	Drinking Water N
H Runoff	22	3.6ppm
D Runoff	48	6.9ppm
Total/Ave	**37.0**	

9.2.2 Scenario 2 resulted in a 20.1% reduction in N loss from base. Due to the requirements to maintain maize production and the contour of the block, this reduction has been achieved with a transferral of animals and feed off the block. The resulting decrease in nitrogen leaching is very likely to be identically matched by a corresponding increase on the home dairy farm. However, with no facilities to handle sheep and no desire to farm them, the options for nitrogen reduction on this block were not ideal.

9.2.3 The above changes resulted in an increase in EBIT of $52/ha to $3,199/ha over the original effective area.

9.2.4 This is equivalent to an annual increase in profitability of $5.57/kg N loss reduction achieved.

Financial comparison of N loss changes

	Base	Scenario 1	Scenario 2
Pasture harvested (kg DM/ha)	11,740		9,641
Stocking rate (SU/ha) [1]	14.2		6.0
Dairy heifers	100%		100%
Carryover dairy cows	0%		0%
Winter dairy cows	0%		0%
Dairy support sub-total	100%		100%
Sheep	0%		0%
Beef	0%		0%
Deer	0%		0%
Net product (kg/SQha)	266		47
Liveweight wintered (kg/ha)	1067		1067
Winter crop used (% farm area)	0%		0%
Cash crop used (% of farm area)	62%		62%
N applied to pasture (kg/ha/year)	0		0
Supplement purchased (kg DM/ha)	0		0
Supplement harvested (% farm area)	33%		151%
EBIT	$ 3,147		$ 3,199
Δ EBIT from Base			$ 52
%			2%
N loss (kg N/ha/year)	46.3		37.0
Δ N loss from Base			-9
%			-20%
Δ EBIT/kg N reduced			$ 5.57

9.3 Scenario 3: Minimise P, sediment and microorganism losses

9.3.1 The only waterway associated with this property is on the boundary, and already fenced off and stock excluded. This waterway also has a grass paddock as a buffer to the maize cropping carried out on the property.

9.3.2 There is a risk of sediment and microorganism loss to waterways due to flooding on the lower paddocks but this is not an issue that is controllable by the farmer. To remove this risk, he would have to avoid grazing livestock on the areas adjacent to the river at any time, which is not feasible.

9.3.3 The VSA results suggest the grazing area has a low sediment runoff risk.

9.3.4 Phosphate fertiliser is currently applied in the autumn, outside of the high risk months.

9.3.5 Olsen P levels are falling by three units annually on the pastoral area of the farm. This will need addressing at some point and P losses will naturally increase when this occurs

9.3.6 Currently, there are no further areas requiring retirement in this dairy support operation, so there are no associated costs.

9.4 Farmer commentary on N and P reductions

9.4.1 This farmer was very comfortable with the removal of the dairy weaner heifers from this block. By creating more baleage, he will still have the feed to maintain them.

9.4.2 The scenario modelled for reduction did not have a huge impact on his operation as the weaner heifers grazed on the block were only part of the overall replacement mob.

9.4.3 As the farmer was not willing to reduce the maize area or yield and the status quo N fertiliser inputs were advised to be required to achieve these yields, any reductions in N fertiliser applications on the Maize area was not modelled as a mitigation. However there is potential to further reduce N losses by more closely aligning fertiliser N inputs with maize N requirements.

9.5 Best Management Practice

9.5.1 This farmer is very conscious of his effects on the environment. His considered approach to continuous cropping of one block for maize silage shows in the results he achieves and the relatively low Nitrogen losses compared with Nitrogen inputs.

9.5.2 He has considered the dynamics of the block and has limited maize production to the better country, away from the waterway, to prevent soil loss and minimise overland losses to waterways.

9.5.1 The farm has an access way but no real lanes through it, so any losses from lanes, and associated areas of bare dirt, are almost negligible.

9.6.1 This farmer has an excellent understanding of the Nitrogen cycles and was very aware of the need to ensure that any reductions in nitrogen loss from his dairy support block were not just transferred to the dairy platform.

9.6.2 With no infra-structure, such as a feed pad on the dairy platform, there was no opportunity for mitigation of N loss from returned animals or feed. For this reason, the opportunity to look at the autumn calving option was relevant to this operation.

9.6.3 This farmer is very conscious of the environment and long-term viability of his whole operation.

APPENDIX 10: FARMER J: ALLOPHANIC MA WINTER COW GRAZING – PREDOMINANTLY PASTURE

10.1 Base Model for Farmer J

10.1.1 Description of operation

- Farmer J has only owned animals on his dairy support operation. This operation is divided into two blocks, one of which adjoins the dairy; the other is in close proximity. The property runs a mixture of calves, yearlings, winter dairy grazers and weaner bulls
- Heifer calves arrive on the support block as 100kg weaners in mid-December. Owned heifers are taken through to 23 months of age before leaving the support block at the end of the June.
- There is no winter cropping undertaken on the property and 76% of the effective area is harvested for pasture silage and baleage. About 75% of this conserved feed is fed on the property with the remainder being used on the adjoining dairy farm.
- Nitrogen fertiliser is applied at 20kg N/ha over the effective area as a foliar spray in autumn.
- Phosphate fertiliser is applied at 32kg P/ha over the effective area in November and March.

10.1.2 Climate and contour

- The rainfall average for this property is 1,360mm per annum.
- This farm is all rolling contour.
- Wetter lower lying areas have already been fenced off and planted up and the whole operation is run with a long-term sustainable approach.
- There are no erosion concerns.
- There is no additional land to be fenced off to improve the environmental aspects of this property

10.1.3 Soil

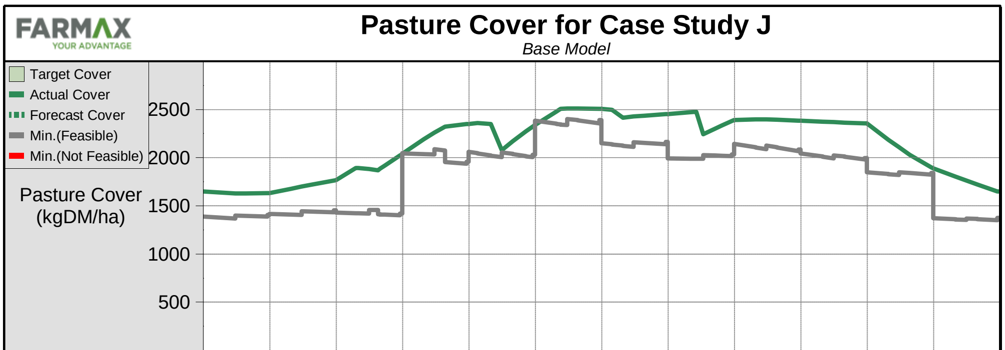
- Soils on the property are Horotiu which is an Allophanic soil. Its soil description from the S-Map data is Otor_19a.1, and recommendation is to use 'Loamy Silt' for the soil texture in Overseer™ inputs.

- Average Olsen P levels over the farm, from soil tests, are 25. The farm nutrient budget indicates no increase in the inorganic P levels in the soil.
- Visual soil assessments (VSA) were completed on a recently regrassed paddock and another that had been set-stocked through the winter period. Soil quality was rated either poor (<10), moderate (10-20) or good (>20).
- Results for the VSA was100%for both areas, in both soil and plant tests. This was the only property in the study to score over 20 earthworms per ‘spade square’.
- With all indicators rating ‘good’ in the VSA assessments this suggests that there is a minimal sediment runoff risk over the majority of the effective area.
- The pasture is exceptionally well managed and with a thick grass sward there is little opportunity for sediment run-off.

Size	0-50ha	**Soil Type**	100% Allophanic
Ave Rainfall	1360	**Ave PET**	845
Ave Olsen P	25	**Area already retired**	1.5ha
Pasture	100% developed rye/clover		
VSA		**Soil score**	**Plant score**
	Average	28/28	30/30

10.1.4 Pasture

- Pastures predominantly consist of ryegrass and white clover species with pasture renovation evident in recent years. The farm has been run under the same management for many years and the farm is now in a stable developed state.



Month	Start	J	A	S	O	N	D	J	F	M	A	M	J
Forecast/Actual	1,648	1,631	1,764	2,037	2,348	2,336	2,505	2,450	2,389	2,382	2,354	1,886	1,648
Minimum	1,387	1,403	1,453	1,418	1,956	2,029	2,389	2,163	2,033	2,085	1,994	1,838	1,374

10.1.5 Limitations to N reductions

- This case study is a smaller owned runoff which needs to fulfil its support role.
- There is very little N being applied as fertiliser, additionally it is foliar N.

10.1.6 Overseer™ outputs from effective area

- Modelling of the base scenario in Overseer™ version 6.1.3 estimated annual losses of 18.8kg N/ha 0.5kg P/ha over the effective area. These losses did not take into account any loses from domestic dwellings on the property nor any areas already retired.

Block	N Leaching kg/ha	AWC Diff	P Losses P kg/ha	Soil	Fert
H Runoff	17	16.6mm	0.5	Low	Low
D Runoff	21	16.6mm	0.5	Low	Low
Total/Ave	**18.8**		**0.5**		

10.2 Scenario 2: Reduce nitrogen leaching (20%)

10.2.1 Due to the close links between the dairy support and the dairy platform, any changes to reduce N loss need to be a system change. The following iterative changes were made to the base model in order to achieve an N loss reduction of 22.2% from the base model:

a) Assume autumn calving on the dairy platform and exchange 70 winter cows with 70 dried off autumn calvers, on from December to March
b) Remove autumn N
c) cut and sell an additional 105 baleage bales, due to better pasture utilisation
d) Alter timing of supplementary feed to fit new feed demands.

Block	N leaching kg/ha	Drinking Water N
H Runoff	14	2.4ppm
D Runoff	16	2.7ppm
Total/Ave	**14.6**	

10.2.2 Scenario 2 resulted in a 22.2% reduction in N loss from base. The move to autumn calving was acceptable to the farmer because it was a management change he was considering employing to reduce the impact of late calvers and dry cows.

10.2.3 The above changes resulted in a reduction in EBIT of ($161)/ha to $359/ha over the original effective area, assuming a reduced summer grazing rate of $15/hd/wk over summer for the autumn calvers.

10.2.4 This is equivalent to an annual loss in profitability of ($38.64)/kg N loss reduction achieved.

Financial comparison of N loss changes

Farmer J

	Base	Scenario 1	Scenario 2
Pasture harvested (kg DM/ha)	10,594		10,297
Stocking rate (SU/ha) [1]	17.1		16.3
Dairy heifers	77%		81%
Carryover dairy cows	0%		0%
Winter dairy cows	23%		19%
Dairy support sub-total	100%		100%
Sheep	0%		0%
Beef	0%		0%
Deer	0%		0%
Net product (kg/SQha)	403		348
Liveweight wintered (kg/ha)	1102		419
Winter crop used (% farm area)	0%		0%
Cash crop used (% of farm area)	0%		0%
N applied to pasture (kg/ha/year)	20		0
Supplement purchased (kg DM/ha)	83		83
Supplement harvested (% farm area)	76%		76%
EBIT	$ 520		$ 359
Δ EBIT from Base			-$ 161
%			-31%
N loss (kg N/ha/year)	18.8		14.6
Δ N loss from Base			-4
%			-22%
Δ EBIT/kg N reduced			-$ 38.64

10.3 Scenario 3: Minimise P, sediment and microorganism losses

10.3.1 Due to the fact that there is no calculated increase in the inorganic soil pool for this property sediment runoff risk the primary area of concern are the critical source areas.

10.3.2 In addition, the VSA results suggest the grazing area has a low sediment runoff risk.

10.3.3 There are no further areas requiring retirement in this dairy support operation, so there are no associated costs.

10.4 Farmer commentary on N and P reductions

10.4.1 This farmer was very comfortable with the change to autumn calving for part of his dairy operation, and understood the dynamics of the changed system.

10.4.2 He was very comfortable that this result was not just transference of nitrogen from one part of his system to another.

10.5 Best Management Practices

10.5.1 This is an exceptional farmer who has a long term, in-depth view of the sustainable nature of his operation.

10.5.2 The pasture management on this property, coupled with a genuine desire to protect the long term environmental viability of this operation is an epitome of "Best Management Practice"

10.5.3 This farmer has an excellent understanding of the Nitrogen cycles and was very aware of the need to ensure that any reductions in nitrogen loss from his dairy support block were not just transferred to the dairy platform.

10.5.4 With no infra-structure, such as a feed pad on the dairy platform, there was no opportunity for mitigation of N loss from returned animals or feed. For this reason, the opportunity to look at the autumn calving option was relevant to this operation.

10.5.5 This farmer is very conscious of the environment and long-term viability of his whole operation.

Appendix 11: Farmer K: Allophanic Heifer Replacement Grazing – Predominantly Pasture

11.1 Base Model for Farmer K

11.1.1 Description of operation

- This property is focussed on a heifer replacement grazing operation, with a small proportion of winter dairy cows on for two months of the year. The dairy support activities comprise 36% of the overall operation
- The majority of the owned stock on the property are a breeding and finishing sheep operation, complemented by a small beef finishing component.
- Dairy heifers arrive on the property in mid December at110kg and remain on the property until the end of April the following year.
- A total of 2% of the effective area of the farm is used for winter cropping, which is predominantly used for the dairy grazing operation.
- 8% of the effective area is used for harvesting silage.
- No supplement is bought in off farm.
- There is no Nitrogen fertiliser applied to the property
- Phosphate fertiliser is applied at an average of 21kg P/ha over the effective area with a small amount in December but the majority in August.

11.1.2 Climate and contour

- The rainfall average for this property is 1,568mm per annum.
- This contour of this farm is 50% in easy hill, with 16% in flats used for finishing and the remainder in rolling hill country.
- Approximately 119ha is already retired, fenced off and stock excluded. This area comprises a mixture of swampy areas, riparian streams and steeper sidlings.
- There is approximately an additional 2ha which requires fencing to remove stock from spring heads within paddock areas.

11.1.3 Soil

- The property is an even split between Allophanic and Podzol with the better country being used for growing the young heifers and finishing cattle.
- Olsen P levels across the farm are 19 for the easy hill country, increasing to 36 on the rolling blocks and 48 on the flat country. The farm nutrient budget indicates a

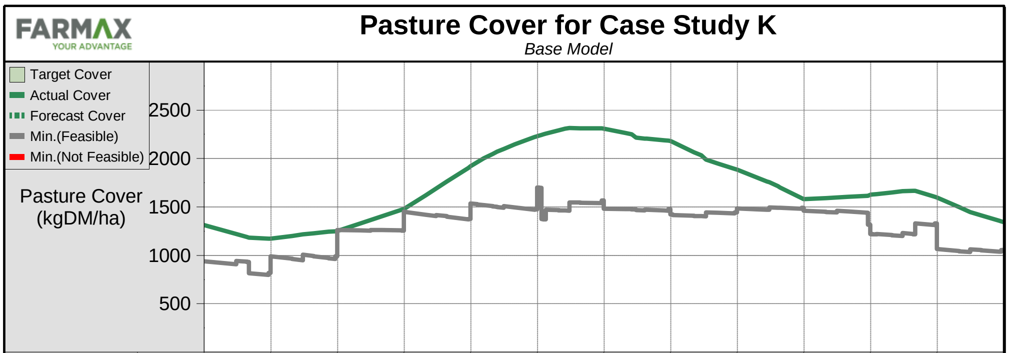
decrease in inorganic P levels in the soil of between 21-28kg P/ha/yr on the Allophanic country. This equates to an increase in Olsen P of approximately 2-3 units per year on these soils.

- Visual soil assessments (VSA) were completed on the property on both of the predominant contour categories; 'Rolling' and 'Hill'. Soil quality was rated either poor (<10), moderate (10-20) or good (>20).
- Results for the soil indicators totalled 32/40 and 30/40 for the rolling and hill areas respectively. The plant indicators totalled 25/28 and 25/28 for the rolling and the hill areas respectively.
- With all indicators rating 'good' in the VSA assessments suggests that there is a minimal sediment runoff risk over the majority of the effective area.

Size	+300Ha	**Soil Type**	50% Allophanic
Ave Rainfall	1568	**Ave PET**	827
Olsen P	19-48	**Area already retired**	119ha
Pasture	100% developed rye/clover		
VSA		**Soil score**	**Plant score**
	Rolling	32/40	25/28
	Hill	30/40	25/28

11.1.4 Pasture

- There has been a small amount of pasture renovation on the flat areas of the farm over the years however the majority of the property is in native species predominantly Browntop.



Month	Start	J	A	S	O	N	D	J	F	M	A	M	J
Forecast/Actual	1,312	1,170	1,249	1,477	1,917	2,229	2,308	2,180	1,883	1,579	1,623	1,596	1,341
Minimum	936	816	990	1,252	1,374	1,474	1,565	1,476	1,441	1,490	1,313	1,328	1,052

11.1.5 Limitations to N reductions

- This property is not currently managed intensively and already has low levels of nitrogen leaching.
- A significant reduction in profitability is not an option for this Farmer.

11.1.6 Overseer™ outputs from effective area

- Modelling of the base scenario for Farmer K in Overseer™ version 6.1.3 estimated annual losses of 17.6kg N/ha over the effective area and 3.6kg P/ha over the effective area. These losses did not take into account any loses from domestic dwellings on the property nor any areas already retired.

Block	N leaching kg N/ha	AWC	P Losses P kg/ha	Soil	Fert
Heifer	17	<10mm	0.7	Low	Medium
Finish	17	<10mm	0.7	Low	Medium
B Finish	13	<10mm	0.3	Low	Low
Store	11	37.1mm	6.5	Extreme	Extreme
Graze	11	37.1mm	6.5	Extreme	Extreme
Kale	202	16.1mm	0.4	N/A	N/A
Total/Ave	**17.6**		**3.6**		

11.2 Scenario 1: Reduce nitrogen leaching (10%)

11.2.1 The following iterative changes were made to the base model in order to achieve an N loss reduction of 9.9% from the base model:

a) Reduce winter crop area by 50%.
b) Cut an additional 7% of the effective area for supplement, which is fed out on farm.

Block	N leaching kg N/ha	Drinking Water N
Heifer	16	2.1ppm
Finish	17	2.2ppm
B Finish	14	1.7ppm
Store	11	N/A
Graze	11	N/A
Kale	224	**22.2ppm**
Total/Ave	**15.8**	

11.2.2 Scenario 1 resulted in a 9.9% reduction in N loss and did not require any destocking therefore was deemed acceptable by the farmer.

11.2.3 The above changes resulted in a decrease in EBIT of $8/ha to $326/ha.

11.2.4 This is equivalent to an annual decrease in profitability of $4.59/kg N loss reduction achieved.

11.3 Scenario 2: Reduce nitrogen leaching (20%)

11.3.1 Further changes were made to Scenario 1 in order to achieve an N loss reduction of 23.3% from the base model.

c) Remove Kale crop completely.
d) Cut an additional 6% of the effective area for supplement, which is fed out on farm
e) Purchase 19kg DM/ha in the form of baleage for winter supplementary feed.

Block	N leaching kg N/ha	Drinking Water N
Heifer	15	1.9ppm
Finish	18	2.2ppm
B Finish	14	1.7ppm
Store	11	N/A
Graze	11	N/A
Total/Ave	**13.5**	

11.3.2 Scenario 2 resulted in a 23.3% reduction in N from the base model. There was no requirement for destocking, and the majority of the supplementary feed required was produced on farm.

11.3.3 These changes resulted in a $30/ha reduction from the original EBIT to $304/ha.

11.3.4 This is equivalent to an annual decrease in profitability of ($7.34)/kg N loss reduction achieved.

11.4 Scenario 2A: Reduce nitrogen leaching (20%) and optimise farm system

11.4.1 Further changes were made to Scenario 2 in order to reduce the impact on operating profitability by improving farm productivity while maintaining an N loss reduction of 24% from the base model:

f) Increase lambing percentage of the MA ewes from 133% to 135%
g) Increase lambing percentage of the 2 tooth ewes from 126% to 135%
h) Mate all ewe hoggets over 40kg liveweight.
i) Cut an additional 3% of the effective area and sell as baleage.

Block	N leaching kg N/ha	Drinking Water N
Heifer	15	1.8ppm
Finish	18	2.2ppm
B Finish	14	1.7ppm
Store	11	N/A
Graze	11	N/A
Total/Ave	**13.3**	

11.4.2 Scenario 2A resulted in a 24.4% reduction in N from the base model. This additional reduction in N loss is primarily due to a decrease in MA ewe numbers.

11.4.3 These changes resulted in a $77/ha increase from the Scenario 2 EBIT to $381/ha.

11.4.4 These changes resulted in a $47/ha increase from the original EBIT to $381/ha.

11.4.5 This is equivalent to an annual increase in profitability of $10.9/kg N loss reduction achieved.

Financial comparison of N loss changes

	Base	Scenario 1	Scenario 2
Pasture harvested (kg DM/ha)	7,246	7,310	7,338
Stocking rate (SU/ha) [1]	13.2	13.3	13.3
Dairy heifers	36%	36%	36%
Carryover dairy cows	0%	0%	0%
Winter dairy cows	0%	0%	0%
Dairy support sub-total	36%	36%	36%
Sheep	55%	55%	55%
Beef	9%	9%	9%
Deer	0%	0%	0%
Net product (kg/SQha)	293	294	294
Liveweight wintered (kg/ha)	925	928	928
Winter crop used (% farm area)	2%	1%	0%
Cash crop used (% of farm area)	0%	0%	0%
N applied to pasture (kg/ha/year)	0	0	0
Supplement purchased (kg DM/ha)	0	0	19
Supplement harvested (% farm area)	8%	15%	21%
EBIT	$ 334	$ 326	$ 304
Δ EBIT from Base		-$ 8.0	-$ 30
%		-2%	-9%
N loss (kg N/ha/year)	17.6	15.8	13.5
Δ N loss from Base		-2	-4
%		-10%	-23%
Δ EBIT/kg N reduced		-$ 4.59	-$ 7.34

11.5 Scenario 3: Minimise P, sediment and microorganism losses

11.5.1 Current applications of P are not sufficient to maintain Olsen P levels in the soil, so a capital fertiliser programme for phosphate will need to be implemented at some point, which will increase P losses from this system.

11.5.2 The majority of P applications are in August and these have been moved to November to avoid the high risk months.

11.5.3 With the VSA results suggesting the grazing area has a low sediment runoff risk the primary area of concern are the critical source areas.

11.5.4 It is estimated 2ha of effective grazing area will need to be retired from the sheep and cattle block given the lay of the land with 2,000m of 4 wire electric fencing required to exclude cattle and sheep.

11.5.5 With the balance of the farming operation remaining unchanged, Scenario 1 is projected to decrease EBIT by $5.00/ha to $329/ha primarily due to increased supplementary feed costs due to a reduction in effective grazing area.

11.5.6 Additionally interest costs are expected to increase by $3.03/ha due to the costs of capital fencing and planting assuming the cost of borrowing at 8%pa.

Block	P Losses		
	P kg/ha	Soil	Fert
Heifer	0.7	Low	Medium
Finish	0.7	Low	Medium
B Finish	0.3	Low	Low
Store	6.5	Extreme	Extreme
Graze	6.5	Extreme	Extreme
Kale	0.4	N/A	N/A
New Riparian	0.1	N/A	N/A
Total/Ave	**3.1**		

11.6 Farmer commentary on N and P reductions

11.6.1 The reduction in EBIT of $8.0/ha in scenario 1 was deemed acceptable by the farmer however the reduction in EBIT of $30/ha in scenario 2 was not deemed acceptable.

APPENDIX 12: CASE STUDY COSTS AND PRICES

Key income assumptions

Livestock revenue

Lamb price	$	5.50	/kg cwt	
Mutton price	$	2.80	/kg cwt	
Cull cow price	$	2.90	/kg cwt	
Beef price	$	3.90	/kg cwt	
Deer price	$	7.50	/kg cwt	
Wool price	$	3.40	/kg greasy 37 micron main shear	
Velvet price	$	50	/kg	

Grazing revenue

<9 months of age	$	6.00	/head/week	
10-22 months of age	$	9.00	/head/week	
Winter grazing	$	23.00	/head/week	(May to August)
Carry over cow	$	9.00	/head/week	(excl (May - August)
Summer Cow grazing	$	15.00	/head/week	(autumn calving cows))

Feed revenue

Baleage (200kg DM)	$	80	/bale
Maize silage	$	0.34	kg DM

Farm working expenses

Stock expenses	UWDSA		
Animal health			/SU
Electricity	$	18.00	/ha
Shearing			
Ewe	$	3.55	/head
Lamb	$	3.25	/head
Ram	$	5.00	/head
Crutch	$	1.50	/head

Feed expenses

Supplement expenses

Grass silage/hay (incl. post-cut fert)	$	440	/ha
Baleage (200kg DM) (incl post cut fert)	$	45	/bale
Maize silage - grown	$	2,400	/ha
Maize silage - purchased	$	0.34	/kg DM
Winter forage crops (incl. fert)	$	1,100	/ha
Summer forage (incl. fert)	$	600	/ha
Palm kernel expeller meal	$	300	/t delivered
Calf feed	$	850	/t delivered

Other working expenses

Fertiliser & lime (case studies > 50ha)	$	10.00	/SU
Nitrogen	$	984	/t urea applied
Farm stores	$	5.00	/ha
Freight	$	5.00	/ha
Regrassing	$	600	/ha
Weed & pest control	$	19	/ha
Vehicle expenses	$	32	/ha
Repairs & Maintenance	$	50	/ha

Overheads

Administration			
Accounting	$	4,000	/entity
Advisory/legal	$	3,000	/entity
General administration	$	2,550	/entity
Insurance	$	14	/ha
Rates	$	45	/ha
Depreciation	$	70	/ha for farms <400ha
	$	35	/ha for farms >400ha