BEFORE THE ENVIRONMENT COURT
CHRISTCHURCH REGISTRY

ENV-2016-CHC-014

IN THE MATTER	of an appeal under Section 120 Resource Management Act 1991
BETWEEN	**SCHRADER MAINS LIMITED**
	Appellant
AND	**SOUTHLAND REGIONAL COUNCIL**
	Respondent

BRIEF OF EVIDENCE OF MIRANDA JANE HUNTER

GALLAWAY COOK ALLAN
LAWYERS
DUNEDIN

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Introduction

1. My name is Miranda Jane Hunter. I hold a Bachelor of Agricultural Science Degree from Lincoln College. I am member of the New Zealand Institute of Primary Industry Management and have been involved in the dairy industry in consultancy, practical farming and dairy industry leadership roles since 1987. I have completed the Sustainable Nutrient Management Courses (Intermediate and Advanced) and am a Certified Nutrient Management Adviser.

2. I am a Director and Shareholder of South Coast Dairies Limited which owns and operates a 135 hectare dairy platform at Curio Bay. The company converted the land to dairying in 2010. My involvement in this property, with my other business partners, has been to develop a sustainable farming business in all facets, including environmental. The property has been awarded several environmental awards including winner of the 2011 Environment Southland Farming Award.

3. In my previous role as DairyNZ Regional Leader for the Southern South Island I worked extensively with dairy farmers in the Waituna Catchment. This involved working in collaboration with the Environment Southland ("ES") Sustainability Team completing on farm visits to support farmers in implementing good practice techniques and develop environmental action plans (in collaboration with ES, Milk Supply Company and Federated Farmers).

4. I resigned from DairyNZ in June 2012 and I am currently self employed as a Farm Consultant (trading as Roslin Consultancy Limited). I work with dairy farmers throughout Southland and Otago supporting them in developing Farm Environmental Management Plans ("FEMP") and improving their on farm management. I also undertake research projects working as team member involving nutrient management, farm systems and economics modelling. Projects completed under contract to

DairyNZ include; “On farm practice for mitigating N losses to water – impacts on dairy farm systems in the Southern South Island” and “Understanding the economic impacts of nutrient limits on Waituna farms and catchment”, which I have **attached** at appendix 1.

5. I have read the Code of Conduct for Expert Witnesses within the Environment Court Consolidated Practice Note 2014 and I agree to comply with that Code. This evidence is within my area of expertise, except where I state I am relying on what I have been told by another person. To the best of my knowledge I have not omitted to consider any material facts known to me that might alter or detract from the opinions I express.

Methodology to develop new farm system proposal

6. When a significant farm system change is being considered (such as land use change) it is critical that the assumptions that sit behind this change are well founded. The methodology I utilise to work through this are as follows:

   (a) Complete a farm inspection;

      (i) Assess resources at hand - physical and management.

   (b) Discuss the proposal with the farmer (and their individual farm consultant if relevant). A key part of this is to determine the farmers farm system preferences in terms of intensity of the operation and level of inputs, their appetite for economic risk and system complexity.

   (c) Use practical and technical experience to develop an achievable long term farming system.

   (d) Run the proposed farm system through a farm systems modelling programme to check that it is feasible from a feed supply and demand perspective.

(e) Cross check the farm system with the farmer / their farm consultant prior to final sign off.

7. Once the above steps are completed, I then run the proposed farm system through Overseer to assess the nutrient losses. This may result in further discussion / modification of the farm system.

My Involvement with Schrader Mains Limited

8. As part of application for the land use consent to establish a dairy farm, Schrader Mains Ltd engaged Roslin Consultancy Limited to prepare nutrient budgets for the current land use and the proposed conversion. A nutrient management plan was also completed. The nutrient budget was prepared using Overseer version 6.2.0. The modelling has been redone in July 2016 to reflect the new version of Overseer (6.2.2, released 2016) and to update the current farm system (2015 /16). My evidence will focus on the revised modelling that has superseded previous modelling.

9. The nutrient budgets were prepared using "Overseer, Best Practice Data Input Standards, May 2016". No deviations from these protocols were made during the modelling assumptions. Farm systems information was provided by Hank Schrader for the existing land use. The proposed land use was modelled under a long term status quo scenario, modelling a system that Schraders have operated on their other properties for several years and are comfortable with operating as a long term practice. Soils information was assessed from the Environment Southland GIS mapping service and soil settings were obtained from SMap. Climate settings were obtained from the Overseer climate station tool. All assumptions have been discussed in detail with Hank Schrader, and Hank displays a good level of understanding of the inputs and assumptions that have been used.

10. The property currently operates as a dairy grazing unit (young stock grazing and dairy cow wintering) and a beef unit. The

proposal is to convert the property to a dairy farm, peak milking 306 cows, with up to 90 cows wintered (on 4 ha of winter crop) on the property. All young stock and the balance of the cows wintered will be off farm.

11. A stand off pad is planned for the property. Because the standoff pad will be utilised during wet weather conditions rather than a set time usage it has not been included within the Overseer modelling. This means that the Overseer model has represents the 'worst case' and is a conservative estimate of the proposed loses. Use of the stand off pad will also contribute to lower nutrient losses than predicted in current nutrient budget modelling.

12. The estimated results of the nutrient budget are as follows:

	Existing Operation 15/16	**Proposed Conversion**
Total Farm N Loss	4337 kg N	3164 kg N
N Loss/ha	39 kg N / ha / year	29 kg N / ha / year
N Concentration in Drainage	Pastoral – 5.1 to 6.3 ppm Fodder crops – 18.4 ppm	Pastoral – 4.0 to 6.0 ppm Fodder crop – 24.2 ppm
Total Farm P Loss	44 kg P	80 kg P
Average P loss/ha	0.4 kg P /ha/yr	0.7 kg P /ha/yr

13. Overseer predicts the N loss to decrease from 39 to 29 kg N / ha / year. The key driver of the predicted decrease in N loss from the property is the decrease in winter crop area (from 20ha to 4ha). The decrease in crop area is due to less animals being wintered on the property.

14. Overseer predicts the P loss to increase from 0.4 to 0.7 kg P / ha / year. The key driver of the predicted increase in P loss from the property is the loss from other farm sources. P loss at a block level remains similar (35 kg P / ha / year compared with 36 kg P /

ha / year). The block level losses are the predicted P losses from pasture and crop areas where the predominant loss pathways are overland flow and/or artificial drainage. The balance of the P loss estimated by Overseer is from 'other sources' including losses from pads, races and yards, and effluent management systems (such as from uncovered stored solid effluent). Refer to a summary of P losses and pathways in table below;

Existing Operation

Block	**Leaching other (kg P / ha / yr)**	**Run off (kg P / ha / yr)**	**Direct (animals, drains) (kg P / ha / yr)**
Pastoral Woodlands		0.2	0.1
Effluent Woodlands			
Pastoral Dacre		0.3	0.2
Kale		0.5	
Whole Farm	0.1	0.2	0.4
Proposed Conversion**Block**	**Leaching other (kg P / ha / yr)**	**Run off (kg P / ha / yr)**	**Direct (animals, drains) (kg P / ha / yr)**
Pastoral Woodlands		0.2	0.1
Effluent Woodlands		0.2	0.1
Pastoral Dacre		0.4	0.2
Kale		0.5	
Whole Farm	0.4	0.2	0.1

Good Management Practices

15. Overseer assumes that certain good management practices are being implemented on each farm. Techniques include:

(a) applying fertiliser and nitrogen at the appropriate rate, form and time; and

(b) effluent applications only occur when soil conditions are appropriate.

Reducing N loss beyond good management practice generally requires farm system change (reduction in stocking rate, reduction in N use, and change in stock type) or investment in infrastructure (off paddock systems).

16. However in respect of P loss Overseer does not currently account for many of the farm management techniques that can be employed to manage P loss from 'other sources' (or non-block losses) or at block level. Other sources account for 9 kg P / ha / year in the existing operation and 44 kg / ha / year in the proposed conversion. Overseer models P lost from other sources including losses from pads, races and yards, and effluent management systems (such as from uncovered stored solid effluent). The numerous techniques that can be employed to eliminate or minimise P loss pathways are receiving considerable research attention to understand their effectiveness. Recent studies have demonstrated that a significant reduction in actual P losses can be achieved.

17. Because individual farm landscape features can impact significantly on P loss, reductions are achieved by applying the right strategies that address source and transport pathways present on each property. The table below identifies opportunities for P loss mitigation and if it is rewarded in Overseer.

Phosphorus Loss Mitigation	Rewarded in Overseer®?
Fencing Streams	Yes
Appropriate fertiliser rates	Yes
Conversion to more efficient irrigation system	Partially - already assumes very high efficiency
Avoiding high risk times for fertiliser application	Yes
Change fertiliser type	Yes
Targeting optimum Olsen P	Yes
Precision fertiliser placement	Partially through lower application rates
Cultivating with contour - rather than up and down slope	No
Infrastructure to keep stock away from unfenced streams (e.g. troughs, shade)	No
Culverts and bridges	No
Managing track runoff	No
Shifting break fences strategically	No
Filter areas downstream of unfenced waterways	Partially - only if wetland able to be captured
Uncultivated ephemeral stream margins	No
Erosion control plantings	No
Spreading fertiliser evenly	No - assumed already
Reducing ability of stock to form camps	No
Avoiding applying fertiliser directly into streams	No

The table shows a list of management tools that will result in less P loss to water, and explains whether or not their use is recognised by Overseer. Please see the report prepared by Rebecca Hyde & James Hoban: *Hurunui-Waiau Nutrient Budgeting Case Studies*, **attached** at appendix 2.

18. Estimating the reduction in P loss that can be achieved by implementing good practice is difficult to do in general terms because it is heavily site specific. On the Schrader Mains property it will include the following techniques:

(a) Managing critical source areas – increasing the buffer zones next to waterways in low lying swale areas by increasing the riparian fencing distance.

(b) Managing laneways and bridges to reduce risk of run off by ensuring that lanes are located away from waterways where possible. Where lanes are located near a waterway they will be sloped so that any run off goes into vegetation. Bridges and bridge approaches will have nib walls constructed to ensure that any run off is not directed into the waterway.

(c) Critical source areas within winter crop paddocks will be managed through strategic grazing.

(d) Containing solid effluent to avoid run off/overland flow from stored solid effluent to ground or surface water.

19. An example of the reduction in contaminants that can be achieved can be found in the work completed in a P21 trail at Telford where strategic grazing of a winter crop (managing the critical source areas) reduced the sediment and P loss by 80 to 90% compared to standard grazing method. **Attached** at appendix 3 is the report *"Reducing Overland Flow and Sediment Losses From Winter Forage Crop Paddocks Grazed By Dairy Cows"* and the Diary NZ Fact Sheet incorporating the findings from the P21 Trial.

20. The following table shows the effectiveness (% total P decrease) of a range of mitigation strategies.

Table 1. Range of cost and effectiveness of good management practices to mitigate plot scale P losses on New Zealand dairy farms (McDowell and Nash, 2012; McDowell, 2014).

Good management practice		Main targeted P form(s)	Cost - Range (USD $/kg P conserved)[1]	Effectiveness (% total P decrease)
Optimum soil test P	Management	Dissolved and Particulate	(highly cost-effective)[2]	5-20
Low P farming system (split pastures)		Dissolved and Particulate	(330)	25-30
Low solubility P fertilizer		Dissolved and Particulate	0-20	0-20
Stream fencing		Dissolved and Particulate	2 - 45	10-30
Restricted grazing of cropland		Particulate	30 - 200	30-50
Greater effluent pond storage / application area		Dissolved and Particulate	2 - 30	10-30
Flood irrigation management[3]		Dissolved and Particulate	2 - 200	40-60
Low rate effluent application to land		Dissolved and Particulate	5 - 35	10-30
Tile drain amendments	Amendment	Dissolved and Particulate	20 - 75	50
Red mud (bauxite residue)		Dissolved	75 - 150	20-98
Alum to pasture		Dissolved	110 - >400	5-30
Alum to grazed cropland		Dissolved	120 - 220	30
Grass buffer strips	Edge of field	Dissolved	20 - >200	0-20
Sorbents in and near streams		Dissolved and Particulate	275	20
Sediment traps		Particulate	>400	10-20
Dams and water recycling		Dissolved and Particulate	(200) - 400[4]	50-95
Constructed wetlands		Particulate	100 - >400[5]	-426-77
Natural seepage wetlands		Particulate	100 - >400[5]	<10%

[1] numbers in parentheses represent net benefit, not cost.
[2] depends on existing soil test P concentration.
[3] includes adjusting check timings to decrease outwash < 10% of inflow, installation of bunds to prevent outwash, and re-levelling of old irrigation borders.
[4] upper bound only applicable to retention dams combined with water recycling.
[5] potential for wetlands to act as a source of P renders upper estimates for cost infinite.

21. There is a significant opportunity to reduce the P loss through targeted good management practices that are not modelled through Overseer.

22. With reference to the tables above the following good management practices will be adopted on the Schrader Mains property:

(a) Optimum soil test P;

(b) Low solubility P fertiliser;

(c) Stream fencing;

(d) Rirparian planting;

(e) Bridges and culverts;

(f) Managing track run off;

(g) Greater effluent pond storage/application area;

(h) No flood irrigation will occur (not applicable to this property);

(i) Use of low rate effluent application to land;

(j) Grass buffer strips/uncultivated ephemeral stream margins (increased sizing for critical source areas);

(k) Strategic grazing of winter forage crop; and

(l) Tile drain amendments.

23. The methods identified above at paragraphs (d), (e), (f), (j), (k) and (l) are not rewarded within Overseer under the best practise data input standard protocols. In my opinion the established riparian margins and management of critical source areas (such as swales) will provide the largest benefit on this property. Laneway management and amendments to bridges will also assist in reducing losses from non-block sources. There is also the

opportunity explore the practicality of putting into place tile drain amendments on the major tile systems (approximately 3) to run drainage outflow into buffer zones prior to entering the waterway. Because these measures are not modelled through Overseer, I believe that the Overseer model is highly likely to be over predicting the P loss. Research identified above would suggest that the likely reductions will be significant, albeit difficult to accurately quantify.

Proposed Southland Water and Land Plan

24. On the 3rd of June 2016 ES notified its Proposed Southland Water and Land Plan ("PSWLP"). The rules seek to control dairy farming and intensive winter grazing. Given that the PSWLP will control the use of the application site in the event that the proposed conversion does not obtain consent I was asked to assess what kind of farm system could be undertaken as a permitted activity under the new rules.

25. The most likely option given the level of development (fencing, riparian planting, lane development) that has already occurred on the property would be to utilise the property as a specialist grazing unit. This could also complement the other farms owned by Schrader Mains.

26. The application site is identified as being within the Gleyed Physiographic Zone which allows up to 50ha of intensive winter grazing to occur as a permitted activity. I have developed a grazing scenario that would comply with the permitted activity rules. This would involve growing 48ha of crop (fodder beet and kale), wintering 900 cows and 150 yearlings. The estimated nutrient loss of this scenario being modelled through Overseer are as follows:

	Existing Operation 15/16	Specialist Grazier
Total Farm N Loss	4337 kg N	4675 kg N
N Loss/ha	39 kg N / ha / year	43 kg N / ha / year
N Concentration in Drainage	Pastoral – 5.1 to 6.3 ppm Fodder crops – 18.4 ppm	Pastoral – 4.4 to 5.6 ppm Fodder crop – 8.8 to 20.2 ppm
Total Farm P Loss	44 kg P	50 kg P
Average P loss/ha	0.4 kg P /ha/yr	0.5 kg P /ha/yr

Under the proposed rules the specialist grazing operation will need to adopt GMP. Therefore many of the same mitigation methods discussed above would also be employed. For the Southern South Island the winter is a high risk period for nutrient loss due to drainage over this period. The graphs below summarise the feed demand of stock under the different scenarios (existing operation, proposed conversion and specialist grazier). The specialist grazier has the majority of stock on during a high risk period.

Existing Operation

The estimated monthly metabolic energy (ME) requirements (MJ ME), dry matter (DM) intake (kg DM) and excreta N (urine + dung, kg N/month) of animal enterprises is shown below

● ME Requirements ○ DM Intake ○ Excreta N

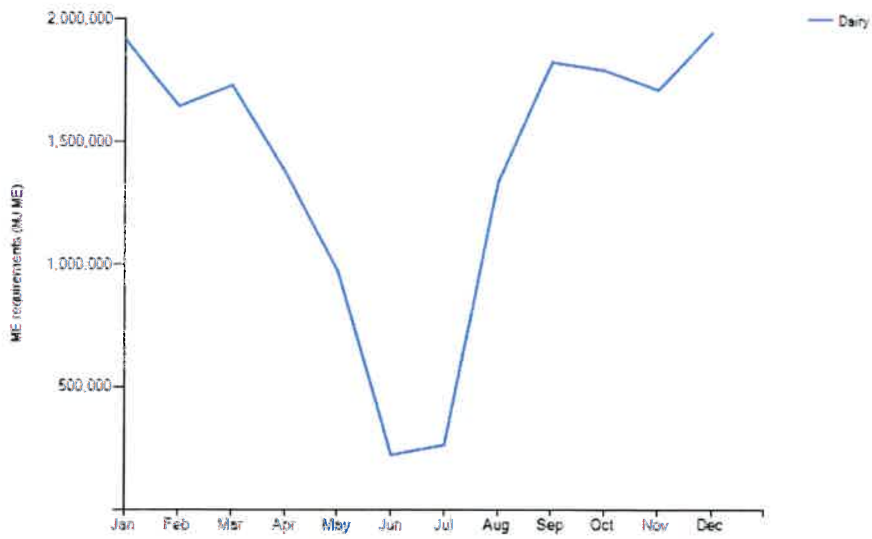
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
/ dairy grazing	1,266,783	1,086,906	1,089,910	1,032,870	699,136	1,081,586	1,096,065	688,911	583,395	654,225	831,594	1,248,472	**11,361,853**
	1,266,783	**1,086,906**	**1,089,910**	**1,032,870**	**699,136**	**1,081,586**	**1,096,065**	**688,911**	**583,395**	**654,225**	**831,594**	**1,248,472**	

Proposed Conversion

The estimated monthly metabolic energy (ME) requirements (MJ ME), dry matter (DM) intake (kg DM) and excreta N (urine + dung, kg N/month) of animal enterprises is shown below

● ME Requirements ○ DM Intake ○ Excreta N

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Dairy	1,919,532	1,644,903	1,731,110	1,375,251	969,875	221,969	262,512	1,338,292	1,825,247	1,790,864	1,711,787	1,945,188	**16,736,340**
Total	**1,919,532**	**1,644,903**	**1,731,110**	**1,375,251**	**969,875**	**221,969**	**262,512**	**1,338,292**	**1,825,247**	**1,790,864**	**1,711,787**	**1,945,188**	

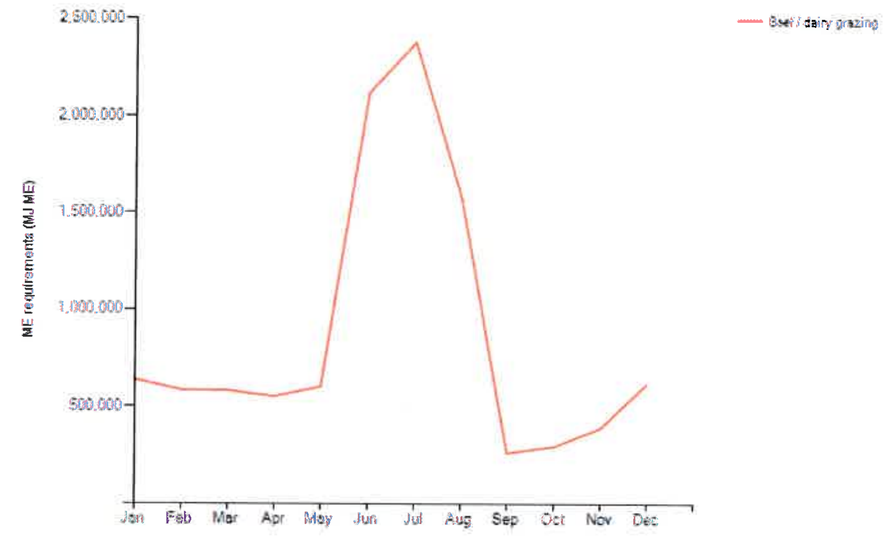


Specialist Grazier

The estimated monthly metabolic energy (ME) requirements (MJ ME), dry matter (DM) intake (kg DM) and excreta N (urine + dung, kg N/month) of animal enterprises is shown below.

◉ ME Requirements ○ DM Intake ○ Excreta N

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Beef / dairy grazing	638,302	582,580	580,713	549,798	600,562	2,117,009	2,376,802	1,573,016	259,193	292,825	387,425	617,970	**10,575,395**
Total	**638,302**	**582,580**	**580,713**	**549,798**	**600,562**	**2,117,009**	**2,376,802**	**1,573,016**	**259,193**	**292,825**	**387,425**	**617,970**	



Miranda Hunter
Roslin Consultancy

15th July 2016

APPENDIX 1

Understanding the economic impacts of nutrient limits on Waituna farms and catchment

Background

To assess the impact of nutrient allocation limits being set in the Waituna Catchment in Southland, a comprehensive economic modelling study was undertaken. This study evaluated the options available to reduce farm nutrient losses and assessed what the impacts of different nutrient reduction targets would be on individual farms and the wider catchment. These findings allow the economic and social values of the catchment to be taken into consideration together with other technical information as part of any decision making process. This work aims to contribute towards finding a long-term solution for the Waituna Lagoon in which sustainable farming and a thriving community can be ensured alongside a healthy catchment and lagoon ecosystem.

Key findings

Impacts on individual farms:

1. On-farm strategies required to reduce N are very different than for P (Fig. 1, Table 1). Uncertainty around which nutrient should be targeted represents a significant business risk to individual farmers.
2. The response of individual farms to different nutrient reduction scenarios is highly variable due to differences in system type, existing leaching rates, soil type, stage of development and farmer practices and philosophy (Fig. 2).
3. A limit setting approach which 'grandparents' existing nutrient loss rates but requires a uniform percentage reduction leaching across all farms irrespective of system or farm type would heavily penalise low intensity farms.
4. Nutrient reduction scenarios of less than 10% for N and 5% for P have relatively small (within 5%) impacts on farm operating profit.

Nitrogen

5. For N reduction, impacts on operating profit are greatest for low intensity farms due to the limited options available to further mitigate N without moving to capital investment (e.g. stand-off pads). High intensity farms have higher N losses and in turn more options available to reduce N leaching.

Phosphorus

6. Reducing P losses is challenging with limited options available for the dominant soil types in the catchment. P reductions greater than 5% will have significant impacts on farm operating profit for most system types. Reductions beyond 15-25% could not be modelled as most farms were no longer viable.

Land Use

7. The profitability of support blocks is heavily dependent on winter grazing. Mitigation strategies aimed at winter grazing will therefore have significant financial risks for these businesses.
8. Wintering cows outside of the catchment will significantly reduce nutrient leaching but is not considered a long-term sustainable solution by Waituna farmers.

Debt Levels

9. Farms with a higher debt, for example farms recently purchased or developed, will be more severely impacted by reductions in farm OP.

10. Higher debt makes farm businesses less resilient to shocks such as low milk prices or adverse weather.

11. Short-term reductions in profit due to mitigation action may also affect the ability of famers to afford new mitigation options through investment in technology or infrastructure.

12. The cost of mitigation is slightly exacerbated by temporarily lower milk prices but the greatest effect is the longer time period needed to recover, because mitigation has reduced the ability to take advantage of the higher payout years.

Impacts on the catchment:

13. Current operating profit (before drawings, debt servicing and taxes) for all Waituna catchment farms is estimated to be 25 million dollars annually (range 20-29 million dollars) (Table 2).

14. Nutrient reductions greater than 15% for N and 5% for P start to demonstrate significant impacts on operating profit at the farm and catchment scale.

15. N reduction scenarios of -25%, -35% and -50% are estimated to lead to reductions in catchment operating profit of 3, 8 and 12 million dollars, respectively, per annum (Table 2).

16. The greatest impacts are observed for Dairy Support and Sheep & Beef farms, with scenarios targeting >25% N reduction leading to businesses no longer being viable (100% reduction in operating profit).

17. Actual impacts at the farm and catchment scale are much greater once debt levels are taken into consideration.

Table 1: Summary of on-farm mitigation strategies required to reduce nitrogen and phosphorus losses by less than 10%, 10 to 20% and more than 20%. Strategies in green are considered practical with little change on existing farm operation, strategies in orange will impact farm operation but can be undertaken if necessary, and strategies in red will have significant impacts on existing farm operations. The best combination of measures within each category is highly farm-specific.

	Nitrogen	Phosphorus
<10%	(green) Nitrogen – reducing use / changing timing (green) Improved management of farm dairy effluent (orange) Reduce crop area (higher yielding crops) or change cultivation technique (orange) Low N autumn feed (red) Decrease stock numbers	(green) Effluent area (green) Optimum Olsen P on soil test (green) Low solubility P fertiliser (orange) Cultivation practices (red) On/off grazing autumn/spring (red) Retiring land (red) Out of catchment wintering
<10-20%	(orange) Remove culls earlier (orange) On / off autumn grazing (red) Off paddock wintering	
>20%	(red) Remove winter crop area (red) Wintering out of catchment (red) Lifting winter crop and feeding out (red) On/off autumn grazing and off-paddock winter (red) Retiring land (red) Significant decrease in stock numbers	

Table 2: Results of four nitrogen reduction scenarios on catchment-wide annual operating profit (OP, in million dollars per year) for Dairy, Dairy Support, Sheep & Beef and all farms in the Waituna catchment. OP reflects farm profit before debt servicing, taxes and principal repayments or drawings beyond estimated market wages, and should not be interpreted as actual profit. Sensitivity of dairy clustering technique represents the economic baseline and impact as a range based on different clustering approaches to extrapolate the model farms to all dairy farms in the catchment. * represents farms are no longer viable for this scenario (100% reduction in operating profit). The end redution scenarios modelled represent hypothetical examples as the limit setting process in this catchment has not yet commenced.

		% Change in OP for each nitrogen reduction scenario			
Farm type	**Base OP (mil$/yr)**	**N-10%**	**N-25%**	**N-35%**	**N-50%**
Dairy	$20.6	-3%	-9%	-18%	-34%
Dairy Support	$2.7	-3%	-46%	-98%	*
Sheep & Beef	$2.1	-5%	-9%	*	*
All farms	$25.3	-3%	-13%	-34%	-46%
Sensitivity of dairy clustering technique	$20.3 to $29.4	-3 to -5%	-8 to -14%	-8 to -26%	-34 to -49%

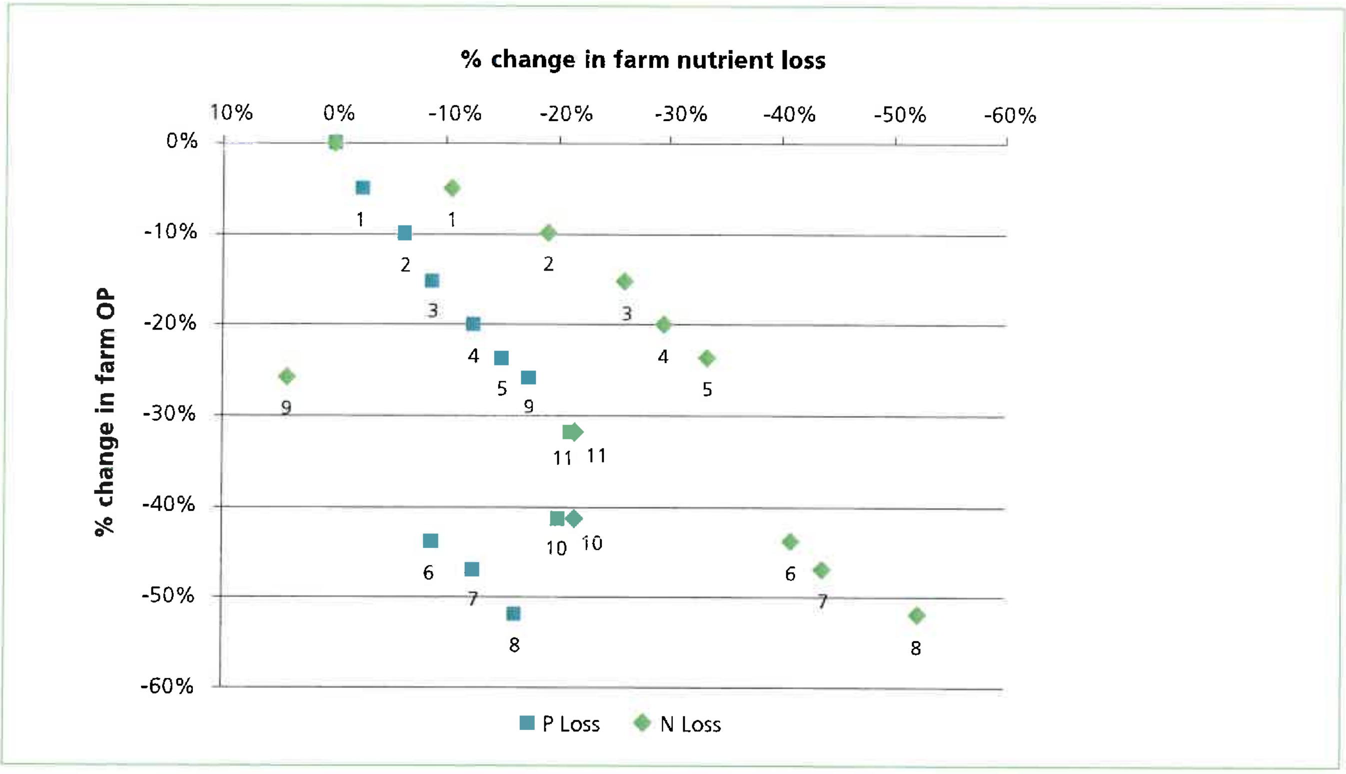


Fig. 1: Model results of the impact of 11 different nitrogen (green) and phosphorus (blue) mitigation scenarios (horizontal scale)) on annual farm operating profit (vertical scale) for one representative Waituna dairy farm. Changes are expressed as a percent difference from the base situation. These results show that most mitigation strategies applied have a different impact on N loss than P loss. For example Scenario 6 achieved a 40% reduction in N loss but only a 10% reduction in P loss, which resulting in an overall 45% reduction in farm OP. Scenario 9 represents once a day milking and Scenarios 6, 7 and 8 covered wintering structures.

DairyNZ

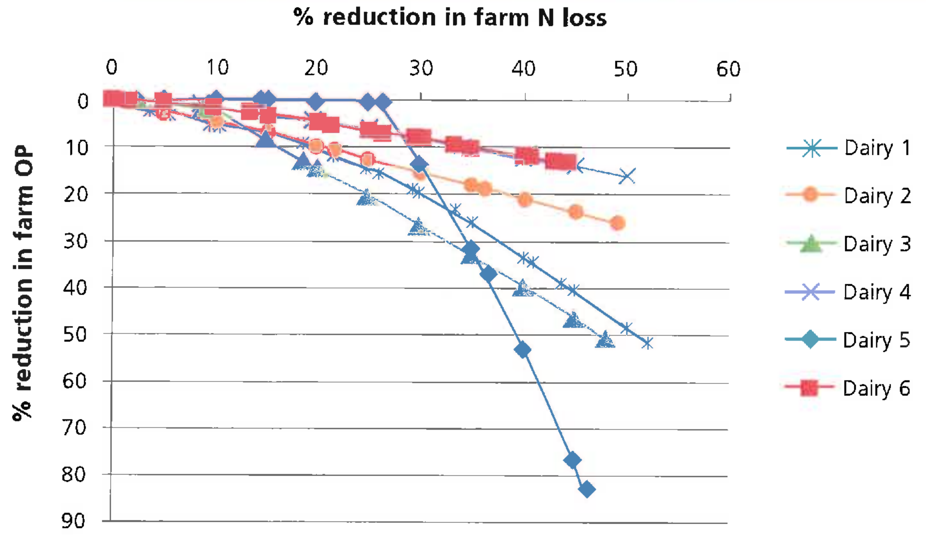


Fig. 2: Model results of the impact of a range of nitrogen reduction scenarios (0 to -50%) on annual farm operating profit for six representative Waituna dairy farms. Changes are expressed as a percent difference from the base situation. For example for Farm Dairy 3 (green line), a 40 % reduction in farm N leached (horizontal scale) results in a 40% reduction in annual farm operating profit (vertical scale).

How was this study done?

A case study approach was chosen to quantify the effect of nutrient loss reductions on farm system and profitability for ten representative Waituna Farms. Model farms were selected based on a clustering approach which recognised groups of farms that were broadly similar, taking into consideration land use, soil type, location in the catchment, intensity of system and farm performance levels. The final farms examined in detail were 6 dairy, 2 dairy support and 2 sheep and beef farms. The modelling tools used were FARMAX Dairy Pro® and Overseer 6.1.2® using the 2012-13 year as the basis.

On-farm visits were undertaken to understand the farmers' goals and objectives, farm system preferences, preferred options for strategies to mitigate nutrient losses and to collect model input data. Four nitrogen (N) and phosphorous (P) reduction scenarios were modelled for each farm; -10%, -20%, -35% and -50% reduction from the existing situation. The overall modelling approach as the mitigation strategies selected for each scenario was peer reviewed through a technical workshop and farmer reference group.

The economic impacts on farm operation were examined based on farm operating profit. Operating profit reflects farm profit before debt servicing, taxes and principal repayments or drawings beyond estimated market wages. Operating profit should not be interpreted as actual profit, but is similar to earnings before interest and tax (EBIT).

The impacts of the four load reduction scenarios on the entire catchment were estimated by extrapolating the model farm results to all catchment farms based on clustering of similar groups, existing N and P losses and farm area. A parallel study examined the potential impact of load reduction targets on the wider socio-economic values of the catchment.

This work was undertaken by Roslin Consultancy, Alfredo A. Adler Agricultural Consultant and DairyNZ, and funded by DairyNZ. We thank Waituna farmers and landowners, in particular the 10 model farms, for their involvement in this study.

For further information contact david.burger@dairynz.co.nz

APPENDIX 2

HURUNUI/WAIAU/JED NUTRIENT WORKING GROUP
December 2014

Hurunui-Waiau Nutrient Budgeting Case Studies

Report Prepared by Rebecca Hyde & James Hoban

This report outlines some considerations for the nutrient working group, relating to the Overseer® nutrient budgeting exercise that Rebecca Hyde (Ballance Agri-Nutrients) has completed with four local farmers.

Introduction

This exercise has been carried out to look at nutrient loss on local dryland farms, under current management and several development scenarios. This has been done using Overseer® for Nitrogen (N) loss while Phosphorus (P) has been handled subjectively through estimating the risk of P loss under each scenario. The ability of Overseer® to provide accurate P loss estimates is discussed, with examples of how the use of a number of farm management practices will (or will not) effect Overseer® outputs.

When considering this project, the following points need to be kept in mind:

1 – P is primarily lost to the environment through runoff. P binds to sediment and soil particles and is transported to streams in this way. Water flowing on farms in wet periods, which looks dirty, will have P in it.

2 – The N loss being focused on is Nitrate leached through the soil. Rainfall, irrigation and free draining soils can all lead to higher leaching losses. A major driver of N leaching loss is urine, therefore the number of cows and heifers is an important influence (because of urine spots).

Overseer® is a model and as such will only ever provide estimates rather than infallible accuracy.

Overseer® assumes:

1 – The use of annual average inputs and annual average outputs over a number of years

2 – Near equilibrium conditions with minimal change each year

3 - Actual and reasonable inputs. Users need to understand how input changes alter outputs.

Also assumed by Overseer® is a level of good management practice.

For each of the four case study farms:

- The 'Actual' Nutrient Budget was completed for 2012/2013
- Scenario 1 outlines a realistic development plan/real system

- Scenario 2 looks at the introduction of dairy grazing to the system

All four case study farms are mostly medium soils with some blocks identified as stony. Overall there was no extreme variation in average nutrient loss figures as a consequence of variation in soil type. Soils have been identified using S-Map as per Overseer® protocol.

NIWA rainfall data has been used, as per Overseer® protocol.

How Topography is defined in Overseer®

Slope Class	Access description	Slope	LRI 1 class *
Flat		0° to 7°	A-B
Rolling	Area mostly navigable by tractor	8° to 15°	C
Easy	>50% area navigable by tractor	16° to 25°	D-E
Steep	<50% area navigable by tractor	26° or more	F-G

This table has been included to as a reference for the group, given the time that has already been spent discussing the potential to limit nutrient loss by land class or slope.

Farm 1

Sheep 84% & Beef 16%

Lambs sold store

Lucerne on river flats

Sulphur Super applied to whole property

Summer Rape grazed by sheep

Cattle numbers variable

Mean Annual Rainfall (MAR) 820mm

Topography	Percentage of Farm
Flat	8.2%
Rolling	0%
Easy	33.4%
Steep	52%
Ineffective	6%

N & P Loss/Risk

	N loss/kg/ha/yr	% Increase N loss/ha	P Risk
Actual	8		Med
Scenario 1 – Improved	14	45	Med
Scenario 2 – Dairy Grazing	22	64	High

Scenario 1 – Changes made

Sheep 92% & Beef 8%

Lucerne sown into grass

Rape rotating through Easy hill – grazed by sheep and cattle

Ewe numbers and lambing % increased

Finishing steers

Hoggets mated

N & S fertiliser added spring and autumn instead of P based fertiliser

Scenario 2 – Changes made

Sheep 72% & Beef 28%

Increased Rape area

N & S fertiliser added spring and autumn instead of P based fertiliser

300 Dairy Heifers Dec - May, 50 R2 steers finished

Decrease ewe numbers, lambing % remains the same as actual

Comments

- Majority of N leaching coming from Rape paddocks
- High Olsen P therefore potential for N & S options
- Property can get very wet during winter months
- Cattle percentage higher in Dairy scenario

Farm 2

Sheep 65% & Beef 35%

Lambs finished

Summer Rape for sheep

Breeding cows and trading cattle

No fertiliser applied

MAR 800mm

Topography	Percentage of Farm
Flat	5.4%
Rolling	28%
Easy	13.6%
Steep	47.3%
Ineffective	5%

N & P Loss/Risk

	N loss/kg/ha/yr	% Increase N loss/ha	P Risk
Actual	7		Low
Scenario 1 – Improved	10	32	Low
Scenario 2 – Dairy Grazing	14	52	Medium

Scenario 1 - Changes made

Sheep 75% & Beef 25%

Increased rape

Added Lucerne

N - P - S fertiliser added

Increased lambing percentage

Mated hoggets

Finished all lambs

Improved pasture

Scenario 2 - Changes made

Sheep 75% & Beef 25%

Kale added for winter grazing

Added less Lucerne

N, P S fertiliser added

Increased lambing percentage

Mated hoggets

Finished all lambs

Improved pasture

600 dairy cows wintered June/July

80 May-May heifers

Breeding cows only beef stock, all claves sold store no trading cattle

Comments

- Majority of extra N leaching coming from Kale paddocks

Farm 3

Sheep 94% & Beef 6%

Summer rape grazed by sheep

Lambs finished

Hoggets not mated

Trading cattle

Areas of the farm in brown top

Lucerne Cut and Carried – not grazed

MAR 650mm

Topography	Percentage of Farm
Flat	34.6%
Rolling	56%
Easy	0%
Steep	2%
Ineffective	7.4%

N & P Loss/Risk

	N loss/kg/ha/yr	% Increase N loss/ha	P Risk
Actual	8		Low
Scenario 1 – Improved	10	31	Low
Scenario 2 – Dairy Grazing	13	40	Medium

Scenario 1 – Changes made

Sheep 93% & Beef 7%

Lucerne increased - grazed and cut

Rape stays the same

Hoggets mated

Phased N applied in spring across flats @ 80kg/ha

Increased Ewe numbers by 200

All pasture ryegrass/white clover

Scenario 2 – Changes made

Sheep 62% & Beef 38%

600 cows added June/July

300 heifers July/may

Ewe numbers dropped

No hoggets

All lambs sold store

Lucerne Cut and Carried – not grazed

Kale added for winter grazing

General Comments

- In 'dairy scenario' more total N leached from kale block than from the whole farm in the 'actual scenario'.

Farm 4

Sheep 29% & Beef 71%

Cattle - MA & young stock

Fertiliser applied to flats only

Pastures unimproved

Hoggets not mated

Lambs sold store

Rape & turnips grown for autumn/winter feed

MAR 1100mm

Topography	Percentage of Farm
Flat	2%
Rolling	9%
Easy	15.5%
Steep	27%
Ineffective	45.6%

N & P Loss/Risk

	N loss/kg/ha/yr	% Increase N loss/ha	P Risk
Actual	3		Med
Scenario 1 – Improved	7	41	Med
Scenario 2 – Dairy Grazing	8	47	High

Scenario 1 – Changes made

Sheep 64% & Beef 36%

Cattle stayed the same

Pasture improved on all areas of the farm

Fertiliser applied to the flats and rolling with spring 30N applied to flats

Turnip area increased

All lambs finished

Hoggets mated

Ewe numbers increase

Scenario 2 – Changes made

Sheep 65% & Beef 35%

Dairy cows grazing kale on flats

May-May heifers

Pasture improved on all areas of the farm

Fertiliser applied to the rolling country

Turnip area increased

All lambs finished

Hoggets mated

Ewe numbers increase

Only breeding cows, all calves sold at weaning

General Comments

- About half of total farm N is being leached from Winter fodder crops – Kale & turnips

Pros & Cons identified by the farmers for each development scenario:

Scenario 1 – Improved

PROS

- Sustainable way of farming
- Hit feed demand curve
- Have control over own stock
- Even out climatic risk
- Make the farm financially viable
- Provides opportunities for the next generation
- Enjoyment

CONS

- More work
- Lambing hoggets

Scenario 2 – Dairy Grazing:

PROS

- Cash flow
- Diversification
- Infrastructure development

CONS

- Issue with P runoff & N Leaching
- Not sustainable
- Environmental impact within the farm gate – pugging of soils
- Infrastructure development
- Ethics of some dairy farmers
- Not having control of your own stock

Phosphorus loss

The P loss risk has been estimated for each scenario as being either low, medium or high.

In making these assessments the following factors were considered:

- Stock numbers
- Stock classes
- Winter grazing
- Olsen P levels
- Farmer's knowledge of the property – i.e. erosion risk, wet winters etc
- Soil type
- Rainfall
- Topography

Note - the estimate is based on **inherent risk** associated with the farming policy – it is **not a reflection of management**. In reality, a high risk is still able to be managed well while a medium risk scenario, if managed poorly, could have a high environmental impact.

There are significant opportunities to reduce or mitigate P loss risk though good farm management practices, many of which will not change Overseer® P loss numbers.

The following table shows a list of management tools that will result in less P loss to water, and explains whether or not their use is recognised by Overseer®.

Phosphorus Loss Mitigation	Rewarded in Overseer®?
Fencing Streams	Yes
Appropriate fertiliser rates	Yes
Conversion to more efficient irrigation system	Partially - already assumes very high efficiency
Avoiding high risk times for fertiliser application	Yes
Change fertiliser type	Yes
Targeting optimum Olsen P	Yes
Precision fertiliser placement	Partially through lower application rates
Cultivating with contour - rather than up and down slope	No
Infrastructure to keep stock away from unfenced streams (e.g. troughs, shade)	No
Culverts and bridges	No
Managing track runoff	No
Shifting break fences strategically	No
Filter areas downstream of unfenced waterways	Partially - only if wetland able to be captured
Uncultivated ephemeral stream margins	No
Erosion control plantings	No
Spreading fertiliser evenly	No - assumed already
Reducing ability of stock to form camps	No
Avoiding applying fertiliser directly into streams	No

In estimating P loss risk for each farm scenario, these tools have not been considered. Use of these tools would, in reality, mitigate increased P loss risk through many farm system changes and can be demonstrated though Farm Environment Plans. The ability of Overseer® to handle these though is insufficient for realistically modelling improved management.

Conclusions

- The 10% rule is triggered by even the most conservative of improvements outlined in these case studies.
- Developments considered in each scenario are not radical – they are simply the type of changes many farmers have made before now.
- It is not possible to foresee what future development options will be available to dryland farmers, so this exercise should be treated carefully and not as the basis for limiting future opportunities
- Regardless of the scenario, N loss per ha from these dryland farms is relatively low, compared to intensive irrigated farming.
- The range in N loss numbers from each farm, despite similar scenarios, is great enough that it makes limit setting by numbers challenging
- P loss risk needs careful consideration with farm system changes but not through Overseer alone. Many P loss risks are able to be addressed through good farm management.

APPENDIX 3

REDUCING OVERLAND FLOW AND SEDIMENT LOSSES FROM WINTER FORAGE CROP PADDOCKS GRAZED BY DAIRY COWS

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Abstract

The scale and extent of dairy farming in southern New Zealand has grown considerably in recent years. However, environmental concerns associated with the loss of nutrients, faecal microbes and sediment to waterways during winter grazing of dairy cows remains an issue in vulnerable landscapes. Winter forage grazing paddocks are believed to contribute a disproportionately large part of annual farm nutrient and sediment losses as a result of intensive stock grazing on soils with high moisture content. A paired catchment study was established at Telford Farm, South Otago to investigate alternative winter grazing management strategies that may reduce the volume and concentration of contaminants in overland flow. Strategies were targeted towards protecting vulnerable areas of the catchment that contribute the greatest amount of sediment and nutrient loading i.e. critical source areas (CSAs). We hypothesised that losses of sediment, phosphorous and *E. coli* could be reduced considerably through protection of the CSA, which accounted for less than 2.5% of total paddock area. In the control catchment the cows strip-grazed the crop from the bottom of the catchment and moved upslope with unrestricted access to the CSA. In the treatment catchment the cows strip-grazed from the top of the catchment and moved downslope, with restricted access to the CSA. Automated sampling and monitoring of overland and subsurface flows indicated smaller and shorter duration overland flow events in the treatment catchment compared to the control catchment, leading to a reduction in yields of sediment and nutrients lost. These findings indicate that simple and low cost techniques that take into account paddock soil type, topography, drainage and stock management can considerably reduce overland flow and contaminant losses from winter forage crop paddocks.

Introduction

Animal wintering is increasingly recognised as a critical phase of pastoral farming that has an important influence on animal performance and on contaminant losses from farms to water. Preliminary research has indicated that areas used for forage crop grazing during winter may make a disproportionately large contribution to nitrogen (N) losses from the total farm system (Shepherd et al. 2012; Smith et al. 2012). Studies in Otago have also highlighted the potential for relatively large losses of phosphorous (P) and sediment in overland flow from rolling landscapes used for winter forage crop grazing by cattle (e.g. McDowell & Houlbrooke, 2009a). Visual observation suggests that much of the overland flow is likely to originate within gullies due to natural convergence and saturation of soil, which can be exacerbated by soil disturbance. Grazing management will likely influence flow and sediment yields, particularly if animal wintering occurs on less resilient soils and landscapes.

Soil type, topography, drainage and stock management are risk factors that contribute to losses of nutrients and sediment in overland flow derived from winter forage crops. Less resilient soil types are more prone to structural damage, which can reduce water infiltration capacity resulting in proportionately greater volumes of overland flow. The topography (slope) of the paddock will also influence losses, with greater slopes having potential for greater rates of soil loss (Dymond, 2010). Soils with poor drainage will also be more prone to damage from stock through compaction and pugging, again increasing the potential for overland flow generation due to lowered soil infiltration. Stock is another risk factor, due to the effects of excretal deposition onto surfaces where overland flow may occur, and soil treading damage (Nguyen et al. 1998). Where-ever possible, limiting the extent of winter forage crop grazing in vulnerable parts of the landscape such as the CSA would help minimise soil damage and the associated risk of overland flow. This could be achieved by practising time restricted (on-off) grazing in the vulnerable areas (McDowell and Houlbrooke 2009b).

This paper presents a summary of results from years 1 and 2 of a 3-year study which intends to examine practical approaches for minimising the risk of overland flow from paddocks used for winter forage crop grazing by dairy cows. Using a paired catchment study approach, we investigated the effectiveness of optimising grazing direction, back-fencing breaks and on-off grazing of the forage crop in those areas of the catchment suspected to result in the greatest overland flow. These measures were designed to reduce overland flow volume, and as a consequence, yields of contaminant losses in this flow. A key focus of the study was the protection of Critical Source Areas (CSAs), which are parts of the landscape where the majority of overland flow and thus contaminant loss are thought to occur. These are typically located in gullies and swales where soil moisture contents can be high, leaving the soil more vulnerable to treading damage by stock. This is also an area where overland flow is most likely to occur, due to saturated soils and flow convergence. Overland flow into and through the CSA is thus a transport vector for the movement of sediments and nutrients.

Methods

The trial site at Telford Farm, Balclutha comprised two adjacent paddocks (6.3 ha and 4.3 ha) each containing a discrete drainage catchment of 2.1 ha (**Catchment A**) and 1.9 ha (**Catchment B**) respectively (Figure 1). The catchments each contained a broad basin area at the upper end that drained into a central gully. The catchments are of similar size although Catchment A has steeper topography leading into the central gully area. The paddocks were located on a Pallic soil (Te Houka silt loam) with rolling topography and were cultivated and sown with a brassica crop in both 2011 (swedes) and 2012 (kale). Average annual rainfall at Telford is approximately 700 mm. Instantaneous stocking densities of cows in the winter forage crop paddocks varied depending on the feed available and were between approximately 1000 and 1400 cows/ha.

It was hypothesised that strategic grazing of cows in a winter forage crop paddock could reduce overland flow and thus sediment and nutrient losses. To test this hypothesis, two treatments were used:

Control	Cows entering at the lower end of the paddock Strip grazed moving in an uphill direction No protection of the CSA No backfencing
Treatment	Cows entering at top end of the paddock Strip grazed moving in a downhill direction Protection of the CSA Backfencing every 4-5 days Final time-restricted grazing of CSA if conditions suitable

In 2011, both paddocks were managed according to the control grazing strategy, and acted as a baseline calibration in order to characterise the hydrology of each catchment. The cows entered both paddocks from the lower end and strip grazed upwards with no back fencing and with free access to the CSA. In 2012, the paddocks were treated differently, whereby Catchment A was managed under a strategic grazing treatment and Catchment B as a control treatment i.e. the same management as in 2011 (Table 1, Figure 1). The research project continues in 2013, where the two catchment treatments will be switched with Catchment A being the control and Catchment B having strategic grazing applied (Table 1).

Table 1. Experimental design of the two trial catchments 2011-2013.

Year	Catchment A	Catchment B
2011	Baseline (Control)	Baseline (Control)
2012	Strategic Grazing Treatment	Control
2013 (Proposed)	Control	Strategic Grazing Treatment

Our research identified the CSA as the bottom of the gully in each catchment (Figure 1). This is the area where saturated soil conditions due to ephemeral overland flow were expected during the rainfall events that occurred throughout winter and spring (May-October). In 2012, the CSA in Catchment A was fenced off to exclude stock (100 metres long and 15 metres wide at the lower end of the gully, tapering to 5 metres wide at the upper end). This area accounted for less than 2.5% of the total paddock area in each of the two paddocks.

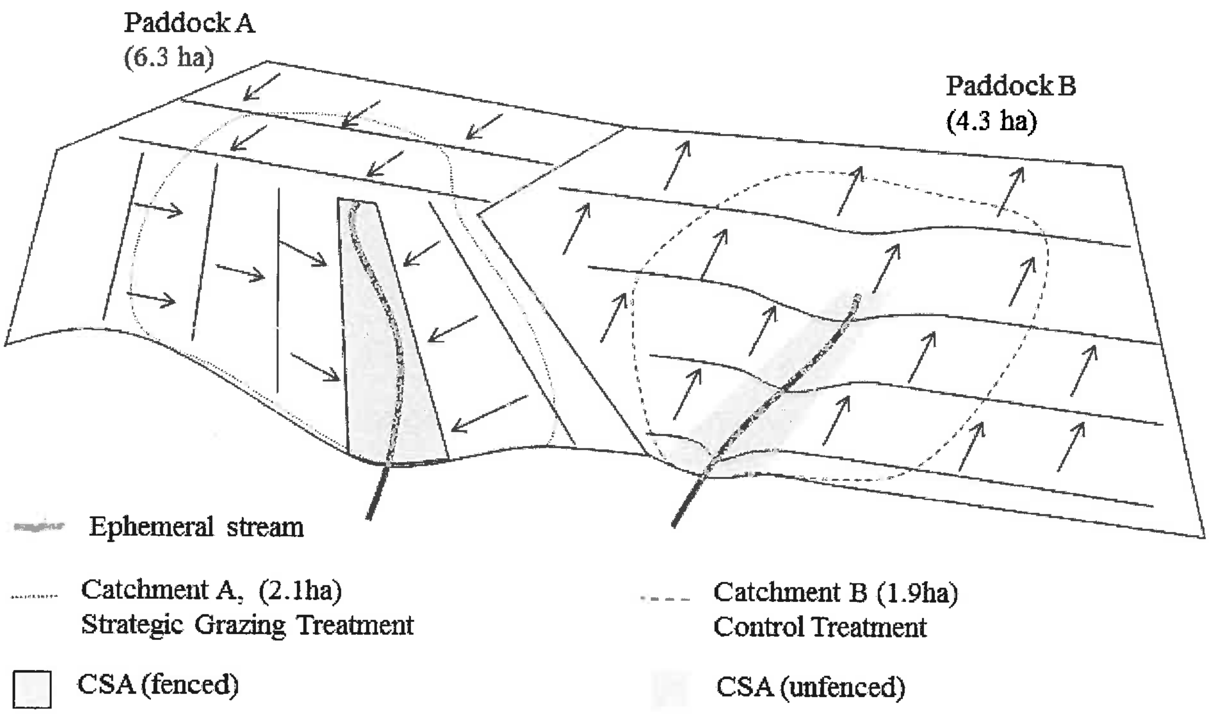

Figure 1. Paddock layout and treatments imposed in the 2012 winter season at Telford Farm. Arrows indicate the different grazing patterns and directions followed for each catchment.

Grazing of the CSA was time-restricted in the treatment paddock (Catchment A). No grazing occurred in the CSA until the rest of the paddock had been grazed. A decision was made to graze the CSA only when soil moisture conditions allowed for minimal disturbance and damage to the soil within the CSA. This final grazing of the crop in the CSA was limited to a 4 hour period, to reduce damage to the soil, yet remove the bulk of the standing crop.

Rainfall was measured with a 0.2 mm electronic tipping bucket. Overland flow was measured as stage height across an H-flume and weir, installed at the overland flow exit point from each catchment. Attached to each flume was a stilling well with a water level sensor (NIWA Hydrologger) and a Manning 4901 vacuum autosampler. The system was set up to automatically begin measuring and sampling any overland flow that occurred. The Manning sampler was programmed to take a sample every hour when stage height was above 10 mm. An automated alert message was generated and sent to a mobile phone so that samples could be retrieved within 24 hours.

Tile drains located at the bottom of each catchment collected subsurface flow. During the winter season, samples of subsurface flow were taken at weekly intervals over the two year trial period. During the second year of the trial, subsurface flow rates were also measured. The results from the subsurface flow are not presented in this paper.

Water samples were returned to the lab and analysed for a range of nutrients and physical measurements. Results for suspended sediment, total phosphorous and ammonium-nitrogen are presented in this paper.

Results and Discussion

Rainfall from June until the end of September in 2011 was 198 mm, and 262 mm in 2012 (Figure 2). In 2011, the occurrence of overland flow during high rainfall events was similar between Catchment A and B suggesting that the catchments were comparable. However, they did yield different volumes of total overland flow, probably due to a number of factors including the slightly larger size and steeper topography of Catchment A. There were 6 overland flow events in 2011 and 10 events in 2012. The biggest events occurred during July and August in both years. There were more events in 2012 that occurred in late winter and spring. During 2011 total overland flow derived from Catchment A was 41 mm, and 27 mm for Catchment B (Figure 2). The annual total overland flow following the implementation of the strategic grazing treatment in 2012 was 10 mm. This was lower than the 56 mm of overland flow measured in Catchment B during 2012, and during 2011 in Catchment A. This marked decline in overland flow occurred despite winter rainfall being higher in 2012, suggesting that the strategic grazing was highly effective in reducing overland flow.

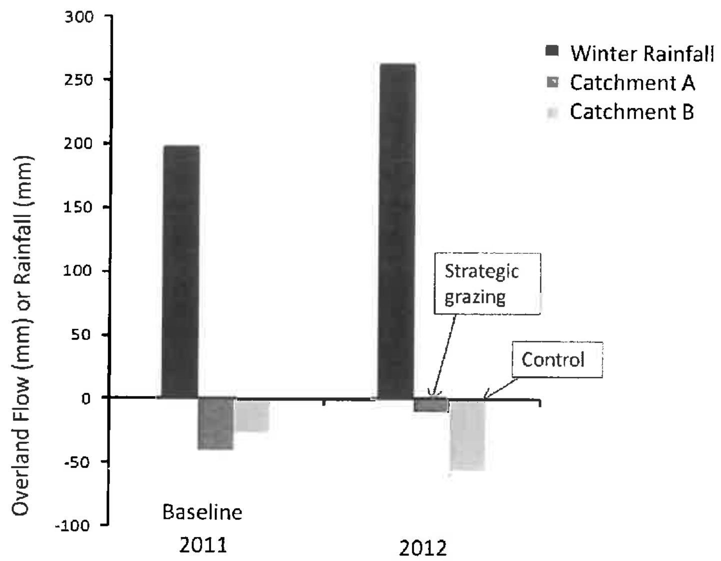

Figure 2. Winter rainfall (1 June to 30 September) and annual overland flow for 2011 and 2012. Rainfall and overland flow are shown as bars above and below the x-axis, respectively.

Estimated sediment yields derived from the catchments are shown in Table 2. Sediment yields appear to be strongly driven by the flow volumes. In the 2011 baseline year, the sediment yields were higher for Catchment A than Catchment B. This was mostly due to the higher flows. Concentration data shows a similar pattern, with slightly higher sediment concentrations in Catchment A, attributable in part to its steeper topography, that makes it more prone to sediment loss.

Table 2. Total sediment load and concentrations in overland flow derived from the catchments.

	Catchment A		**Catchment B**	
	Yield kg ha^{-1}	**Concentration g m^{-3}**	**Yield kg ha^{-1}**	**Concentration g m^{-3}**
2011	720	1780	280	1060
2012	130	1280	1140	2050

In 2012, when the strategic grazing management was implemented in Catchment A, there was a marked decline in sediment yields compared to both the baseline data and also the control Catchment B. This was largely driven by the reduction in flow in Catchment A as a result of the strategic grazing. The sediment concentrations were also reduced in Catchment A, suggesting that the strategic grazing management was reducing the amount of sediment available for loss or entrainment in overland flow. Larger amounts of sediment were expected in Catchment A due to its steeper topography making it more susceptible to sediment loss. However, strategic grazing in Catchment A reduced the sediment load, even with the steeper topography.

The annual yield of total P measured in 2011 (baseline) in Catchment A (2.1 kg/ha) was higher compared to Catchment B (0.7 kg/ha). This follows the pattern of greater overland flow and sediment losses in Catchment A which had steeper topography. During 2012 there was a considerable reduction in the yield of total P lost under the strategic grazing treatment. This is clearly highlighted in Figure 3, where the yield of total P in the strategic grazing treatment was approximately 20% of the control.

Ammonium-N yields (Figure 3) responded in a similar way to total P whereby losses were reduced in the strategically grazed catchment (Catchment A).

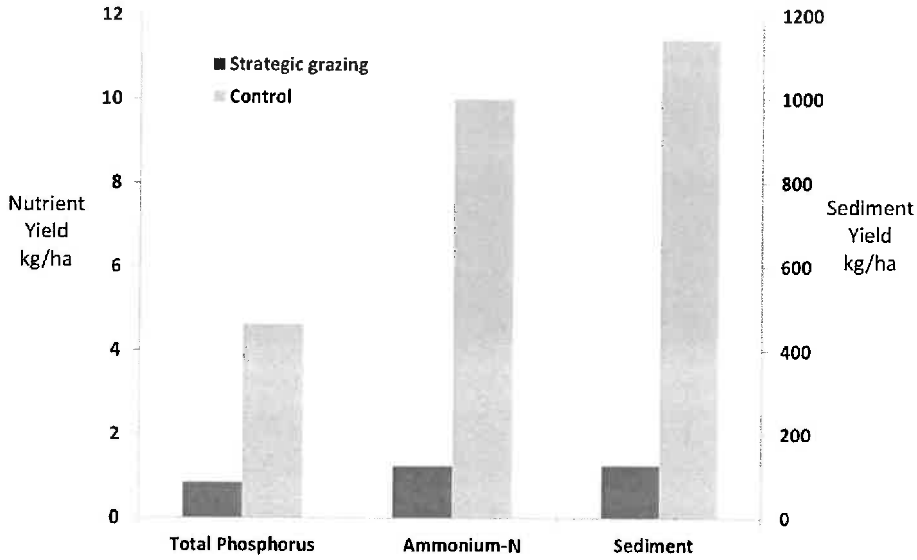

Figure 3. Yields (kg/ha) of total P, ammonium-N and sediment in overland flow during winter 2012.

There is a strong link between the yield of sediment and nutrients lost and the volume of overland flow from each of the catchments. Any decrease in the size or frequency in overland flow events will assist in reducing the overall yield of sediment and nutrients entering waterways and may improve water quality.

Summary

This trial has shown that strategic grazing of dairy winter forage paddocks can considerably reduce volumes of overland flow. By reducing overland flow, the yields of sediment and nutrients carried in the flow were also reduced considerably. The strategic grazing method was a combination of protecting the CSA from stock by fencing, and grazing the least risky areas first and grazing towards the higher risk areas. This effectively left the most vulnerable areas (e.g. the CSA) with minimal soil damage for as long as possible throughout the winter season. Protection of the CSA, gullies and areas prone to soil saturation is a key part to reducing overland flow and sediment loss. Grazing the CSA can still occur, but only when soil conditions allow. These grazing managements are relatively simple to implement and low cost.

Acknowledgments

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Reducing surface runoff from grazed winter forage crop paddocks by strategic grazing management

Key messages

- Research has shown that grazed winter forage crops contribute significantly to the risk of phosphorus (P), sediment and faecal losses to water. Critical source areas (CSAs) such as gullies and swales are a particularly important part of the landscape involved in the transport of these contaminants to water.
- Strategic grazing and careful management of CSAs can reduce losses of sediment and phosphorus (P) by 80-90%.
- The reduction is achieved by minimising stock movements and thus soil treading damage in the CSA. This means any rainfall and runoff that occurs is more likely to infiltrate the soil, minimising the amount of runoff and losses of sediment and P.
- Strategic grazing will not greatly reduce nitrogen (N) losses observed from grazed winter forage crops, which are largely due to the urine patches left behind following crop grazing.

What is a critical source area?

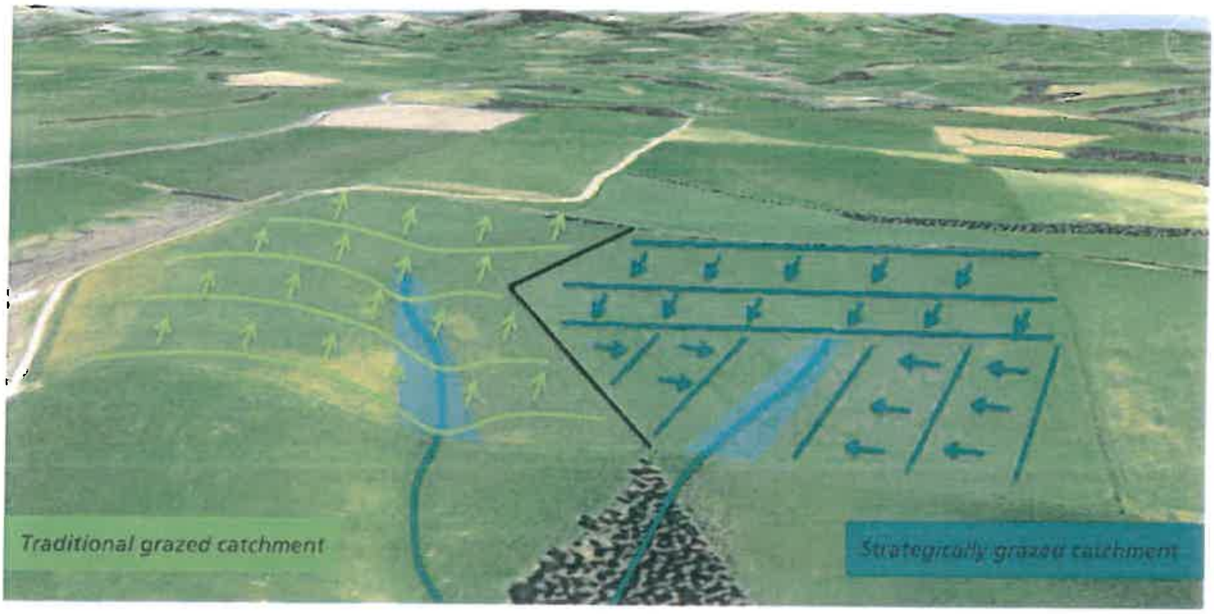
Critical source areas are those parts of the landscape, such as swales and gullies, where overland flow and seepage converges to form small channels of running water, which may then flow to streams and rivers. (Figure 1).

Figure 1. Examples of critical source areas

Management tips to reduce surface run off in a CSA

- When selecting future winter forage crop paddocks, if possible, avoid paddocks with large CSAs that will be difficult to manage
- Work out a grazing strategy before putting up fences, thinking about the location of stock water sources. i.e. do you need portable water troughs?
- Use a winter crop calculator to work out feed requirements to achieve BCS targets at calving
- Set up baleage in paddocks ahead of winter
- Leaving CSAs uncultivated and not planted in crop will make it easier to fence them off and reduce the amount of soil treading damage by stock. The pasture will also provide an additional filter for any runoff that occurs
- Fence off CSAs to provide as much of a buffer area as possible. This type of buffer strip should be at least 10 m wide and as long as possible (will depend on landscape)
- Ensure cows begin grazing the least risky parts of the paddock first to minimise the period of runoff risk. This usually means that cows should enter at the top of paddock catchments/gullies, and graze their way downhill (Figure 2).
- Back-fence as much as possible – this will help minimise soil pugging and compaction damage, and thus reduce the volumes of surface runoff generated.
- The CSA should be the last break grazed in the paddock (if it needs to be grazed at all). Changing the break layouts to graze into the CSA from each side will allow this to happen (Figure 3)
- On-off graze any crop left in the CSA, ideally at a time when soil moisture content is not too high.

Figure 2. Strategic grazing of critical source areas.



< Figure 3. Last break critical source areas.

The potential for surface runoff to occur

Risk = Soil + Slope + Moisture + Stock Disturbance

- **Soil:** Poorly-drained and/or weakly structured soils are at greater risk of compaction and pugging during grazing in wet conditions. This treading damage seals the soil surface, resulting in more water moving across the soil (runoff), hence increasing the loss of sediment and nutrients.
- **Slope:** The greater the slope in a paddock, the greater the risk of surface runoff.
- **Moisture:** The greater the moisture content of the soil, the greater the risk of compaction and pugging.
- **Stock disturbance:** The greater the number of animals on wet soils, the higher the risk of soil treading damage leading to compaction and pugging.

The research trial

The paired catchment trial at Telford Dairy Farm used two grazing methods to demonstrate the benefits of strategic grazing of winter forage crops:

Control/traditional grazing: cows entered at the lower end of the paddock; strip grazed, moving in an uphill direction; no protection of the CSA; no back-fencing.

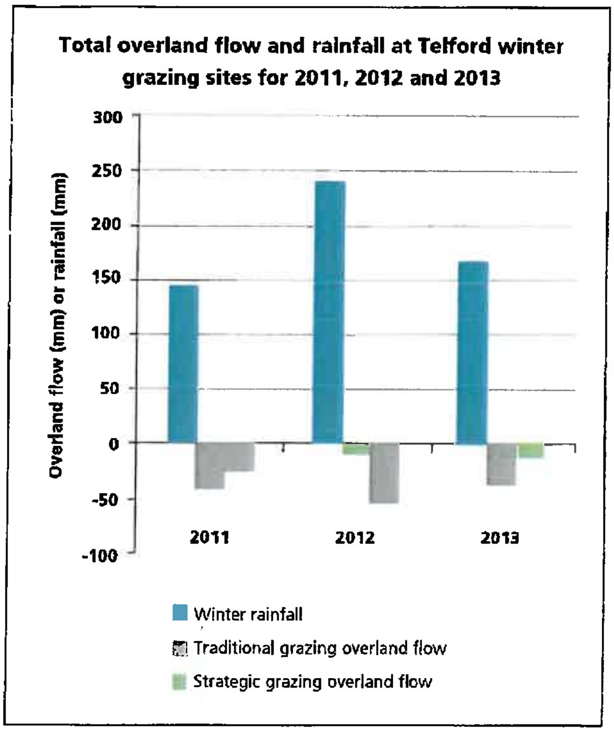
Strategic grazing: cows entered at the top end of the paddock; strip grazed moving in a downhill direction; protection of the CSA; back-fencing every 4-5 days; final time-restricted grazing of the CSA when soil conditions were suitable.

Research results

This trial ran over three years. In 2011, each catchment was grazed as per the control method. In 2012 the strategic grazing approach was implemented in one of the catchments and compared against the other (Control) catchment. These treatments were then reversed in 2013.

The results show that through the use of strategic grazing, the volume of overland flow can be significantly reduced when compared to traditional grazing (Figure 4).

Figure 4. Total overland flow and winter rainfall



The results also show that strategic grazing of the crop paddocks over a two year period reduced sediment and P losses by approximately 80-90%. (Table 1).

Table 1. Losses of sediment and P in surface runoff

	Sediment loss kg/ha	Total P loss kg/ha
Control grazing	6635	6.9
Strategic grazing	656	1.2
Reduction	90%	83%

Available resources

Go to **dairynz.co.nz** for:

DairyNZ fact sheets:

- Crop Paddock Selection
- Southland Stock Movement Fact Sheet
- Guidelines for Southland farmers moving stock to and from winter grazing
- Transitioning Cows onto Crops Fact Sheet
- Drying-off Cow Management Fact Sheet

DairyNZ Farmfacts:

- DairyNZ Farmfact: Fodder beet - feeding to dairy cows (1-73)
- DairyNZ Farmfact: Kale - growing a high yielding crop (1-74)
- DairyNZ Farmfact: Winter Crops - Feeding to Dairy Cows (1-75)
- DairyNZ Farmfact: Swedes - growing a high yielding crop (1-76)
- DairyNZ Farmfact: Fodder beet - growing a high yielding crop (1-77)

Calculators:

- Winter Crop Allocation Calculator

References

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