BEFORE THE HEARINGS PANEL

IN THE MATTER of hearings on submissions concerning the Proposed One Plan notified by the Manawatu-Wanganui Regional Council

---

SECTION 42A REPORT OF DR MARK ANTHONY SHEPHERD

ON BEHALF OF HORIZONS REGIONAL COUNCIL

---

1. INTRODUCTION

My qualifications/experience

1. My full name is Mark Anthony Shepherd. I have a Doctor of Philosophy degree (PhD) in Soil Science from the University of Newcastle upon Tyne, UK. I hold a Bachelor of Agricultural Chemistry Honours Degree from University of Leeds, UK.

2. I joined AgResearch in February 2008 to take up a role as senior scientist researching nutrient cycling in farming systems and the interactions between land management and diffuse pollution.

3. Previously (1983-2008), I was a soil scientist with ADAS UK Ltd (formerly the Agricultural Development and Advisory Service, a part of UK's Ministry of Agriculture). My specialist research area was nutrient management in agricultural systems with an emphasis on decreased environmental impact. Throughout my career, I have been involved in agricultural extension as well as research. This has involved regular contact with a range of end-users: farmers, consultants, scientists, policy makers and private industry. This has given understanding of agri-environmental issues from different perspectives.

4. Latterly, I was head of the ADAS Catchment Management Group, which undertakes National and International research-based consultancy relating to all aspects of the interaction of land management and water quality. Much of this work was done to underpin UK Government policy.

5. I am a Special Professor at the University of Nottingham. I am an Executive Editor for the Journal of Science of Food and Agriculture and I have published many papers in peer-reviewed journals (40+), conference proceedings (60+) as well as book chapters and numerous client reports.

6. My current position is as a senior scientist and Team Leader in AgResearch in the Climate, Land and Environmental (CLE) Group based on the Ruakura campus in Hamilton. The current focus of my research is again on nutrient cycling within farming (predominantly pastoral) systems with an emphasis on environmental protection, mitigating against losses of nutrients to water (and air). My main research programmes are funded through FRST, MAF, DairyNZ, Regional Councils and commercial companies.

7. As a Team Leader within CLE, I also manage two teams that are directly relevant to the evidence that I shall give in this document:

- The Nutrient Management Unit – this team are experts in the use of the OVERSEER® Nutrient Budget model (OVERSEER) and its application on farms. This requires not only an understanding of OVERSEER, but also a sound knowledge of NZ farming systems so that the model can be applied correctly. The Nutrient Management Unit undertakes farm analysis using OVERSEER for a number of clients, mainly Regional Councils. The Unit undertook the work reported in this evidence. They are also undertaking the baseline farm nitrogen discharge assessments in the Lake Taupo catchment.
- The OVERSEER Development Team – this team is responsible for developing and maintaining the OVERSEER model on behalf of the Owners (MAF, FertResearch and AgResearch).

8. I have read the Environment Court's practice note 'Expert Witnesses – Code of Conduct' and agree to comply with it.

My role in the Proposed One Plan

9. I and my team (Nutrient Management Unit) have provided expertise to Horizons Regional Council in undertaking test FARM strategies.

Scope of evidence

10. The scope of my evidence is to inform the Committee of the five test FARM strategies that were undertaken by my Nutrient Management Team:

- Overview of the test FARMS project and what was set out to be achieved
- Farms included and rationale
- Overview of the results
- Suggested areas for improvement

11. The farm visits were undertaken by Bob Longhurst of the Nutrient Management Unit. Bob also compiled most of the reports, with help from Ian Power and Geoff Mercer of the Unit. I have been involved throughout the process in agreeing with Horizons the scope of the work, advising Bob, Ian and Geoff on technical aspects during the project and having overall responsibility for the reports submitted to Horizons.

2. EXECUTIVE SUMMARY OF EVIDENCE

12. The proposed single whole-farm consent process under the One Plan replaces the traditional approach of multiple consents. A FARM (Farmer Applied Resource Management) Strategy (FARMS) would be a necessary pre-requisite for whole-farm consent. The structure and content of a FARMS report, along with the process of developing such a report for a farm was previously developed for Horizons by Manderson and Mackay (2008). To further test the FARMS reporting process, AgResearch was contracted to produce ‘Medium level’ FARMS reports on behalf of Horizons for five case study farms.

13. The purpose was to undertake a farm nutrient budget using the OVERSEER nutrient budget model 2009 (OVERSEER) to assess if the farm is operating within the Horizons proposed nitrogen leaching limits; and to identify example containment management options and to make recommendations on other FARM Strategy compliance requirements.

14. The five participating farms were selected by Horizons. The aim was to select a mix of enterprises and also farms that might face a challenge in meeting the proposed N limits. Farm types were: an irrigated beef unit; an intensive cropping farm; and three dairy units. The dairy farms were: a new conversion (*c.* 2.4 cows/ha) with plans for expansion over the next 5 years; an intensive dairy farm (*c*. 3.3 cows/ha on the milking platform, with an additional support block almost of the same area) and an irrigated dairy unit on sandy soils (*c.* 2.8 cows/ha).

15. The process that we undertook to develop the final FARMS report was: an initial farm visit for data collection; go back to the office to collate information, identify gaps and obtain missing information from the farmer and run OVERSEER; send draft report to check with the farmer that OVERSEER input data is correct; seek feedback from farmer and Horizons on the report; follow up visit to the farm to fill gaps and ensure no misinterpretation of information; produce final report.

16. We concluded that the FARMs reporting process is useful in that it assembles all of the farm information into one document. Furthermore, it is useful to be able to follow a prescriptive approach (ie. that developed by Manderson and Mackay and evidence reported on separately) to help streamline the time involved in producing a report and to ensure the correct information is collected.

17. Nevertheless, the success of the approach depends on:

a. Effective farmer engagement; all of the farmers in this test study indicated they were pleased to be involved and were willing to contribute to the project

b. Available resource to undertake the FARMS report – both from the farmer and the contractor undertaking the reporting process

c. A robust model such as OVERSEER to underpin the assessment (evidence on OVERSEER has been provided separately by Dr Stewart Ledgard, AgResearch)

18. Regarding resources, two farm visits were required. These were about 2-3 hours each, but could have taken more time if a farm walk had been included (to complete the farm audit). Including running OVERSEER, checking and reporting, the process could take 2-4 days per farm, plus several hours of the farmer's time.

19. The farms were chosen, in part, because it was thought that they may have struggled to meet the proposed N leaching limits under the One Plan. The OVERSEER modelling for each farm shows this largely to be the case, especially for the dairy farms.

20. Because different catchments within Horizons' region will be phased into the proposed scheme in different years, N leaching targets throughout the report have been expressed as 'baseline' implementation year (ie. the first year that the scheme applies to that farm) and 'baseline plus x years' where x = 5, 10 or 20 years, which are the incremental time periods when the permissible N leaching limit is decreased.

21. The two non-dairy farms would be able to meet the initial proposed N leaching limits (for the baseline implementation year) under current farming practice: the irrigated beef unit and the intensive cropping farm.

22. For the baseline implementation year, two of the three dairy farms would need to substantially decrease nitrate leaching to meet the initial limits, based on their current farming practice. The initial required reduction would be 9 kg N/ha/year for both farms. This represents a required decrease against current practice of 32-36%, depending on the farm.

23. The third dairy farm (Farm 3) would meet the initial limits. This is because the farm has an additional non dairy area approximately the same size as the dairy platform that offsets large losses from the dairy platform, such that the whole farm average is just below Horizon's proposed limit for the baseline implementation year.

24. As the proposed limits under the One Plan decrease with time, the challenge for all but one farm increases. The irrigated beef unit has sufficiently low input that it meets all of the proposed N leaching targets going forward. By baseline plus 10 years, the intensive cropping farm would need to decrease N leaching by 6 kg N/ha/year (a 20% decrease compared with now).

25. However, again, the dairy units have the greatest challenge. If the proposed expansion of the dairy conversion goes ahead (Farm 1), required decreases in baseline plus 10 years would be 24 kg N/ha/year (a 60% reduction in N leaching) for that farm, and 25 kg N/ha in baseline plus 20 years. The irrigated dairy farm (Farm 5) would need to decrease losses by 10 kg N/ha in baseline plus 10 years (40% reduction). The intensive dairy farm, Farm 3, (able to meet targets in the baseline implementation year) would need to decrease losses in baseline plus 10 years by 5 kg N/ha from current practices (18% reduction).

26. The FARMS reports explored the effectiveness and cost of selected potential mitigations that farms could adopt, though some are already in place. These were generally based around good fertiliser and effluent management, use of nitrification inhibitors and stock exclusion during key autumn/winter periods. These generally bore a significant cost (especially wintering-off) and were insufficient to meet all of the targets.

27. Few other compliance issues were identified from the farm audit. Compliance with the (voluntary) Clean Streams Accord was good; only one farm had a significant area of streamside that needed fencing. Farms had culverts for stock crossing and effluent management was good. It should be noted that all the five case study farmers were keenly aware of the need for good stewardship of land. The five test farmers expressed to us that they were content to be involved in the project and therefore we might assume that they are leading in terms of concern for the environment.

28. Because the aim was to test the process, inevitably, we have been able to identify where the process might be improved.

3. EVIDENCE

Background

29. The proposed single whole-farm consent process under the One Plan replaces the traditional approach of multiple consents. A FARM (Farmer Applied Resource Management) Strategy would be a necessary pre-requisite for whole-farm consent. A

FARM Strategy (FARMS) represents an assessment of permitted and controlled activities for a farm and a strategic plan to ensure those activities comply with One Plan specifications and water quality targets.

30. The structure and content of a FARMS report, along with the process of developing such a report for a farm was previously developed for Horizons by Manderson and Mackay (2008). It was proposed by Manderson and Mackay that there could be three levels of reporting, each varying in complexity and level of detail.

31. As a part of the process of developing a reporting procedure, Manderson and Mackay had undertaken a number of farm visits and produced associated reports. To further test the FARMS reporting process, AgResearch was contracted to produce 'Medium level' FARMS reports on behalf of Horizons for five case study farms. The purpose of these reports was fourfold:

- To undertake a farm nutrient budget using OVERSEER nutrient budgets 2009 (OVERSEER: Wheeler et al., 2003).
- Assess if the farm is operating within the Horizons proposed nitrogen loss limits.
- Identify example containment management options for minimising nitrogen (N), phosphorus (P) nutrient losses, and faecal microbial contamination of freshwater resources.
- Assess and make recommendations on other FARM Strategy compliance requirements.

32. Although there was a strong focus on nutrient inputs and outputs from the farms, the FARM Strategy plans also took into account soil management, sediment loss and other issues such as faecal bacteria that impact on water quality.

Five test cases

33. The five participating farms were selected by Horizons. The aim was to select a mix of enterprises and also farms that might face a challenge in meeting the proposed N limits. Table 1 and Figure 1 identify the enterprises and their locations.

Table 1. Farm description.

Farm #	Farm type	Location	Catchment	Farm ID
1	Dairy conversion	Norsewood	Upper Manawatu	Paul Janssen
2	Irrigated beef unit	Dannevirke	Upper Manawatu	Gerrit Arends
3	Intensive dairy unit	Feilding	Oroua River	Bryan Guy
4	Intensive cropping	Marton	Lower Rangaitiki	Brendon Williams
5	Irrigated dairy on sand	Foxton	Lower Manawatu	Noel Johnston

Figure 1. Test farm locations

34. Farm 1 - The Janssen Farm is a 156 ha dairy conversion from dry stock farming located close to the headwaters of the Manawatu River near Norsewood. Projected milk solids production from the genetically high breed 380 dairy herd for Year One is 190,000 kg (500 kg MS/cow). Average annual rainfall is 1718 mm.

35. Farm 2 - The Oringi Farm is a 225 ha[1] beef finishing unit located near Dannevirke. Beef cattle of mixed breeds are bought in as weaner calves and R1s and sold as either R2s or R3s. The stocking rate is 2,940 beef stock units (13 SU/ha/yr); 81% of cattle are male.. All feed supplements (grass silage, and hay) are made on the property and no other stock feeds are imported. Maize silage is made on the property and exported off-farm. Irrigation via centre-pivots is applied to pastures during November to March to complement the long-term average annual rainfall of 1168 mm.

36. Farm 3 - Byreburn Ltd farm comprises a milking platform of 203 ha and supporting block of 208 ha used for rearing replacements, and growing supplementary feeds (whole farm 411 ha). The peak dairy herd comprises 666 Friesian cows, milk solids production is 352,500 kg MS (1740 kg MS/ha) from the milking platform. A high level of feed supplementation (2.7 t DM/cow/yr) is imported onto the farm. This property is a very intensive dairy operation across the Oroua River from Feilding Township. The Byreburn Ltd farm is not located in a priority catchment, however the farm was chosen and has been treated as if it were in a sensitive catchment for 2010 so that the methodology for Horizons Regional Council proposed One Plan could be tested.

37. Farm 4 - Pencoed Trust farm a 115 ha intensive mixed-cropping operation (Legal area: 116.87 ha) located near Marton. The main crops grown are potatoes, maize, winter wheat and spring wheat. In addition about 23% of the property is in pasture grazed by sheep. During winter 120 dairy cows also graze the pasture block.

38. Farm 5 - The Johnston Farm is a 257 ha irrigated seasonal supply dairy farm located on sand country near Foxton. A dairy herd of 730 Friesian/Jersey cross cows are milked at 2.8 cows/ha and milk solids production is 1,114 kg MS per effective ha. Water is irrigated to pastures during November to March with up to 500 mm/yr applied to complement the average annual rainfall of 837 mm. The Johnston Farm is not located in a priority catchment, however the farm was chosen and has been treated as if it were in a sensitive catchment for 2010 so that the methodology for Horizons Regional Council proposed One Plan could be tested.

---

1 Farm survey and land resource inventory area; legal area 227 ha

39. Table 2 shows the relative areas of each LUC class across each farm, in way of context.

Table 2. Relative area of each LUC class across the 5 case study farms (expressed as a % of the total area of that farm).

Farm ID	Total area (ha)	LUC class (% of area)							
		I	II	III	IV	V	VI	VII	VIII
Farm 1	156		16	25	26		33		
Farm 2	225		59	39	2				
Farm 3	411	2	85		8		4		1
Farm 4	115	69	30	1					
Farm 5	257			46	21		28	4	1

Content of the FARMS report

40. The content of the FARMS report was based on the recommendations of Manderson and Mackay (2008) and agreed with Horizons at the start of the project. Table 3 summarises the content of a typical report. Length of the report will vary with complexity of the farm but typically might be 20-30 pages.

41. The report contained sections of standard text (eg. background to the project, details of the Clean Streams Accord, background to Land Use Capability). However, the majority of the report was based on an assessment of each individual farm and was tailored to that farm.

Table 3. Summary of the content of a typical 'Medium level' FARMS report

Section heading	Content
Executive summary	Brief summary of the key conclusions arising from the exercise
Introduction	Standard text detailing the project background and objectives
Farm description	Contains: • A physical description of the farm including owner, address, area, topography, main soil types, water management zone and sub-zone • Legal description and area of the farm • Property map with all the relevant features (farm boundary, farm waterways, water bodies, active offal holes, active farm dumps, public roads, residences, public buildings, recreation areas, bores, and water takes) • Annual rainfall – long-term average supplied by Horizons • Nutrient management blocks – describes how the farm was separated into management units for inputting data into *Overseer*
Clean Streams Accord status	Contains: • A summary of the Clean Streams Accord, with targets and farmer's obligations.

Section heading	Content
	• An assessment of the farm's performance against The Accord in terms of managing waterways and effluent on the farm
Land Use Capability	Contains: • Background to the Land Use Capability (LUC) system in NZ • A summary table of proposed N loss limits against LUC • Map of the farm's LUC units
Contaminant status	• Reports the results of the *Overseer* modelling in terms of Farm N loss. This is based on current farming practice and may also include an assessment of losses under any proposed major changes to the farm in the future (eg. increase in stock numbers). • Compares the calculated losses with the proposed N loss limits for the farm (target based on proposed N loss limit for each LUC and the area of each LUC on the farm). • Reports the P runoff risk assessment as estimated by *Overseer*.
Contaminant Minimisation Strategies	Contains: • An assessment of the need for reductions in N leaching losses (ie. compares modelled losses with proposed targets set by the One Plan) • Potential mitigation strategies appropriate to the farming system, the potential reduction in N leaching as a result of deploying the mitigation and very broad, indicative costs of implementation (or savings where there is a financial benefit to the system) • As above for P rather than N
Other compliance requirements	Covers any other compliance issues identified during the farm visits (and based on a compliance checklist developed by Horizons and completed during the visit – and summarised in Appendix III of the report).
Recommendations to achieve compliance	Conclusions from the report.
References	References for any reports/papers cited in the report.
Appendices:	
Overseer *inputs and assumptions*	A summary of the main data inputs for *Overseer*. These are based on the information provided by the farmer and have to be signed off by the farmer as a true representation of the farm.
Overseer *output reports*	Printouts and screenshots of the main outputs from the *Overseer* model, eg. nutrient budgets for each block on the farm.
Horizons One Plan compliance checklist	A standard checklist of all of the compliance requirements for the farm under the One Plan. This checklist was completed during the farm visits and inclusion in this report serves as a permanent record.

The FARMS reporting process

42. Central to the whole FARMS reporting process is the use of OVERSEER. The technical background and description of OVERSEER is covered by the evidence of Dr Stewart Ledgard.

43. Figure 2 summarises the process that we undertook to develop the final FARMS report: an initial farm visit for data collection; go back to base to collate information, identify gaps and obtain missing information from the farmer and run the OVERSEER model; send draft report to check with the farmer that OVERSEER input data is correct; seek feedback from farmer and Horizons on the report; follow up visit to the farm to fill gaps and ensure no misinterpretation of information; produce final report.

44. During the process, two issues that are critical to the FARM strategy were identified; farm area and regional vs farm assessment of LUC.

a. Farm area - The definition of what is the farm area can present at least three possibilities: 1) the legal area; 2) the farm boundary area as mapped by the surveyor; or 3) the farmer's 'farmed land' or effective area. Generally, farmers tend to ignore lower class areas in what they consider farmed land. However, even though these lower class areas will carry a smaller permissible N leaching limit, they will increase the farm's total permissible limit.

b. Regional vs Farm LUC areas - Permissible N limits were calculated using Regional scale LUC and then compared to a Farm scale LUC after each property had been mapped by LandVision. A summary of the permissible N limits for the five farms using both the Regional and Farm scale LUC is presented in Table 4. In all but one case study farm, using the Regional scale LUC classification would make no difference or increase the permissible N limit, compared to the Farm scale LUC.

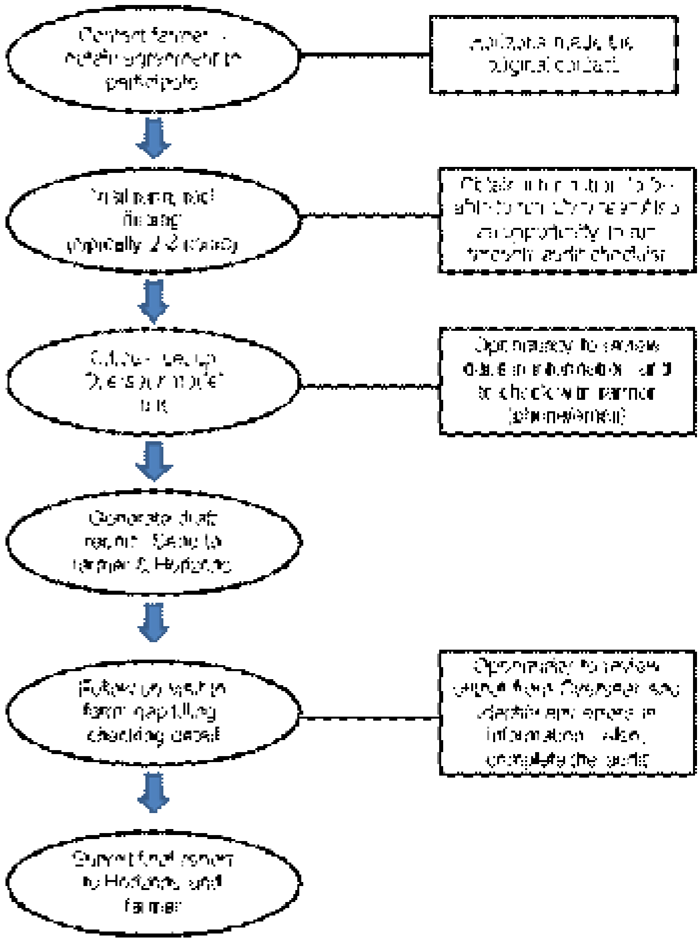

Figure 2. Summary of the process employed to develop the FARMS report.

Table 4. Permissible N loss limits (kg N/ha/yr) calculated for each case study farm at Regional and Farm LUC scales for the initial One Plan (baseline implementation) period

Farm No.	Farm type	Regional Scale	Farm Scale	Difference kg N/ha/yr	Difference %
#1	Dairy conversion	19	18	1	5
#2	Irrigated beef unit	25	26	-1	-4
#3	Intensive dairy unit	29	27	2	7
#4	Intensive cropping	31	31	0	0
#5	Irrigated dairy on sand	16	16	0	0

Overview of results - Clean Streams Accord Compliance

45. Under the Accord, dairy farms are obliged to:

- Exclude cattle from lakes, rivers, and perennial streams deeper than a 'Red Band' and "wider than a stride"

- Ensure farm races include bridges or culverts where stock regularly (more than twice weekly) cross a watercourse.
- Manage dairy effluent appropriately according to regional council specifications
- Manage nutrients using a nutrient budget.
- Protect regionally important wetlands.

46. Four of the five farms had waterways that qualified under the Accord. Only one farm, the new dairy conversion, had not fenced these waterways – a length of 1.6 km would require fencing. Another farm had dealt with most waterways but had a small area that needed further work.

47. Culverts were generally in place (thus avoiding stock crossing through the water), though one farm still needed to divert water from the culvert to avoid it directly entering the watercourse.

48. Regarding nutrient budgets, 2 farms had prepared a budget (or had one prepared on their behalf). A third was planning to get a nutrient budget done by a fertiliser company.

49. Again, for these five case study farms, effluent management was good, with the checklist not identifying any problems on any of the farms. Table 5 summarises the questions on the checklist relating specifically to effluent management and which show that all aspects of effluent application are covered by the assessment.

Table 5. Summary of checklist points relating to effluent management

Store animal effluent?	1. No direct discharge of effluent to water from ponds and sumps 2. Ancillary storm water must not discharge into pond or sump 3. Effluent storage must be sealed and not leaking
Apply effluent to land	1. No substantial leaks in irrigation pipes and equipment 2. Discharge application must be > 20m from surface water bodies, or Coastal Marine Areas 3. Discharge application must be > 20m from public areas and roads, or residences 4. Discharge application must be > 50m from protected archaeological or biodiversity areas 5. Must have a nutrient budget (emphasis on N) 6. Must not apply on days when drift will cause problems for neighbours 7. No surface ponding for more than 5 hrs after application

Overview of results - Nitrogen leaching losses

50. Because different catchments within Horizons' region will be phased in to the proposed scheme in different years, N leaching targets throughout the report have been expressed as 'baseline' implementation year (ie. the first year that the scheme applies to that farm) and 'baseline plus x years' where x = 5, 10 or 20 years, which are the incremental time periods when the permissible N leaching limit is decreased.

51. *Farm 1* (Dairy conversion) - As the farmer had plans for the converted property, OVERSEER nutrient budgets were prepared for Year 1 and Year 5 of the proposed operation. A summary of the permissible N limits compared to the modelled N losses for years one and five is presented in Table 6.

52. Despite the farmer's best efforts of managing nitrogen and employing best farming practices, the estimated N leaching will be above the proposed N limits. As the planned dairy conversion develops over time with increased stock numbers, the gap between N loss from farm and targeted N limits widens. The farm is in a high rainfall area (1718 mm/yr). More than half the farm is classified between LUC 4 and LUC 8, which means that the property attracts a low permissible N limit.

Table 6. Calculated N losses ('N loss farm' from OVERSEER) and the N leaching targets ('Farm-N limits') in the proposed One Plan (kg N/ha/year) for each case study farm

Farm #		One Plan period				Required N
		baseline	+5 yrs	+10 yrs	+20 yrs	reduction
1	Farm N limits	19	17	16	15	
Dairy conversion	N loss year 1	28	28	28	28	9-13
	N loss year 5	-	40	40	40	23-25
2	Farm N limits	25	23	20	19	
Irrigated beef unit	N loss farm	19	19	19	19	0
3	Farm N limits	29	25	23	22	
Intensive dairy[1]	N loss farm	28	28	28	28	0-6
4	Farm N limits	31	27	25	24	
Intensive cropping	N loss farm	30	30	30	30	0-6
5	Farm N limits	16	16	15	14	
Irrigated dairy (sand)	N loss farm	25	25	25	25	9-11

[1] Milking platform plus support block

53. *Farm 2* (Irrigated beef unit) - Fertiliser N inputs are small and, as a result, calculated farm surplus N was 70 kg N/ha/yr on this farm. Under the current management regime, Oringi Farm would not be required to reduce N losses as they are already under the permissible N loss targets for the next 20 years (Table 6).

54. *Farm 3* (Intensive dairying) – Calculated nitrogen leaching losses of 28 kg N/ha from the whole farm, as presented in Table 6 are below what is currently considered the typical range of 30-50 kg N/ha for a NZ dairy farm. We calculated that that a reduction in N leaching in the order of 8-12 kg N/ha per year would have been required from the dairy platform if this was considered independently from the supporting (dry stock) block, depending on the One Plan proposed target. However, also including the N leaching from the non dairying area (an additional 208 ha) in the farm total decreases the farm average from 37 to 28 kg N/ha (Table 6). The actual area used for the basis of the assessment therefore has important implications for the farmer.

55. *Farm 4* (Intensive cropping) - The current OVERSEER model cannot run both arable and pastoral scenarios together in the same model (a future upgrade will accommodate this) so they had to be run separately. Four cropping blocks with a total area of 84 ha were modelled using the arable model and one pastoral block of 27 ha of grazed pasture plus a 4 ha of non pastoral area using the pastoral model. Nutrient management block areas and N leaching data were then entered onto an Excel spreadsheet to calculate the overall whole farm N loss. The calculations show that the farm is currently operating within the farm-N limit (as proposed under the One Plan), but decreases would be required going forward (Table 6).

56. *Farm 5* (Irrigated dairy unit) – Annual average N leaching losses from the farm, at 25 kg N/ha (Table 6), are smaller than what is currently considered typical of the average NZ dairy farm (30-50 kg N/ha). If the farm fell under Horizons One Plan proposed limits, further reductions in N leaching would be required. This is mainly because of the LUC classes across the farm, with over 50% of the area falling into LUC classes 4-8.

Overview of results – N leaching mitigation strategies

57. *Farm 2* (Irrigated beef unit) – the N leaching losses are calculated to be below the proposed targets, so no further management changes were required of this farm.

58. *Farm 4* (Intensive cropping) - Under the current mixed cropping system N losses are 1 kg N/ha/yr below the proposed One Plan N loss targets. However, to achieve the

permissible N loss targets for the subsequent time periods some mitigation strategies would be required to decrease N losses.

59. Farm 4 already practices sound N management and the list of potential mitigation options to decrease N leaching is limited for such an intensive mixed cropping system. The main N mitigations to consider would be:

a. To improve fertiliser N recommendations. This would involve taking account of all N sources when deciding on the amount of fertiliser N to apply. For example, a major source of N results from mineralisation that occurs in a mixed cropping rotation following cultivated pasture (before the potatoes) and from the ploughed in annual ryegrass before the maize crop and before the spring wheat crop.

b. The effects of the old grass may well continue beyond the first year of the crop rotation. The release of N from the old grass may be contributing to soil N supply throughout the rotation beyond the potato crop. That is, the amount of N supply and length of its effect through the rotation will depend on the past history of the pasture; the more N that was applied in fertiliser or fixed by legumes (or returned in excreta), the greater the longevity of N supply after cultivation.

c. Pencoed Trust attempt to take account of soil N supply by sampling soils for their N status prior to planting, however, this could be improved by deeper soil sampling (0-60 cm as opposed to their current practice of 0-15 cm).

d. Improving fertiliser N recommendations is probably the major mitigation that could be used. If present yields could be maintained while reducing fertiliser N inputs by 5% then reductions of 1 kg N/ha/yr are predicted both for the whole year maize and potato crops.

e. Minimising bare soil over the winter months – maintaining crop cover will enable some N uptake and reduce winter leaching. This appears to be already practiced by Pencoed Trust. If not, cover crops are probably the most single effective method of decreasing nitrate leaching in the autumn/winter from an arable rotation.

f. Ensure that fertiliser N is spread evenly – this achieves better efficiency of use by the crop and consequently allows less N to be leached.

g. Changing the crop rotations – this approach would be more radical, changing the mix of crops or extending the rotation to include more ryegrass. For example, swapping potatoes and maize in the rotation could be considered. Maize can be grown with minimal fertiliser N following long-term pasture and has greater N removal by plant than potatoes (Andrea Pearson, FAR, pers. comm.). Assessing the economic costs would involve a more complex analysis and is difficult to gauge at present.

h. Winter grazing of dairy cows – by not having the 120 dairy grazers on the farm for two months during winter could reduce N leaching by 6 kg N/ha/yr on the pastoral block. The overall effect to the whole farm N leaching losses would be a reduction of 1 kg N/ha/yr. The lost revenue from winter grazing would be approximately $21,000. However, grazing extra sheep could be considered to offset this cost.

60. Two dairy farms (Farms 1 and 5) would have a considerable challenge on their hands if the proposed One Plan N leaching limits were implemented in their catchments. Under their current farming systems, large annual reductions in N leaching would be required, of the order 9 kg N/ha, representing a 32-36% reduction in annual N leaching; even larger reductions would be required in the future on Farm 1 if the proposed intensification goes ahead. An analysis of some of the mitigations available to the farms shows that:

- Some reduction in N leaching could be achieved
- This will generally bear a cost
- It may be insufficient to meet future targets under Horizons' proposed One Plan.

61. *Farm 1* (Dairy conversion) - While some N mitigations could reduce N losses by up to 5 kg/ha/yr, obtaining greater reductions would be exceedingly challenging for this property and in all likelihood would require either reductions in stock numbers or the construction of restricted grazing facilities such as Herd Homes (Longhurst & Luo, 2006) can reduce stock urinations on pasture. Studies have shown that restricting cow grazing to 6-hours/day can reduce N leaching by 25%. Possible strategies that could have an impact on reducing N losses include:

a. Grazing 50% of the herd off-farm for an extra month (May) could reduce N losses by 3 kg N/ha/yr from 28 to 25 kg N/ha/yr. The cost of grazing 50% of herd off-farm during May-July is approximately $22/cow/week or ~$18,400 for the extra month. Grazing the herd back on the original farm nearby would reduce these costs significantly.

b. Stocking rates: reducing the herd size in Year One by 30 cows from 380 to 350 cows (and reducing feed imports correspondingly) could reduce N losses from 28 to 26 kg N/ha/yr. Cost in lost milk solids production (30 cows x 500 kg MS/cow = 15,000 kg MS x $5.10 kg MS = $76,500).

c. Reducing herd size to 350 cows and grazing 50% of herd off-farm for three months (May-July) could reduce N losses to 24 kg N/ha/yr. Costs for grazing-off for extra month: ~$17,000; lost milk solids production: $76,500.

62. *Farm 3* (Intensive dairying) – a number of points were identified where improvements could be made to the current farming system: fertiliser N applications generally focus on the drystock (and maize) blocks and should occur outside high risk months for leaching, ie. not during May-July; the size of the effluent block is too small (13% of milking platform), resulting in extremely high N and K loadings; management of the effluent system could be adapted to ensure that nutrients are better distributed between the milking platform and other farm areas.

63. Consequently, a number of mitigation options were identified:

a. Applying fertiliser N applications outside the high risk months is predicted to reduce N leaching from 37 to 36 kg N/ha/yr (3% N reduction). Minimal cost involved if any, however, could be change in feed supply wedge ie. when feed becomes available, and thus may require some pasture management changes.

b. The farm dairy effluent block area should be increased to at least 75 ha; this would supply 123 kg N/ha/yr through Farm Dairy Effluent (however, K loadings are still excessive at 162 kg K/ha/yr). N loss is predicted to be reduced by 7 kg N/ha/yr, from 37 to 30 kg N/ha/yr (19% reduction). This would require investment in extra irrigation lines and possibly pumping capacity. Effluent irrigation costs would depend on the system chosen. These costs could be offset largely through saving in N fertiliser (~5.65 t N/yr or ~12.3 t Urea fertiliser @ $695/t* = $,8550).

c. The required size of farm dairy effluent block could be reduced by scraping solids from feed pad, collecting and exporting them off the milking platform.

d. Use of nitrification inhibitor, DCD, applied according to manufacturers' specifications, could reduce N losses by 1 kg N/ha/yr, from 28 to 27 kg N/ha/yr (4% reduction). The approximate cost of DCD applied on the ground is $100/ha (Ravensdown price January 30, 2009).

64. Farm 5 (Irrigated dairying) – options for this farm would involve reviewing irrigation and fertiliser N inputs, considering DCD applications and reviewing stocking policy:

a. Each nutrient management block should be considered and reviewed regarding strategic applications of irrigations and fertiliser N inputs rather than a blanket application approach. For example, reducing the volume of irrigation on the Waitarere sands from 500 mm/yr to 250 mm/yr is likely to reduce N leaching by 3 kg N/ha/yr (from 25 to 22 kg N/ha/yr), this suggests that N leaching can increase/decrease by ~1 kg N/ha/yr for approximately every 80 m^3 of irrigation for this soil type on this farm.

b. N fertiliser inputs have a greater impact on the Waitarere sands as reducing fertiliser N inputs by 50 kg/ha, from 200 kg N/ha/yr to 150 kg N/ha/yr is likely to reduce N loss from 25 to 21 kg N/ha/yr; ie. this suggests that N leaching can increase/decrease by 1 kg N/ha/yr for approximately every 12 kg N/ha/yr of fertiliser N input for this soil type on this farm.

c. Reducing irrigation and/or fertiliser N inputs will reduce pasture growth. For example each kg N/ha of fertiliser N would produce approximately 10 kg DM/ha of pasture. Therefore reducing fertiliser N inputs by 50 kg N/ha/yr is likely to reduce pasture production by 500 kg DM/ha/yr and in turn reduce milk solids production by approximately 42 kg MS/ha/yr (assuming a feed conversion of 12 kg DM per kg MS). As a consequence there is a financial cost of ~$140/ha (assuming milk payout of $5.10/kg MS = $214/ha, minus savings in fertiliser N reduction of $75/ha).

d. Using nitrification inhibitor, DCD, applied according to manufacturers' specifications, could reduce N losses from 25 to 20 kg N/ha/yr (20% reduction). The approximate cost of eco-N applied on the ground is $100/ha (Ravensdown price list 30 January 2009), but may be offset by extra pasture growth.

e. Avoiding applying fertiliser N (currently 33 kg N/ha/yr) during high risk N loss months (May-July) is likely to reduce N leaching by 2 kg N/ha/yr (from 25 to 23 kg N/ha/yr). This is likely to involve minimal cost (same amount of N fertiliser applied for year) but could change the amount of winter pasture grown and may require closer management of the feed supply during this period.

f. Avoiding applying fertiliser N (currently 33 kg N/ha/yr) during high risk N loss months (May-July) and reducing fertiliser N inputs by 50 kg/ha, from 200 kg N/ha/yr to 150 kg N/ha/yr is likely to reduce N loss from 25 to 20 kg N/ha/yr. However, as already mentioned there is potential loss of pasture production and changes in feed supply.

g. Consider increasing area of effluent blocks and reducing fertiliser N inputs. Generally, the cost of extending irrigations lines could be largely offset by savings in fertiliser N costs.

h. Consider a decrease in stock numbers and focus on per cow milk solids production. Fewer cows on farm would mean less stock urination per paddock and subsequently lower N losses from such paddocks. The construction of restricted grazing facilities such as Herd Homes (Longhurst and Luo, 2006) would reduce the time animals spend grazing pasture and have the same benefits outlined for Farm 1.

65. Another option for the dairy farms would be to consider organic production. Research conducted at Massey University compared an organic farmlet with a conventionally run dairy unit and found 50% less N loss under the organic system (Christian, 2008). In an

Upper Waikato project by Environment Waikato investigating improved nutrient efficiency on dairy farms in sensitive N loss catchments, the organic conversion option was found to be both environmentally sound (25% reduction in N loss) as well as being economically sound (especially at the lower $5/kg milk solids payout) (Longhurst and Smeaton, 2008).

Overview of results - other compliance issues

66. A checklist of compliance issues was worked through with each farmer. This served as an *aide memoire* to ensure that all potential compliance issues were reviewed during the visit. The checklist comprised of the questions relating to effluent (summarised in Table 5) and the additional questions in Table 7.

67. Generally, the audit did not identify any major problems. However, this may have been because the farms selected for the project were happy to participate and, it might be inferred, they were already well ahead in terms of environmental management. Also, given the time available to complete each farm visit and the priority on collection of input data for OVERSEER, the checklist was completed in the farm office rather than during a farm inspection.

68. Nevertheless, the exercise served as a useful assessment for the farmer of areas for further work. Issues relating to the Clean Streams Accord (stock access to waterways and effluent management) have been commented on earlier in this evidence. There were no other compliance issues.

Table 7. Checklist of questions that formed a part of the farm audit (see Table 5 for questions relating specifically to effluent management)

Activity	Requirements	Comments
Farming within N-loss target?	1. Farm N-loss must be within N-loss targets	
Produces animal effluent?	1. No direct discharge of effluent to water from yards or pads	If farm produces animal effluent, then the questions in Table 5 are included
Surface or ground water take?	1. Surface or ground water takes require a consent	
Use biosolids or soil conditioners?	1. Application of biosolids and/or 'soil conditioners' requires a consent	
Active farm dump or offal hole?	1. Farm dumps or offal holes require a consent	

Activity	Requirements	Comments
Stock have direct access to waterways?	1. Stock must have adequate (reticulated) trough water available in each paddock (ideally to meet peak demand)	
	2. Waterways that qualify under the Clean Streams Accord must be fenced	
	3. Stock crossings must have bridge or culvert	
	4. Runoff from bridges and culverts must be directed to land rather than water	
Apply fertiliser?	1. No application of fertiliser directly to water bodies	
	2. No application into protected biodiversity areas	
	3. Must be applied in accordance with industry Code of Practice	
	4. N-fertiliser use requires a nutrient budget	
	5. Must not apply on days when drift or odour will cause problems beyond the farm boundary	
Store and feed supplements?	1. Feed storage areas must be sealed to restrict effluent seepage (downward percolation). Excludes silage pits <500m^2 and presumably hay sheds	
	2. Feed storage areas must be protected from water runoff entry	
	3. Runoff from feed storage areas must not enter surface water bodies	
	4. Feed storage areas must not be sited within 50m of protected areas, or within 20m of bores, water bodies or the CMA[2]	
	5. Feeding out must not take place within 50m of protected areas, or within 20m of bores, water bodies or the CMA	
	6. Feed storage and feeding out shall not result in objectionable odour, dust or drift beyond the farm boundary	

69. In addition, an assessment was made of the risk of phosphorus run-off. Loss is generally through lateral surface/sub-surface pathways rather than downward leaching as with nitrate (McDowell et al., 2001). The OVERSEER model makes a risk assessment of phosphorus run-off, depending on the size of the P source (eg. soil Olsen P status, effluent and fertiliser applications) and a number of factors that relate directly to the risk of movement of water across the soil surface (McDowell et al., 2005); eg. soil-type, vegetation cover, climate, slope.

[2] Coastal Marine Area

70. To a large extent, these same transport factors will influence the risk of soil and pathogen movement across the soil (Knox et al., 2008). Losses of these contaminants are generally through lateral surface/sub-surface pathways (McDowell et al., 2001). This was our justification for using the same approach as with P loss to provide a broad farm-level assessment of risk of erosion and pathogen contamination of surface waters.

71. This could perhaps be considered as a 'Tier 1' assessment; more detailed information and a detailed farm walk would be required to identify specific areas at risk of loss from these contaminants as the losses are very site specific and can be thought of in terms of 'Critical Source Areas' (Strauss et al., 2007).

72. Results of this assessment are summarised in Table 8. In the majority of situations, risk of contamination was low or low/medium.

Table 8. Summary of the risk assessment of losses of phosphorus, pathogens and silt to water for each case study farm

Farm type	P runoff	Pathogen loss	Silt loss	Comments
Dairy conversion	LOW	MEDIUM	MEDIUM	Potential loss from tracks. Farmer plans to establish filter strips
Irrigated beef unit	LOW	LOW	LOW	Risk of overland flow is small on this land, combined with fenced watercourse which decreases the risk of bank erosion
Intensive dairy	MEDIUM	LOW/MEDIUM	LOW	Potential loss from tracks
Intensive cropping	LOW	LOW	LOW	Introduced stock increase risk slightly
Irrigated dairying	LOW/MEDIUM	LOW	LOW	Medium risk of P loss is related to particular areas of sandy soils

Conclusions

73. The FARMS reporting process is useful in that it assembles all of the farm information into one document. Furthermore, it is useful to be able to follow a prescriptive approach (ie. that developed by Manderson and Mackay) to help streamline the time involved in producing a report. Nevertheless, the success of the approach depends on:

a. Effective farmer engagement; all of the farmers in this test study indicated they were pleased to be involved and were willing to contribute to the project

b. Available resource to undertake the FARMS report – both from the farmer and the contractor undertaking the reporting process

c. A robust model such as OVERSEER to underpin the assessment (evidence on OVERSEER has been provided separately by Dr Stewart Ledgard)

74. Regarding resources, two farm visits were required. These were about 2-3 hours, but could have taken more time if a farm walk had been included (to complete the farm audit). Including running OVERSEER checking, reporting, the process could take 2-4 days per farm, plus several hours of the farmer's time.

75. The farms were chosen, in part, because it was thought that they may have struggled to meet the proposed N leaching limits under the One Plan. The OVERSEER modelling for each farm shows this largely to be the case, especially for the dairy farms:

a. The two non-dairy farms would be able to meet the initial proposed N leaching limits (for baseline implementation year) under current farming practice: the irrigated beef unit and the intensive cropping farm.

b. Two of the three dairy farms would need to substantially reduce nitrate leaching to meet the initial limits (2010), based on current farming practice. The required reduction would be 9 kg N/ha/year. This represents a required decrease of 32-36%, depending on the farm.

c. As the proposed limits under the One Plan decrease, the challenge for all but one farm increases. The irrigated beef unit is sufficiently low input that it meets all of the proposed N leaching targets going forward. By baseline plus 10 year, the intensive cropping farm would need to decrease N leaching by 6 kg N/ha/year (a 20% decrease compared with now).

d. However, again, the dairy units have the greatest challenge. If the proposed expansion of the dairy conversion goes ahead (Farm 1), required decreases in baseline plus 10 years would be 24 kg N/ha/year (a 60% reduction in N leaching) for that farm, and 25 kg N/ha in baseline plus 20 years. The irrigated dairy farm would need to decrease losses by 10 kg N/ha in baseline plus 10 years (40% decrease). The intensive dairy farm (with no problem in the baseline implementation year) would need to decrease losses in baseline plus 10 years by 5 kg N/ha from current practices (18% reduction).

76. The reports explored the effectiveness and cost of potential mitigations that farms could adopt, though some are already in place. These were based around good fertiliser and effluent management, use of nitrification inhibitors and stock exclusion during key autumn/winter periods. These generally bore a significant cost (especially wintering-off) and were insufficient to meet all of the targets. In some cases, destocking might be required to meet the proposed targets on the dairy farms, although restricting stock

access to pasture at key periods using, for example, Herd Homes would also have a significant benefit.

77. Few other compliance issues were identified from the farm audit. Compliance with the (voluntary) Clean Streams Accord was good; only one farm had a significant area of streamside that needed fencing. Farms had culverts for stock crossing and effluent management was good. It should be noted that the five test farms were happy to be involved in the project and therefore we might assume that they are leading in terms of concern for the environment.

78. Because the aim was to test the process, inevitably, we have been able to identify where the process might be improved. These suggestions are identified in the following paragraphs.

Suggested areas for improvement in the FARMS reporting process

79. *The process* - The FARM Strategy needs to be: 1) simple, 2) effective, and 3) easy to implement. If the process is too complicated then it is prone to error. If the process is too time-consuming then it becomes an issue of costs for the farmer and the Regional Council. Most of the farm visits were 2-3 hours long, however, on one property almost one hour was spent sorting out legal descriptions and land areas.

80. *Information gathering* - The farmer needs to have an overview of FARM Strategy objective to know what is required. It is a useful process that gets all the farm information together in one place. While the focus is on N, the FARM Strategy also deals with P and faecal contamination. Clear instructions should be given on what information is needed. Using template forms for data input would greatly assist in this area.

81. *Verification* - Use of reliable data for OVERSEER is critical. Clear guidelines are required regarding the evidence needed to back up information supplied. This is likely to more of an issue in sheep/beef situations where stock movements are required in detail because of their impact on N losses. In our test cases, we provided farmers with a summary of the input data to agree that it was a fair record of the farm.

82. *Data entry into* Overseer - It is our experience that protocols are required for entry of data into OVERSEER. This is because there are several methods of data entry available for livestock input such as: stock units (SU), age, and live weight. Some

methods of stock entry are 'better' than others, ie. they are better able to represent the farm. For operational purposes, it is recommended at the outset that protocols for data entry be developed thus ensuring consistency of approach between farms. The OVERSEER model cannot yet represent every farming system. In these cases, usually there are 'work-arounds'. As for other aspects of data entry, procedures need to be put in place to ensure a consistent approach is taken and that all farms are treated equally. The model continues to be developed and some of these issues will be addressed in future releases.

83. *Mapping* - Mapping is an area that requires clear guidelines, including area of the farm to be modelled; Legal, Surveyed, Farmed.

84. *Nitrogen mitigations* - Examples of nitrogen mitigations, such as avoiding fertiliser applications during high-risk drainage months over winter and reducing fertiliser N inputs, were included to provide a broad indication of what potentially is achievable. However, this was by no means a detailed assessment with complete scenario analysis. These mitigations may have a negative impact on the pasture growth curve and total dry matter production and therefore changes that may occur as a result of implementing N mitigations should also be considered. To determine the full extent of such mitigations would require a separate exercise which would also involve farm business planning and an economic assessment. This was outside the scope of the FARM Strategy reports.

4. REFERENCES

Christian, G. (2008). Organic wins N-loss trial. Dairy Exporter July: 79. Reporting on 2008 Dairy3 Conference.

Knox, A.K., Dahlgren, R.A., Tate, K.W., Atwill, E.R. (2008). Efficacy of Natural Wetlands to Retain Nutrient, Sediment and Microbial Pollutants. Journal of Environmental Quality 37: 1837-1846.

Longhurst, RD., Luo, J. (2006). On-off farm winter management practices: potential environmental benefits and issues. In *Designing sustainable farms: Critical aspects of soil and water management*. (Eds L.D.Currie and L.J.Yates). Occasional Report No. 20. Fertilizer and Lime Research Centre, Massey University, Palmerston North, 403-410.

Longhurst, R.D. and Smeaton, D.C. (2008). Improving nutrient efficiency through integrated catchment management in Little Waipa and Waipapa – Reporting summary for Upper Waikato Project. AgResearch client report for Environment Waikato, 41p.

Manderson, A., and Mackay, A. (2008). FARMS test farms project. Testing the One Plan approach to containment management and linking the FARM Strategy to the SLUI Whole Farm Plan design. AgResearch client report for Horizons. 112p.

McDowell, R.W., Monaghan, R.M. and Wheeler, D.M. (2005). Modelling phosphorus losses from pastoral farming systems in New Zealand. *New Zealand Journal of Agricultural Research* 48: 131–141.

McDowell, R.W., Sharpley, A.N., Beegle, D., Weld, J. (2001). Comparing phosphorus management strategies at the watershed scale. Journal of Soil and Water Conservation 56: 306–315.

Strauss, P., Leone, A., Ripa, M.N., Turpin, N., Lescot, J.-M. and Laplana, R. (2007). Using critical source areas for targeting cost-effective best management practices to mitigate phosphorus and sediment transfer at the watershed scale. Soil Use and Management 23 (Supplement): 144-153.

Wheeler, D.M., Ledgard, S.F., De Klein, C.A.M., Monaghan, R.M., Carey, P.L., McDowell, R.W., Johns, K.L. 2003: OVERSEER® nutrient budgets – moving towards on-farm resource accounting. Proceedings of the New Zealand Grassland Association 65: 191-194.

Mark Shepherd
August 2009