Bay of Plenty Regional Council

Update of the 2014 NDA Impact Analysis

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PERRIN
AG CONSULTANTS

REPORT PREPARED BY

PERRIN
AG CONSULTANTS

REGISTERED FARM MANAGEMENT CONSULTANTS

Perrin Ag Consultants Limited
1330 Eruera Street, P O Box 596, Rotorua

Phone: 07 349 1212, Fax: 07 349 1112
Mobile: 021 955 312 (D J Perrin)/ 0292 955 312 (T Laan)
0293 955 312 (L Matheson) / 027 340 3984 (D Walker)

Email: consult@perrinag.net.nz

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1. Executive summary

1.1 The Bay of Plenty Regional Council ("BOPRC") is in the process of developing Nitrogen Discharge Allowances ("NDA") for all pastoral land in the Lake Rotorua catchment with the purpose of improving water quality by reducing nitrogen and phosphorus inflows into the lake. An analysis of the farm-level profit impact on meeting likely nitrogen discharge levels was undertaken by Perrin Ag Consultants Ltd in 2014 ("NDA Impact Analysis").

1.2 In November 2015, with draft rules almost at the notification stage and a methodology for allocating Provisional Nitrogen Discharge Allowances ("pNDAs") having been developed, the BOPRC engaged Perrin Ag to provide an update the original study – primarily in relation to how successful the original mitigations were in relation to achieving the outcomes of the likely draft rules.

1.3 To do this, the hypothetical farm systems modelled in the original study (including their mitigation scenarios) were migrated to OVERSEER 6.2.0, hypothetical pNDAs were then assigned to the farm models based on their current levels of N loss (as a proxy for non-existent historic N losses) and then the N loss output from the mitigation scenarios compared with the pNDAs. The financial impact of the mitigation scenarios was also updated based on revised medium-term price expectations.

1.3.1 As expected, the migration of scenario OVERSEER files to v6.2.0 further increased N losses, with the dairy scenarios base N losses increasing by an average of 94% compared to their assessed losses in OVERSEER 5.4.11 and the dry stock base scenario N losses increasing by 82% compared to OVERSEER 5.4.11.

1.4 Comparison of base system N losses against the actual historic farm N losses in the catchment suggests models for 90-100 kg N/ha N loss dairy farms and the 50-100kg N/ha/year dry stock farms are lacking from the data set. These gaps are due to production systems that aren't captured, rather than gaps in the geo-physical mix.

1.4.1 When migrated to OVERSEER v6.2.0, the mitigation scenarios as modelled were insufficient to achieve the required N loss reductions for two of the dry stock scenarios (SDG and DG), both of which involved dairy support. Three of the six dairy farm scenarios were able to meet new pNDA targets as modelled in the original study. We also note that two dry stock farms were already assessed as being at their 2032 pNDA level and would have to make no changes.

1.5 Observing the differences in the financial assumptions between the original 2014 study and this update on the "cost" of mitigation demonstrates the potential that market prices have on how the impact of meeting N reductions is perceived.

1.6 Sensitivity analysis of the main mitigation scenarios clearly demonstrates that the economic impact of variation in key input and output prices merely reflects the nature of the mitigations modelled. In the study, reducing N losses typically resulted in a reduction in milk production on dairy farms as a result of fewer inputs [of N in feed and fertiliser] and improving the efficiency of use the remaining inputs. Accordingly, when milk price is low, the economic impact of lowering milk production reduces; likewise, when input prices are high, reducing their [inefficient] use improves the cost structure of the business.

1.7 This is consistent with the dry stock farm systems where increasing sheep:cattle ratio, decreasing cattle and increasing ewe productivity all featured heavily in the scenarios; all of which have revenue impacts. In comparison, input mitigations (like reducing N fertiliser, reducing cropping) are limited for these farm types, reflecting the lower intensity of most of these dry stock systems.

1.8 It is apparent that the mitigation scenarios presented in the 2014 NDA Impact Report provide some value in helping farmers and regulators alike in understanding how farmers might meet the likely N loss reduction targets mooted for the Lake Rotorua catchment. Just over half of the modelled farm systems were able to achieve their pNDA targets utilising the scenarios developed in the original study, two dry stock farms were close to meeting their pNDAs and two of the dry stock farms were already operating at or under their likely 2032 NDA.

1.9 The revision of the medium term pricing assumptions used in the study had little impact on the economic outcomes of the mitigations for the dry stock scenarios. But expectations of lower medium term milk prices clearly demonstrated how the changes in the prices of inputs and outputs associated with a mitigation strategy can alter the perceived and actual economic impacts of meeting N loss targets.

1.10 More work is potentially required to address an apparent gap in the earlier study as regards how dairy farms historically leaching 90-100kg N/ha will be affected by the proposed rules and what additional mitigations might be required by those farm systems previously thought to have made enough system change to meet the “35/13” targets.

2. Background and terms of reference

2.1 The Bay of Plenty Regional Council ("BOPRC") is in the process of developing Nitrogen Discharge Allowances ("NDA") for all pastoral land in the Lake Rotorua catchment with the purpose of improving water quality by reducing nitrogen and phosphorus inflows into the lake. In 2014, the BOPRC and the Stakeholder Advisory Group ("StAG") suggested draft restricted NDA levels of 35kgN/ha/year for dairy, 13kgN/ha/year for dry stock farms and 3kgN/ha/year for trees. These draft NDA values were based on analyses using versions of OVERSEER v5.

2.2 Perrin Ag Consultants Ltd ("Perrin Ag", "PAC") was engaged at that time to analyse the financial implications of the NDA levels at an individual farm level. This was accomplished using a range of hypothetical and real farm case studies that were deemed to be illustrative of farms within the Lake Rotorua catchment. The case study farms were modelled in Farmax and OVERSEER v5 and v6.1 to determine how operating profitability changed as farmers made realistic decisions to optimise their farm systems in a restrictive N loss environment. These changes were limited to those appropriate within the existing farming systems.

2.3 In November 2015, with draft rules almost at the notification stage and a methodology for allocating Provisional Nitrogen Discharge Allowances ("pNDAs") having been developed, the BOPRC engaged Perrin Ag to provide an update of the original study as follows:

(i) Migrate all OVERSEER output from the hypothetical farms into OVERSEER v6.2.0;

(ii) Provide commentary about where in the Rule 11 spectrum of benchmarks the assessed range of hypothetical farm systems sit to provide the BOPRC with a sense of how representative they are of typical farm systems in the catchment;

(iii) Assess the efficacy of the original mitigation scenarios for the hypothetical farms against the likely pNDAs that would be assigned to these properties;

(iv) Update the farm system status quo profitability estimates with any necessary changes to medium term pricing expectations (if any) and provide additional sensitivity analysis around key output prices.

3. Methodology

3.1 Detailed methodology for the original NDA Impact Analysis is well documented in the 2014 report. However it is worth briefly summarising the original methodology here again.

3.2 <u>Original methodology (2014)</u>

3.2.1 The NDA impact analysis was originally based around a mix of broadly representative hypothetical and real farms. Each of the 14 hypothetical (8 dry stock, 6 dairy) and four real farm systems (2 dry stock, 2 dairy) were modelled to reflect two alternative NDA scenarios, in addition to their current state: a range NDA scenario and a single NDA scenario.

3.2.2 All of the hypothetical farm systems were deemed to be at a static stage of development, with all non-marginal expenditure assumed at business-as-usual ("BAU") levels and pasture growth parameters were based on what we considered to be "normal" climate expectations going forward.

3.2.3 The hypothetical and real farm systems are briefly outlined below.

3.2.4 The dairy systems case studies were:

- HH – high pasture eaten , high supplement per cow
- HM – high pasture eaten, medium supplement per cow
- HL – high pasture eaten, low supplement per cow
- MM – medium pasture eaten, medium supplement per cow
- LH – low pasture eaten, high supplement per cow
- LM – low pasture eaten, medium supplement per cow

3.2.5 The dry stock systems the case studies were:

- HSB - high pasture harvested , sheep & beef breeding/finishing
- LSB - low pasture harvested, sheep & beef breeding/finishing
- SDG – sheep breeding/finishing and dairy grazing
- SDW - sheep breeding/finishing and winter dairy grazing
- WGS – winter dairy grazing using crop and silage
- DG – dairy heifer grazing
- BBT – bull beef trading
- DBF – deer breeding/finishing

3.2.6 Range NDA was defined as being 25% less than the current level of N loss as assessed in OVERSEER v5, subject to being within the range of 30-40kg N/ha/year for dairy systems and 10-20kg N/ha/year for dry stock systems.

3.2.7 The single NDA scenario was 35kg N/ha/year for dairy farms and 13kg N/ha/year for dry stock systems.

3.2.8 Where the current level of N loss was assessed as being below the single NDA target, or where the Range and Single NDA target were equivalent, no additional modelling was deemed necessary.

3.2.9 The system changes modelled in the range and single NDA scenarios were done on the basis of targeting key pathways within the N cycle, simultaneously trying to minimise any reduction in profitability associated with achieving the required extent of N loss, albeit within the broad parameters of the existing systems.

3.2.10 Where possible, an attempt was made to retain the general policy direction of the individual farm systems e.g. dairy support properties were left as dairy support. Scenarios were assessed for practical implementation and realism based on the authors' professional judgement and practical experience.

3.2.11 Given the 18-20 year timeframe proposed for farmers to make the necessary changes to meet the draft NDA targets, under the terms of the RFQ, "productivity" improvements were allowed as a means of mitigating the financial impacts of system[1]. Any modelled increases reflected the authors' professional assessment of each farm system's immediate capacity for productivity increase, rather than what is ultimately achievable. This has resulted in the "optimised" scenarios still having a range of productivity levels.

3.2.12 Product and input prices used in all financial analysis reflected current seasonal averages for the 2013/14 year (which the authors considered appropriate as regards medium pricing expectations). The solitary exclusion was the milk price, which achieved record levels in 2013/14 for all of the three milk processers Rotorua farmers are currently supplying or able to supply. Accordingly a medium term milk price of $6.60/kg MS was used.

3.2.13 While all of the nitrogen loss assessments were done in OVERSEER 5.4.11, as part of the original analysis these files were then converted to Overseer v6.1.2 using the prescribed Data Input Standards for Overseer and the equivalent levels of N losses calculated.

3.3 Updated methodology (2015)

3.3.1 For the 2015 analysis update, the OVERSEER scenarios for seven of the hypothetical dry stock and all six of the hypothetical dairy farm systems were migrated to version 6.2.0.

3.3.2 The major changes between OVERSEER 6.1 and 6.2 relate to how soil properties (derived from s-Map data[2]) and climate data influence N leaching.

3.3.3 Bringing the original files up to protocol for OVERSEER 6.2.0 involved finding GPS locations for all of the theoretical farms within the catchment.

3.3.4 Using the S-map name from the original project, which links to the soil data in S-map Online, the best fit of location and rainfall were identified from within the catchment. In some cases this necessitated a slight changing of S-map soils (i.e. Kopuroa_1a.1 to

[1] The original study noted that the inclusion of productivity improvements within a mitigation framework potentially confounds estimates of changes in profitability associated with achieving N loss reduction.

[2] See http://smap.landcareresearch.co.nz/home

Kopuroa_8a.1). While these two soil types would give different outputs under OVERSEER 6.2.0, because they were previously entered by order and topsoil parameters, there should have been no difference in the original files. We note that there was not the same degree of finesse in the soil data inputs in earlier versions of OVERSEER. For this reason, it was not always possible to get a GPS point that gave an identical rainfall and climate data set to the original data used. However, GPS was required to be used because OVERSEER 6.2 also uses this to calculate temperature and potential evapotranspiration (PET) – and this data can't be gleaned from elsewhere. Therefore slight compromises had to be made on rainfall in order to complete the modelling.

3.3.5 Had the original project been undertaken in the current versions of OVERSEER, sourcing appropriate GPS co-ordinates would have been a starting point. However, when the previous versions of OVERSEER were being used, there was no option for using GPS data and so the precise location of the farm down to a GPS point was not relevant. In converting real farms to OVERSEER 6.2.0 and beyond there have frequently been changes in climate data – between the original data used for benchmarking to the OVERSEER generated numbers of OVERSEER v6.2.0. Therefore some changes are not unusual. As can be seen from Table 1 (below) these have been managed to under 2% variation, in all but two properties.

3.3.6 As a general rule the change from OVERSEER v6.1 to 6.2 resulted in a further increase[3] in the level of N leaching assessed in OVEERSEER from farm systems on soils derived from pumice.

3.3.7 We note that since this migration occurred, OVERSEER has undergone a further version upgrade to 6.2.1. This will likely have altered farm system N outputs again, but these latest changes have not been considered in this report.

3.3.8 A single dry stock file, WGS, was unable to be migrated. This was because 5.4.11 was not able to effectively model this system due to the large area of forage crop grown. A "work-around" was developed to allow representative data to be created for the original analysis, but there was insufficient time to allow this to be appropriately recreated for the current analysis. Accordingly this scenario was discarded.

3.3.9 Block N loss output data from the migrated base scenario files were then provided to the BOPRC staff, who calculated hypothetical pNDAs for these properties. In line with the Integrated Framework that forms the basis for the proposed rules, pNDAs were calculated as a 31.3% reduction from current level for dairy and 20% reduction from current for dry stock subject to dairy pNDAs sitting within a 54.6-72.8 kg N/ha/year range and dry stock sitting within a 18 – 54.6 kg N/ha/year range.

3.3.10 NDA Impact Analysis block names, descriptions, S-Map soils used and rainfall data are presented in Table 1 below.

3.3.11 For the purposes of this analysis, it was assumed that the base scenarios for the hypothetical farm systems were equivalent to historic N losses, with pNDAs calculated based on current state losses. These pNDAs were also presented in OVESEER v6.2.0.

3.3.12 The update of cost and revenue assumptions was brought as close as possible into line with financial data used for other recent analysis assisting in the development of the

[3] In addition to the increased in N leaching from migration from v5.4.11 to 6.1.2

Lake Rotorua rules framework, specifically the recent "Economic Impacts Report" [Parsons *et al* (2015)[4]], but adapted for the differences in financial modelling systems.

3.3.13 Dairy system data was primarily based off the 2012/13 Central Plateau Owner-Operator benchmark from DairyBase data. A milk price of $5.50/kg MS was used for determining dairy farm milk revenue, while an appropriate medium term price expectation for manufacturing beef ($4.20/kg) was applied to the normal seasonal schedule distributions. We note that the milk price used is lower than both the nominal average Fonterra milk price ($6.07/kg MS)[5] for the period 2006/07 through 2014/15, the real (CPI adjusted) NZ milk price since 1975, at just under $6/kg MS[6] and the milk price used in the original NDA Impact Analysis report. However, we believe this price represents more fairly the current global medium term outlook for milk. These are summarised in Appendix 1.

3.3.14 For the dry stock farms, Beef+Lamb NZ data for Class 4 farms from the 2014/15 Beef + Lamb Economic Service Sheep & Beef Farm Survey was used to inform the operating expense parameters. Our own medium term revenue expectations were applied to normal seasonal schedule distributions for sheep meat ($5.50/kg), beef ($4.20/kg base price), venison ($6.75/kg), velvet ($100/kg) and wool ($3.40/kg). A summary of the operating expense parameters and how they were applied are in Appendix 2.

[4] http://www.rotorualakes.co.nz/EconomicImpacts
[5] Source: interest.co.nz and Fonterra Cooperative Group Ltd
[6] LIC, BERL 2015

Table 1: NDA Impact Analysis block names, descriptions, S-Map soils used and rainfall data

No	Name	Reference	Soil Name	Soil Type	New Rainfall	Old Rainfall	% Change
	DAIRY						
1	HH	High pasture eaten; high supplements/cow	Turangi_1a.1	Orthic Pumice	2,298	2,292	0%
2	HM	High pasture eaten; medium supplements/cow	Mamaku_4a.1	Orthic Podzol	2,339	2,339	0%
3	HL	High pasture eaten; low supplements/cow	Turangi_10a.1	Orthic Pumice	2,164	1,950	10%
4	MM	Medium pasture eaten; medium supplements/cow	Haparangi_1a.1	Orthic Allophanic	1,933	1,650	15%
5	LH	Low pasture eaten; high supplements/cow	Haparangi_2a.1	Orthic Allophanic	1,558	1,569	-1%
6	LM	Low pasture eaten; low supplements/cow	Turangi_1a.1	Orthic Pumice	2,090	2,067	1%
	DRYSTOCK						
1	HSB	High pasture harvested Sheep/beef, breed/finish	Oropi_1a.1	Orthic Pumice	1,787	1,780	0%
2	LSB	Low pasture harvested Sheep/beef, breed/finish	Te Rangiita_5a.1	Typic Tephric Recent	1,498	1,500	0%
3	SDG	Sheep breed/finish; dairy grazing	Mamaku_1a.1	Orthic Podzol	1,961	1,930	2%
4	SDW	Sheep breed/finish; winter dairy grazing	Haparangi_1a.1	Orthic Allophanic	1,664	1,650	1%
5	WGS	Winter dairy grazing; using crops and silage	Turangi_1a.1	Orthic Pumice	1,650	1,650	0%
6	DG	Dairy heifer grazing	Turangi_1a.1	Orthic Pumice	1,650	1,650	0%
7	BBT	Bull beef trading	Kopuroa_8a.1	Buried-pumice tephric recent	1,473	1,467	0%
8	DBF	Deer breed/finish	Oropi_1a.1	Orthic Pumice	1,787	1,780	0%

4. Results and discussion

4.1 Impact of OVERSEER version change on base N losses

4.1.1 As expected, the migration of scenario OVERSEER files to v6.2.0 further increased modelled N losses.

4.1.2 For the dairy scenarios, assessed N losses in the base (current state) scenarios increased by an average of 94% compared to their assessed losses in OVERSEER 5.4.11. The dry stock scenario N losses increase by 82% compared to OVERSEER 5.4.11. These relative increases are consistent with the observations for actual farm data from the catchment when being migrated to OVERSEER 6.2.

4.2 Relativity of hypothetical farm systems to actual farms in the catchment

4.2.1 In order to better understand the applicability of the NDA Impact analysis, the BOPRC wanted to see how the "historic" (current) N losses of the modelled farm systems related to the actual distribution of Rule 11 N losses across the actual farms in the catchment.

4.2.2 These are presented in in Figure 1 and Figure 2 below.

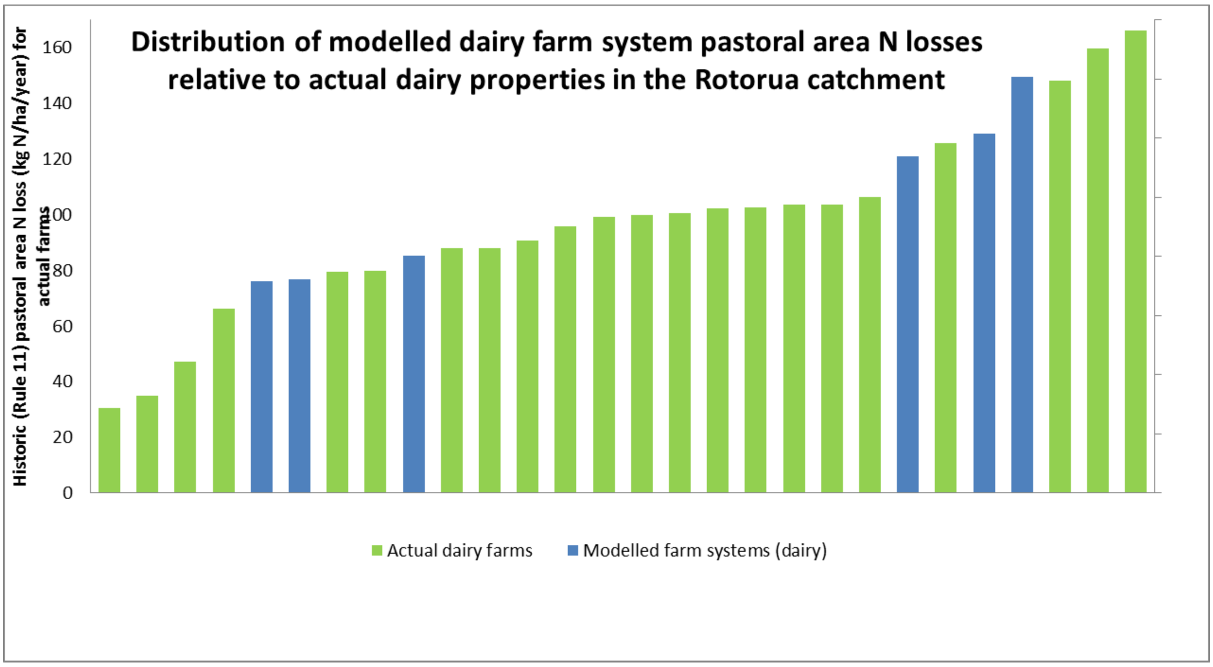

Figure 1: Distribution of modelled dairy farm system pastoral losses relative to actual historic losses from dairy properties in the Rotorua catchment, as modelled in OVERSEER 6.2.0 (Source: BOPRC, Perrin Ag Consultants).

4.2.3 As can be seen in Figure 1, the modelled farm systems don't provide good representation of the 90-100 kg N/ha N loss dairy farms in the catchment.

4.2.4 The dry stock models have a better degree of representation. The very high end of the N leaching range (50-100kg N/ha/year) are not modelled, although this would probably be captured by the WGS model that wasn't able to be migrated for this analysis.

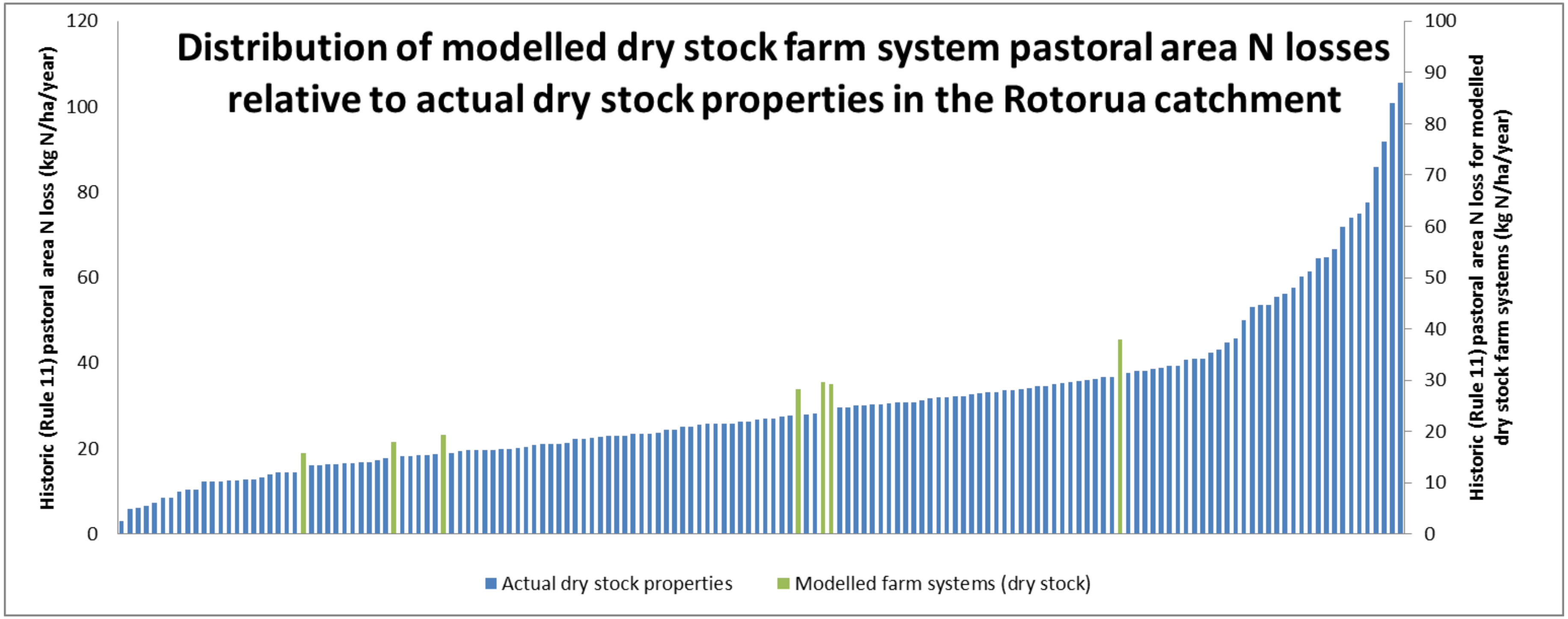

Figure 2: Distribution of modelled dry stock farm system pastoral losses relative to actual historic losses from dry stock properties in the Rotorua catchment, as modelled in OVERSEER 6.2.0 (Source: BOPRC, Perrin Ag Consultants). Note that the modelled farms don't have a higher N loss than the adjacent properties. The scale of the N losses from the modelled farms has been adjusted to allow their easy identification if the graph isn't printed in colour. These farms have N losses equivalent to the averaged of the properties either side in the graph.

Table 2: Summary of drystock systems

Base model	HSB	LSB	SDG	SDW	DG	BBT	DBF
Pasture harvested (t DM/ha)	7.9	6.5	8.0	6.2	7.8	7.7	6.1
Stocking rate (SU/ha) [1]	14.4	11.8	14.6	11.3	14.1	14	11.2
Breeding ewes	48%	69%	66%	73%			
Breeding cows							
Dairy heifers					100%		
Winter cows			34%	27%			
Beef trading	52%	31%				100%	
Deer							100%
Liveweight wintered (kg/ha)	613	579	573	1,666	487	475	520
Winter crop used (% farm area)	0%	3%	4%	11%	0%	0%	4%
N applied (kg/ha/year)	6	11	7	16	30	80	10
Supplement harvested (% farm area)	34%	5%	19%	42%	48%	34%	7%
EBIT ($/ha)	$ 65	$ 301	$ 336	-$ 53	$ 640	$ 348	$ 240
($/SU)	$ 5	$ 26	$ 23	-$ 5	$ 45	$ 25	$ 21
Netkg product/kg lwt wintered	59%	51%	60%	13%	84%	105%	26%
N loss (kg N/ha/year) [2]	19.3	15.8	38.0	29.7	29.2	17.9	28.3

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

[2] Overseer 6.2.0

Range scenario	HSB	LSB	SDG	SDW	DG	BBT	DBF
Pasture harvested (t DM/ha)	7.6	6.3	7.5	6.4	5.2	6.9	5.7
Stocking rate (SU/ha) [1]	13.8	11.5	13.6	11.5	9.4	12.5	10.4
Breeding ewes/lambs	66%	69%	72%	87%			6%
Breeding cows							
Dairy heifers					100%		
Winter cows			28%	13%			
Beef trading	34%	31%				100%	
Deer							94%
Winter crop used (% farm area)	0%	2%	0%	0%	0%	0%	0%
N applied (kg/ha/year)	0	0	0	16	30	0	33
New forestry (% farm area)	0%	0%	0%	0%	0%	0%	0%
Supplement harvested (% farm area)	34%	5%	19%	42%	131%	34%	7%
EBIT/ha	$ 239	$ 309	$ 330	$ 9	$ 843	$ 354	$ 353
Δ EBIT from Base	$ 174	$ 8	-$ 6	$ 61	$ 203	$ 5	$ 113
%	266%	3%	-2%	N/A	32%	2%	47%
N loss (kg N/ha/year) [2]	15	14	24	11	26	14	18
Δ N loss from Base	-5	-2	-14	-19	-4	-4	-10
%	-24%	-10%	-37%	-64%	-12%	-20%	-36%
Δ EBIT/kg N reduced	$ 37	$ 5	-$ 0	$ 3	$ 57	$ 2	$ 11

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

[2] Overseer 6.2.0

Single scenario	DG	DBF
Pasture harvested (t DM/ha)	4.9	6.0
Stocking rate (SU/ha) [1]	8.9	10.9
Breeding ewes/lambs		6%
Breeding cows		
Dairy heifers	100%	
Winter cows		
Beef trading		
Deer		94%
Winter crop used (% farm area)	0%	0%
N applied (kg/ha/year)	0	47
New forestry (% farm area)	0%	0%
Supplement harvested (% farm area)	131%	7%
EBIT/ha	$ 786	$ 364
Δ EBIT from Base	$ 146	$ 124
%	0%	0%
N loss (kg N/ha/year) [2]	25	20
Δ N loss from Base	-4	-8
%	-14%	-46%
Δ EBIT/kg N reduced	$ 35	$ 15

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

[2] Overseer 6.2.0

Table 3: Summary of dairy farm systems

Base model	HH	HM	HL	MM	LH	LM
Pasture harvested (tDM/ha)	11.0	12.5	11.9	10.4	9.4	10.4
Cows/ha[1]	3.34	3.15	3.03	2.82	2.95	2.70
MS/cow[2]	376	368	355	351	373	351
MS/ha	1,256	1,161	1,073	991	1,101	946
Supplement fed (tDM/cow)[3]	1.60	1.11	0.52	0.83	1.44	1.05
N applied kg/ha/year	158	160	124	93	146	47
EBIT ($/ha)	$ 1,486	$ 1,273	$ 1,815	$ 1,461	$ 1,275	$ 1,267
N loss (kg N/ha/year)[4]	121	141	114	72	72	80

[1] Cows milked at peak (1 Dec) per effective milking area

[2] Milksolids to the factory per cow milked at peak

[3] Includes winter cow grazing

[4] Overseer 6.2.0

Range scenario	HH	HM	HL	MM	LH	LM
Pasture harvested (tDM/ha)	10.8	10.9	11.5	10.4	9.0	8.7
Cows/ha[1]	2.53	2.56	2.62	2.57	2.89	2.28
MS/cow[2]	376	368	369	364	378	370
MS/ha	950	943	968	934	1,093	843
Supplement fed (tDM/cow)[3]	0.8	0.6	0.3	0.9	1.8	0.2
N applied kg/ha/year	61	76	79	46	33	27
EBIT/ha	$ 1,579	$ 1,245	$ 1,793	$ 1,499	$ 1,214	$ 1,380
Δ EBIT from Base	$ 93	-$ 29	-$ 22	$ 39	-$ 61	$ 113
%	6%	-2%	-1%	3%	-5%	9%
N loss (kg N/ha/year)[4]	70	81	86	52	48	72
Δ N loss from Base	-51	-60	-28	-20	-24	-8
%	-42%	-43%	-25%	-28%	-33%	-10%
Δ EBIT/kg N reduced	$ 2	-$ 0	-$ 1	$ 2	-$ 3	$ 14

[1] Cows milked at peak (1 Dec) per effective milking area

[2] Milksolids to the factory per cow milked at peak

[3] Includes winter cow grazing

[4] Overseer 6.2.0

Single scenario	HH	HM	HL	MM	LH	LM
Pasture harvested (tDM/ha)	10.5	10.5	11.6	10.4	9.0	9.9
Cows/ha[1]	2.34	2.46	2.62	2.57	2.89	2.56
MS/cow[2]	375	368	383	364	378	369
MS/ha	878	905	1,005	934	1,093	944
Supplement fed (tDM/cow)[3]	0.8	0.6	0.4	0.9	1.8	1.1
N applied kg/ha/year	35	40	102	46	56	29
EBIT/ha	$ 1,438	$ 1,208	$ 1,878	$ 1,499	$ 1,214	$ 1,289
Δ EBIT from Base	-$ 48	-$ 65	$ 62	$ 39	-$ 61	$ 22
%	-3%	-5%	3%	3%	-5%	2%
N loss (kg N/ha/year)[4]	64	76	94	52	48	59
Δ N loss from Base	-57	-65	-20	-20	-24	-21
%	-47%	-46%	-18%	-28%	-33%	-26%
Δ EBIT/kg N reduced	-$ 1	-$ 1	$ 3	$ 2	-$ 3	$ 1

[1] Cows milked at peak (1 Dec) per effective milking area

[2] Milksolids to the factory per cow milked at peak

[3] Includes winter cow grazing

[4] Overseer 6.2.0

Table 4: Summary of original NDA Impact Analysis farm system N loss modelling compared with provisional NDAs in OVERSEER 6.2.0

Dry stock farm systems

Scenario	Base N loss		% change from migration	pNDA (6.2.0) per ha	Required reduction from base	Range scenario N loss per ha	Reduction achieved	pNDA achieved?	Single NDA scenario N per ha	pNDA achieved?
	5.4.11 per ha	6.2.0 per ha								
HSB	13	19	53%	18	-6%	15	-24%	Yes		
LSB	11	16	47%	19	None	14	-10%	Yes		
SDG	14	38	181%	23	-39%	24	-37%	No		
SDW	13	30	129%	22	-27%	11	-64%	Yes		
DG	20	29	45%	24	-19%	26	-12%	No	25	No
BBT	13	18	41%	18	None	14	-20%	Yes		
DBF	16	28	79%	19	-32%	18	-36%	Yes	20	No

Dairy farm systems

Scenario	Base N loss		% change from migration	pNDA (6.2.0) per ha	Required reduction from base	Range scenario N loss per ha	Reduction achieved	pNDA achieved?	Single NDA scenario N per ha	pNDA achieved?
	5.4.11 per ha	6.2.0 per ha								
HH	70	121	74%	71	-41%	70	-42%	Yes	64	Yes
HM	64	141	120%	73	-48%	81	-42%	No	76	No
HL	43	114	165%	73	-36%	86	-24%	No	94	No
MM	46	72	57%	56	-23%	52	-28%	Yes	52	Yes
LH	40	72	79%	55	-24%	48	-33%	Yes	48	Yes
LM	47	80	70%	57	-29%	72	-11%	No	59	No

4.3 Efficacy of original mitigation scenarios on achieving pNDAs

4.3.1 The original analysis essentially considered the ability of farm systems in the catchment to reduce N losses by a targeted 25% of existing losses (tempered by the constraints of a sector range) and ultimately to the nominal levels of 35kg N/ha and 13kg N/ha for dairy and dry stock farms respectively, as assessed in OVERSEER v5.4.11.

4.3.2 The current proposed rules framework for the Rotorua catchment will require an average N loss dairy block to reduce N losses by 31% and an average N loss dry stock block by 20%, under a sector range allocation method. The dairy sector as a whole is required to achieve a 35% reduction while the dry stock sector is required to achieve a 17% reduction.

4.3.3 The output from the modelled farm systems using OVERSEER v6.2.0 and the revised financial assumptions is summarised on pages 13 & 14 above and in Table 2 and Table 3 (above).

4.3.4 When migrated to OVERSEER v6.2.0, the mitigation scenarios as modelled for two of the dry stock systems (SDG and DG) were insufficient to achieve the required N loss reductions. Both these systems involved dairy support.

4.3.5 We also note that of the seven dry stock production systems modelled, two dry stock farms were already assessed as being at their 2032 pNDA level and would have to make no changes. This is as a result of their being at the bottom of the historical range of N losses within their sector (see Figure 2) and therefore eligible to receive an allocation equivalent to or higher than their historic N losses. Under the proposed rules this surplus NDA could be used to intensify production in the future or potentially sold.

4.3.6 The two dairy grazing scenarios both failed to meet their pNDA targets as modelled. Further reductions in cattle numbers with either increasing sheep numbers (for SDG) or increasing pasture exported as supplement (DG) would likely be required to meet targets and retain similar production systems. The alternative would be to purchase/lease NDA from farms with a surplus. The financial impact of this wasn't modelled.

4.3.7 Three of the six dairy farm scenarios were able to meet new pNDA targets as modelled in the original study. For farm systems that were unable to meet the pNDA target, the extent or "extremity" of further system change required to achieve the target varies depending on the "gap" between current N loss and the pNDA. Where only a minimal gap exists, the purchase of NDA might be viable, but this will depend on the extent of any financial loss expected to be incurred through system change versus the opportunity cost of investing capital in N loss rights.

4.3.8 For some systems where higher stocking rates are required to maintain pasture quality and pasture control, retirement of steeper areas into forestry may be required, given the practical implications of operating a farm with too low a stocking rate. Given our current experience in systems analysis in relation to the farms meeting the targets in the draft rules, we believe that partial conversion of dairy farms to dry stock systems isn't a realistic option for most dairy farmers given a lack of infrastructure (i.e. sheep proof fences and handling facilities), incompatible classes of livestock (bulls and cows aren't a good mix) and the fact that reducing cow numbers and keeping young stock at home doesn't appear to deliver a net decrease in N losses to water (as there is invariably net reduction in the export of N off the farm).

4.3.9 These results are relatively unsurprising given that the average reduction target for dairy farms in the catchment is 35%, compared with the 29-30% average reduction in N losses achieved by mitigations in the original analysis. However, given that achieving an N loss of 35kg N/ha (v5.4.11) was successfully modelled in the original study for each scenario it is clear that certain combinations of production systems and geo-physical characteristics are assessed in newer versions of OVERSEER as leakier than they had previously been, which in turn requires greater levels of N loss reduction under the sector range allocation framework.

4.4 Financial analysis

4.4.1 The changes in the underlying input/output prices for the dairy farm systems resulted in the average base operating profitability across the six farm systems reducing by 52% from the original analysis, to $1,430/ha from $2,967/ha. This loss of profitability is primarily due to a reduction in milk price by $1.10/kg MS, as well as a slight increase in modelled farm working expenses. As would be readily recognised by most people involved in the sector, dairy farm profitability is highly correlated to milk price.

4.4.2 What is more interesting and possibly more important as regards assessing the impact of the rules on farmers is how underlying market conditions can alter the economic impact of meeting nitrogen reductions.

4.4.3 Sensitivity analysis on the change in dairy farm operating profit from reducing N losses by an average of 30% (this average reduction for the "Range" scenario was the same in v5.4.11 and v6.2.0) with changes in milk price (revenue) and PKE (expenses) revealed interesting results.

4.4.4 The average "cost" of this N reduction increased as both the milk price increased and as the price of PKE decreased (Table 5). An identical relationship exists for the price of nitrogenous fertiliser. This essentially reflects the nature of the mitigations modelled. In the study, reducing N losses typically resulted in a reduction in milk production as a result of fewer inputs [of N in feed and fertiliser] and improving the efficiency of use the remaining inputs. This analysis implies that as farm profits increase, then the opportunity cost of system change increases.

Table 5: Sensitivity of the cost of achieving 30% reductions in N loss to milk price and key inputs (change in EBIT)

PKE price ($/t landed)	Milk price ($/kg MS) $ 5.00	$ 5.50	$ 6.00	$ 6.50	$ 7.00
$220	$28	-$22	-$73	-$123	-$174
$250	$55	**$4**	-$47	-$97	-$148
$280	$81	$30	-$21	-$71	-$122
$310	$107	$56	$6	-$45	-$96
$340	$133	$82	$32	-$19	-$69

Urea price ($/t applied)	Milk price ($/kg MS) $ 5.00	$ 5.50	$ 6.00	$ 6.50	$ 7.00
$600	$25	-$25	-$76	-$126	-$177
$700	$38	-$12	-$63	-$113	-$164
$800	$51	$0	-$50	-$101	-$151
$900	$64	$13	-$37	-$88	-$139
$1,000	$76	$26	-$25	-$75	-$126

4.4.5 When milk price is low, the economic impact of lowering milk production reduces; likewise, when input prices are high, reducing their [inefficient] use improves the cost structure of the business. The difference in the financial assumptions between the original 2014 study and this update has a considerable impact on how the impact of meeting N reductions is perceived. In the original study, achieving the range reduction targets was assessed as resulting in a reduction in *average* dairy operating profit of $100/ha – under the current assumptions, implementing identical system change is likely to increase *average* farm EBIT by $7/ha. This is solely as a result of changes in prices of outputs, with the reduction in the medium term milk price from $6.60/kg MS to $5.50/kg MS.

4.4.6 The updates in the underlying input/output prices for the dry stock farm systems resulted in base operating profitability reducing by 5% to $268/ha from $282/ha across the seven assessed farm systems. This was almost entirely a result of increased labour costs in the new assumptions.

4.4.7 Notwithstanding that two of the seven drystock farm systems would comply with their provisional NDA with no system changes, the three remaining systems that were able to achieve compliance with their pNDA increased profitability by $116/ha in doing so. Even the two dry stock farms in which the original scenarios failed to reach the pNDA level were adjudged to essentially sustain or increase profitability despite reducing N losses by 37% and 12% respectively. This sits in contrast with the dairy systems, for which economic outcomes are likely to be more variable. We suggest this is possibly due to the modelled dry stock farm systems having a wider range of productivity than the dairy farm systems and, on average, having greater capacity to lift productivity in response to the need to mitigate N losses.

Table 6: Sensitivity of the cost of achieving 29% reductions in N loss to red meat prices and key inputs (change in EBIT)

Beef price ($/kg cwt)	Lamb price ($/kg cwt)					
	$4.00	$4.50	$5.00	$5.50	$6.00	$6.50
$3.50	$76	$58	$40	$22	$4	-$15
$3.75	$77	$59	$41	$23	$5	-$13
$4.00	$79	$61	$42	$24	$6	-$12
$4.20	$80	$62	$44	$26	$7	-$11
$4.50	$81	$63	$45	$27	$9	-$9
$4.75	$83	$65	$47	$29	$11	-$7
$5.00	$84	$66	$48	$30	$12	-$6

Urea price ($/t applied)	Winter cropping costs ($/ha cropped)						
	$850	$900	$950	$1,000	$1,050	$1,100	$1,150
$600	$70	$71	$73	$74	$75	$77	$78
$700	$73	$74	$75	$77	$78	$79	$81
$800	$75	$76	$78	$79	$80	$82	$83
$900	$78	$79	$80	$82	$83	$84	$86
$1,000	$80	$81	$83	$84	$85	$87	$88

4.4.8 Sensitivity of the average drystock farm operating profit to changes in beef and lamb price is similarly interesting. Table 6 shows the change in EBIT for a drystock farm achieving the average reduction of 29% (Table 4). As lamb price increases, the average cost from mitigating N losses decreases, but as beef price increases (and heifer grazing prices, which we've linked by way of a simple linear regression), the cost from mitigation increases due to higher opportunity cost of the system change. Changes in input prices appear to have a much reduced impact.

4.4.9 Again, like with the dairy systems, these relationships reflect the nature of the mitigation strategies – for the dry stock properties modelled increasing sheep:cattle ratio, decreasing cattle and increasing ewe productivity all feature heavily in the scenarios, all of which have revenue impacts; in comparison, input mitigations (like reducing N fertiliser, reducing cropping) are limited, reflecting the reduced intensity of most of these dry stock systems.

5. Conclusions

5.1 It is apparent that the mitigation scenarios presented in the 2014 NDA Impact Report will still provide some value in helping farmers and regulators alike in understanding how farmers might meet the likely N loss reduction targets for the Lake Rotorua catchment.

5.2 Just over half of the modelled farm systems were able to achieve their provisional NDA targets utilising the scenarios developed in the original study and two of the dry stock farms were adjudged to already be operating at or under their likely 2032 NDA.

5.3 However, some farms will have to move beyond changes within their current farm systems to achieve the pNDA. For dairy farmers where only a minimal gap exists, the purchase of NDA might be viable, particularly if the farm system is highly profitable. For some systems where higher stocking rates are required to maintain pasture quality and pasture control, retirement into forestry of steeper areas may be required. Partial conversion of dairy farms to dry stock systems isn't considered a realistic option for most dairy farmers. For dry stock farms we expect the primary option for reducing N further will be strategic afforestation (assuming significant productivity improvement isn't necessarily achievable).

5.4 With such a limited data set, it is difficult to ascertain whether or not geophysical characteristics make a significant difference to the capacity of an existing farm system to meet their pNDA. At this juncture we suspect that historic land use and its impact on the pNDA allocation as well as individual farmer preference and management ability are probably more significant factors in the capacity of a current landowner to meet their 2032 target.

5.5 The revision of the medium term pricing assumptions used in the study had little impact on the economic outcomes of the mitigations for the dry stock scenarios. But revised expectations of lower medium term milk prices clearly demonstrated how the changes in the prices of inputs and outputs associated with a mitigation strategy can alter the perceived and actual economic impacts of meeting N loss targets.

5.6 More work is potentially required to address an apparent gap in the earlier study as regards how dairy farms historically leaching 90-100kg N/ha will be affected by the proposed rules and what additional mitigations might be required by those farm systems previously thought to have made enough system change to meet the "35/13" targets. These will likely be dairy farms and dairy support properties.

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Appendix 1: Dry stock farm system input price assumptions

Stock expenses		
Animal health	90	/cow
Breeding (incl. lease bulls and repro. intervention)	37	/cow
Electricity	42	/cow
Shed expenses	18	/cow
Feed expenses		
Grazing expenses		
<9 months of age	6.5	/head/week
10-22 months of age	8.5	/head/week
Winter grazing	24	/head/week
Supplement expenses		
Grass silage/hay	450	/ha
Baleage (220kg DM) purchased	70	/bale
Maize silage - grown	3,500	/ha
Maize silage - purchased	0.32	/kg DM
Winter forage crops	1000	/ha
Summer forage crops	600	/ha
Palm kernel expeller meal	250	/t delivered
Calf feed	650	/t delivered
Other working expenses		
Fertiliser & lime	450	/t superten 15k applied
Nitrogen	828	/t urea applied
Farm stores	4	/cow
Freight		
<9 months of age	15	/head
10-22 months of age	24	/head
MA cows	28	/head
General	2	per cow
Regrassing	600	/ha
Landscaping	3	/ha
Weed & pest control	34	/ha
Vehicle expenses		
Tractor fuel	37	/ha
Tractor R&M	85	/ha
Vehicle fuel	37	/ha
Vehicle R&M	85	/ha
Repairs & Maintenance		
Effluent	8	/cow
Fences and yards	25	/ha
Houses	5,000	/house
Buildings	10	/cow
Plant & machinery	30	/cow
Tracks & races	25	/ha
Water supply	35	/ha
Overheads		
Administration		
Accounting	4,000	/entity
Advisory/legal	5,000	/entity
General administration	3,000	/entity
Insurance	62	/ha
Rates	107	ha
Depreciation	0.4	/kg MS

Source: DairyBase 2012/13 Central Plateau Owner Operator Survey

Appendix 2: Dry stock farm system input price assumptions

Stock expenses	NDA Impact	
Animal health	$ 4.00	/SU
Breeding (incl. lease bulls and repro. intervention)	$ -	/SU
Breeding (stag or bull lease)	$ 600	/animal
Electricity	$ 1.20	/SU
Shearing		
Ewe	$ 3.30	/head
Lamb	$ 2.90	/head
Ram	$ 4.00	/head
Crutch	$ 0.50	/head
Feed expenses		
Supplement expenses		
Grass silage/hay (incl. post-cut fert)	$ 490	/ha
Baleage (220kg DM) purchased	$ 70	/bale
Maize silage - grown	$ 3,500	/ha
Maize silage - purchased	$ 0.36	/kg DM
Winter forage crops (incl. fert)	$ 1,000	/ha
Summer forage (incl. fert)	$ 600	/ha
Palm kernel expeller meal	$ 330	/t delivered
Calf feed	$ 850	/t delivered
Other working expenses		
Fertiliser & lime	$ 410	/t superten applied
Nitrogen	$ 828	/t urea applied
Farm stores	$ 0.40	/SU
Freight		
Cattle	$ 20	/head
Deer	$ 7	/head
Sheep	$ 2	/head
Wool	$ 0.25	per kg
Regrassing	$ 600	/ha
Landscaping	$ 0.50	/ha
Weed & pest control	$ 19	/ha
Vehicle expenses		
Tractor fuel	$ 15	/ha
Vehicle fuel	$ 15	/ha
Tractor R&M	$ 16	/ha
Vehicle R&M	$ 16	/ha
Repairs & Maintenance		
Fences and yards	$ 15	/ha
Houses	$ 2,500	/house
Buildings	$ 0.50	/SU
Plant & machinery	$ 1.00	/SU
Tracks & races	$ 10	/ha
Water supply	$ 20	/ha
Overheads		
Administration		
Accounting	$ 4,000	/entity
Advisory/legal	$ 5,000	/entity
General administration	$ 3,000	/entity
Insurance	$ 14	/ha
Rates	$ 30	/ha
Depreciation	$ 37	/ha

Source: Beef+Lamb Economic Service Survey 2014, Perrin Ag Consultants Ltd