



THE UNIVERSITY OF  
**WAIKATO**  
*Te Whare Wānanga o Waikato*

Research Commons

<http://researchcommons.waikato.ac.nz/>

## Research Commons at the University of Waikato

### Copyright Statement:

The digital copy of this thesis is protected by the Copyright Act 1994 (New Zealand).

The thesis may be consulted by you, provided you comply with the provisions of the Act and the following conditions of use:

- Any use you make of these documents or images must be for research or private study purposes only, and you may not make them available to any other person.
- Authors control the copyright of their thesis. You will recognise the author's right to be identified as the author of the thesis, and due acknowledgement will be made to the author where appropriate.
- You will obtain the author's permission before publishing any material from the thesis.

# The financial costs of environmental compliance through reducing nitrogen leaching for a range of Waikato dairy farm system intensities

---

A thesis submitted in partial fulfilment of the requirements for the degree of  
Master of Management Studies in Agribusiness  
at the University of Waikato

Thomas Macdonald  
Department of Agribusiness  
University of Waikato



THE UNIVERSITY OF  
**WAIKATO**  
*Te Whare Wānanga o Waikato*

**2014**

## Abstract

The New Zealand dairy industry has grown significantly over the past decade through increasing both area farmed and the number of cows milked. Dairy farm systems have intensified as a result of the use of supplementary feeding, increased stocking rate and land use changes. Environmental regulations have been implemented as a means to limit and mitigate the negative environmental impacts of dairy under the National Policy Statement for Fresh Water. In the Waikato, regulation to date has predominately been focused on effluent storage and application. As such, regulation has not yet shaped how Waikato farm systems are implemented. It is likely that future regulation for the Waikato will include nitrogen loss limits. Management of nutrient cycles will therefore become a high priority for effective farm management as well as being used to inform the adoption of changes to farming systems.

Four nitrogen (N) loss mitigation strategies were modelled for Waikato dairy farm systems of low, medium and high input to show the changes in N leaching and economic farm surplus per hectare. Reductions in N leaching for farm environmental compliance were able to be achieved through farm management practices as well as through additional farm infrastructure. Large reductions of 20 percent and 17 percent were achieved through destocking and cow housing scenarios respectively. A corresponding lift in farm surplus per hectare of 1 percent and 11 percent was recorded. Similarly, moderate reductions in N leaching were achieved through winter grazing off farm (9 percent) and increased effluent management facilities (8 percent). However a 4 percent reduction in farm surplus was noted for the winter grazing scenario while increasing the effluent area had no material impact on farm working expenses or revenue.

This research identified cow housing as farm infrastructure which for low, medium and high input farm systems was able to return a reduction in N leaching greater than 15 percent and increase farm surplus by greater than 9 percent.

The implementation of cow housing was modelled for a large scale farm system in the Taharua catchment where N limits are currently being enforced. Results of the modelling show a cow housing facility for large scale dairy farming has a positive internal rate of return of 13 percent.

Waikato dairy farmers were surveyed to gather data on the initial capital cost of compliance and the farm system implications of increased regulation to date. The survey illustrated that effluent compliance has been the focus of investment and highlights the significant cost to the dairy industry of internalising environmental impacts. Aggregated survey results indicate that the capital cost of environmental spending to date for the average Waikato farm system has totaled \$1.02 per kgMS, \$1487 per hectare or \$404 per cow. This equates to an average investment of \$110,000 per farm.

A clear understanding of the impact of environmental regulation and the relative cost of compliance for different farm systems is needed to produce accurate measures of environmental performance and to improve the cost efficiency of dairy production systems. Importantly there is a need to understand how different farming systems can work together at a catchment, regional and national level to achieve both value creation and environmental sustainability as set out in the national policy frameworks.

## **Pre-published results**

New Zealand Institute of Primary Industry Management National Conference 4<sup>th</sup>  
August 2014 – *Presentation: The comparative cost of compliance*

New Zealand Grassland Association Newsletter September 2014 – *Measuring the  
cost of compliance*

Fertilizer and Lime Research proceedings 2015 *Measuring the comparative cost  
of compliance and mitigation options for Waikato dairy farm systems*

## Table of Contents

<b>Abstract</b> .....	<b>1</b>
<b>Pre-published results</b> .....	<b>3</b>
<b>Table of Contents</b> .....	<b>4</b>
<b>List of Figures</b> .....	<b>8</b>
<b>List of Tables</b> .....	<b>9</b>
<b>Glossary of Terms</b> .....	<b>10</b>
<b>Acknowledgments</b> .....	<b>11</b>
<b>1.0 Introduction</b> .....	<b>12</b>
<b>2.0 The Dairy Industry</b> .....	<b>15</b>
<b>3.0 Literature Review</b> .....	<b>25</b>
3.1 Introduction.....	25
3.3 Environmental Regulation.....	26
3.4 Farm Systems .....	32
3.5 Farm System Analysis.....	37
3.6 Overseer .....	39
3.7 N Cycling on Farm.....	42
3.8 Cow Housing in New Zealand .....	48
3.9 Implications for this Research .....	50
<b>4.0 Methodology</b> .....	<b>52</b>
4.1 Introduction.....	52
4.2 Paradigm .....	54
4.3 Research Design .....	56
4.3.1 Case Study .....	57
4.3.2 Document Analysis.....	58
4.3.3 Interviews.....	59
4.3.4 Survey.....	59
4.4 Farm Analysis .....	62
4.4.1 DairyBase.....	62
4.4.2 Dairy Feed Planner .....	63
4.4.3 Climatic variances.....	64
4.4.4 Regional analysis .....	64
4.5 Methodology Summary.....	65
<b>5.0 Environmental Regulation</b> .....	<b>66</b>

5.1 The Resource Management Act (1991).....	66
5.2 National Policy Statement.....	69
5.3 Waikato Environmental Regulation .....	70
5.4 Variation 6 .....	70
5.5 Variation 5 .....	73
5.6 Effluent Storage and Application Requirements.....	75
<b>6.0 Waikato Farming Systems.....</b>	<b>77</b>
6.1 Low input ( DairyNZ System 1 & 2) .....	79
6.2 Medium input (DairyNZ System 3).....	80
6.3 High Input (DairyNZ Systems 4 & 5) .....	82
6.4 Financial Sensitivity Analysis of Farm System Variables .....	85
<b>7.0 Waikato Farm Systems – Nutrient Modelling.....</b>	<b>88</b>
7.1 Introduction.....	88
7.2 Assumptions.....	89
7.3 Overseer Output.....	93
7.3.1 Sandy Loam Soils.....	95
7.3.2 Peat Soils .....	96
7.3.3 Clay Soil .....	97
7.4 Financial, Physical and Environmental .....	98
<b>8.0 Comparative Nutrient Modelling – The Same Farm with Varied Intensity.....</b>	<b>100</b>
8.1 Financial Modelling .....	102
8.2 Nutrient Modelling.....	103
<b>9.0 Options for Mitigation- The Cost of Compliance.....</b>	<b>107</b>
9.1 Scenarios for Reducing Environmental (N) Impact. ....	107
9.2 Scenario 1) Decrease Stocking Rate .....	109
9.2.1 Low Input.....	109
9.2.2 Medium Input.....	110
9.2.3 High Input System .....	111
9.2.4 Summary of Destocking Scenario.....	112
9.3 Scenario 2) Build Effluent Storage & Expand Application Area .....	114
9.3.1 Low Input.....	115
9.3.2 Medium Input.....	115
9.3.2 High Input.....	115
9.3.4 Summary of Increasing Effluent Storage and Application Area. ....	116

9.4 Scenario 3) Winter Grazing Herd.....	117
9.4.1 Low Input.....	117
9.4.2 Medium Input.....	118
9.4.3 High Input.....	119
9.4.4 Summary of Winter Grazing Scenario .....	120
9.5 Scenario 4) Build Covered Feedpad or Cow Housing .....	122
9.5.1 Low Input.....	123
9.5.2 Medium Input.....	123
9.5.3 High Input.....	124
9.5.4 Summary of Cow Housing Scenario .....	126
9.6 Implications of Scenario Analysis .....	128
9.6.1 Environmental Performance .....	128
9.6.2 Financial Performance.....	131
9.7 Conclusion .....	136
<b>10.0 Cow Housing Implementation Case Study .....</b>	<b>137</b>
10.1 Introduction .....	137
10.2 Background: .....	139
10.2.1 Physical Description .....	139
10.3 Hawkes Bay Region- Environmental Policy .....	141
10.4 Methodology: Assumptions for Cow Housing Analysis.....	144
10.4.1 Costs .....	144
10.4.1.1 Initial cost of the wintering facility.....	144
10.4.1.2 Increased feeding costs.....	145
10.4.1.3 Increased tractor and feeding out cost.....	148
10.4.1.4 Increased animal health expense.....	148
10.4.1.5 Repairs and maintenance to housing facility .....	148
10.4.1.6 Borrowing and repayment .....	148
10.4.2 Benefits .....	149
10.4.2.1 Estimated cost saving associated with winter grazing.....	149
10.4.2.2 Increased milk solid production .....	149
10.4.2.3 Increased pasture production .....	151
10.4.2.4 Reduced death rate .....	151
10.4.2.5 Reduced empty rate .....	152
10.4.3 Other Assumptions.....	152

10.5 Optimisation of Taharua .....	153
10.5.1 Base Scenario .....	153
10.5.2 Housing Scenario .....	156
10.5.3 Financial Implications .....	157
10.5.4 Nutrient Implications .....	160
10.6 Housing Scenario Discussion .....	162
<b>11.0 Survey of Compliance Cost .....</b>	<b>164</b>
11.1 Characteristics of the Survey .....	164
11.2 Survey Results .....	165
11.3 Quantitative Results .....	166
11.4 Qualitative Results .....	170
11.4.1 Farmer Uncertainty .....	171
11.4.2 Poor Public Perception .....	172
11.4.3 High Capital Cost Requirements .....	173
11.4.4 Support structures .....	174
<b>12.0 The Costs of Compliance .....</b>	<b>175</b>
<b>13.0 Conclusion.....</b>	<b>183</b>
<b>14.0 References .....</b>	<b>185</b>
<b>Appendix 1 Dairy Feed Planner Results of Mitigation Scenarios.....</b>	<b>193</b>
<b>Appendix 2 Nutrient Budgets for Mitigation Scenarios .....</b>	<b>194</b>
<b>Appendix 3 Cow Housing Model – Calculation of NPV and IRR .....</b>	<b>195</b>
<b>Appendix 4 Cow Housing Model – Valuation of Assumptions .....</b>	<b>196</b>
<b>Appendix 5 Survey to Waikato Dairy Farmers.....</b>	<b>199</b>
<b>Appendix 6 Research Ethics Approval.....</b>	<b>203</b>

## List of Figures

Figure 2.1 Growth via expansion and conversion of land use –Central Canterbury.....	16
Figure 2.2 Growth via intensification of existing dairy land - Waikato .....	16
Figure 2.3 Percentage change in cow numbers per region 1991 to 2011 .....	17
Figure 2.4 Livestock numbers in New Zealand 1993/94-2013/14 .....	18
Figure 2.5 Increase in cow numbers and effective hectares.....	19
Figure 3.1 Distribution of New Zealand farm systems 2000-2010.....	34
Figure 3.2 Correlation between N leaching and farm profit.....	44
Figure 3.3 Correlation between NCE and N leached per kgMS produced .....	45
Figure 3.4 The nitrogen cycle .....	47
Figure 5.1 Framework for implementing the Resource Management Act (1991).....	67
Figure 5.2 Percentage of Waikato farms with discharge to land.....	75
Figure 6.1 Map of the Waikato Region .....	77
Figure 7.1 Nitrogen efficiency indicators - sandy loam soils.....	95
Figure 7.2 Nitrogen efficiency indicators – Peat Soil .....	96
Figure 7.3 Nitrogen efficiency indicators – Clay Loam Soil .....	97
Figure 7.4 Operating profit versus N leaching .....	98
Figure 8.1 Comparative N modelling of same farm system intensified .....	105
Figure 9.1 Change in profit per hectare, per KG of N mitigated by destocking .....	113
Figure 9.2 Change in operating profit - Winter grazing scenario .....	121
Figure 9.3 Change in profit per hectare, per kg of N mitigated through cow housing ...	127
Figure 9.4 Scenario results N leaching .....	129
Figure 9.5 Reduction in N leaching.....	130
Figure 9.6 Sensitivity to payout- Low input system .....	132
Figure 9.7 Sensitivity to payout- Medium input system .....	133
Figure 9.8 Sensitivity to payout- High input system .....	134
Figure 9.9 Change in profit per ha, per kg N loss/ha reduced .....	135
Figure 10.1 Outline of the Mohaka region Taharua sub catchment.....	142
Figure 10.2 Land use in the Taharua Catchment .....	142
Figure 10.3 Nitrate measurements in the Taharua Catchment .....	143
Figure 10.4 Total nitrogen lost in the Taharua Catchment .....	143

## List of Tables

Table 6.1 Multiple year, multiple system: physical benchmark .....	84
Table 6.2 Multiple year, multiple system: financial benchmark.....	85
Table 6.3 Operating profit per hectare for Waikato farm systems .....	85
Table 6.4 Return on asset (percent) for Waikato farm systems .....	86
Table 6.5 Comparative system benchmarks 2010/11 season .....	87
Table 7.1 Overseer modelling of average Waikato farm systems .....	92
Table 7.2 Summary of operating profit versus Nitrogen efficiency.....	98
Table 7.3 Summary statistics for average Waikato farming systems .....	99
Table 8.1 Standardised farm system parameters.....	101
Table 8.2 Financial modelling of standardised farm system.....	102
Table 8.3 Nitrogen efficiency results of comparative system analysis .....	103
Table 8.4 Summary of comparative farm system .....	106
Table 9.1 Financial results of low input system destocking.....	110
Table 9.2 Financial results of destocking medium input system .....	111
Table 9.3 Financial results of high input system destocking.....	111
Table 9.4 Nutrient modelling for destocking scenario.....	112
Table 9.5 Nutrient budget results for increasing effluent area and storage .....	116
Table 9.6 Financial results of winter grazing scenario – Low Input .....	118
Table 9.7 Financial results of winter grazing scenario – Medium Input System.....	119
Table 9.8 Financial results winter grazing scenario – High Input System .....	120
Table 9.9 Nitrogen efficiency metrics- Winter grazing scenario.....	121
Table 9.10 Financial results of cow housing –Low Input System.....	123
Table 9.11 Financial results cow housing – Medium Input System .....	124
Table 9.12 Financial results –High Input System .....	125
Table 9.13 Nutrient budget for cow housing scenario .....	126
Table 9.14 Percentage base change in N leaching.....	130
Table 10.1 Amount of feed used in housing scenario (% of diet & total feed).....	146
Table 10.2 Current feed usage.....	146
Table 10.3 Feed usage housing scenario .....	147
Table 10.4 Allocation and cost of additional supplementary feed .....	147
Table 10.5 Nutrient budget base scenario.....	154
Table 10.6 Summary of current scenario.....	155
Table 10.7 Sensitivity to initial capital cost.....	158
Table 10.8 Sensitivity to milk price payout .....	158
Table 10.9 Sensitivity to discount rate.....	159
Table 10.10 Sensitivity to cost of purchased Palm Kernel Expeller .....	159
Table 10.11 Nutrient budget housing scenario versus base scenario .....	160
Table 10.12 Summary of housing scenario .....	161
Table 11.1 Survey results by farm system .....	167
Table A.1 Yr 1-15 discounted cash flow model.....	195
Table A.2 Cost Assumptions.....	196
Table A.3 Benefit Modelling.....	197
Table A.3 Assumptions of Production Increases.....	198

## Glossary of Terms

<b>Days in milk</b>	Number of days between start and end of lactation
<b>Ha</b>	Hectare (10,000m <sup>2</sup> )
<b>Imported Feed</b>	Feed purchased from off the milking platform
<b>KgMS</b>	Kilogram of milksolids (Fat/Protein content of milk)
<b>KgDM</b>	Kilogram of dry matter -Measure of mass of feed
<b>Milking platform</b>	Land used in the production of milk solids
<b>N</b>	Nitrogen
<b>Nitrogen leaching efficiency</b>	Milk solids produced for every kg of N leached
<b>Nitrogen conversion efficiency</b>	Percent of N input converted into N output
<b>Palm Kernel</b>	Animal Feed – By-product of palm oil production,
<b>Peak cows</b>	Total number of cows milked at peak of lactation
<b>Supplement feed</b>	Feed not consisting of pasture grown on farm
<b>Stocking rate</b>	Number of cows per hectare on milking platform

## Acknowledgments

I wish to acknowledge the support of the following people, without whom this research would not have been possible.

Professor Jacqueline Rowarth for her guidance throughout the writing of this thesis and for the many weekends spent discussing and checking assumptions.

Professor Frank Scrimgeour for oversight of the economic analysis and insightful proofing comments.

Landcorp Farming Limited for the use of Dairy Feed Planner farm model and for the generous offer of time away to complete this thesis.

I would also like to acknowledge the financial support from The Sir Don Llewellyn Fieldays Scholarship as well as the Ballance Agri-nutrients scholarship.

## 1.0 Introduction

The New Zealand dairy industry is a key contributor to the domestic economy through export receipts, employment and regional development. Further, the national dairy platform covers 1.68 million hectares of land giving the industry a substantial oversight and responsibility for maintaining New Zealand's natural environment. In essence, both the economic and land management implications of the dairy industry are of significant value to New Zealand as a society, now and into the foreseeable future.

Over the past decade, New Zealand's dairy farmers have lifted per cow productivity and land use efficiency through increased supplementary feeding and in some cases higher stocking rates. This is commonly referred to by industry and government as the intensification of dairy. Dairy farms are now classified as farm systems, reflecting both the quantity and seasonality of imported supplementary feed. Although the output and total factor productivity of the dairy industry has increased, best management practices and an understanding of the implications of intensification with regard to the environment have not advanced as quickly. This can be attributed to both the lack of available scientific understanding as well as the intangible nature of environmental performance with regard to nutrient losses.

With increased scale and intensity in the dairy industry, there has been concern from the Government, the public and consumers (both domestic and foreign), about the ensuing tangible environmental impacts of intensive dairying in New Zealand, namely, deterioration of water quality and increased consumption of fresh water. More and more, there is debate between the dairy industry and society as to the desired ratio of economic benefit to environmental impact. This represents the sentiment that without ongoing investment into research and development for on

farm solutions, the economic and environmental provisions of dairy are mutually exclusive at current output levels. With both the economic and environmental provisions valued highly by the dairy industry and by the nation alike, there is a need to consider the opportunities for New Zealand -specifically the dairy industry - to balance the negative environmental impacts against the positive economic contributions upon which the nation's economy is dependent.

As an industry, dairy farmers are becoming increasingly aware of the need to implement sustainable production practices into the farming system. It is evident in the relevant discourse that there is a widening gap between perception and reality with regard to the environmental performance of dairy farmers. The industry as a whole is suffering from perceptions created by a minority of dairy farmers who continue to operate non-compliant farm systems. There is a general consensus between industry good bodies and by farmers alike that economic gains and environmental impacts do not have to be mutually exclusive. Managing this trade-off can be facilitated by the equitable distribution of abatement costs in reducing the environment impacts of dairy.

Regulation has been, and will continue to be highly topical within the move to promoting both environmental and economic efficiency within the industry. It is undisputable that environmental regulations are necessary to set suitable thresholds, to enable industry participation and to monitor performance against the identified limits. However, the extent to which regulation will be required in the future is yet to be determined. The cost of environmental compliance is now a reality for every New Zealand dairy farmer. In July 2014 The Federated Farmers Farm Confidence Survey reported the biggest concern of farmers was regulation and the cost of compliance (23.7 percent of respondents). Further, regulation and compliance costs

were identified as being the second highest concern for government (11.6 percent), behind monetary policy (19.6 percent). Efficient management of these costs from both farm gate and governing levels will be a key determinant of farm business performance in the years to come.

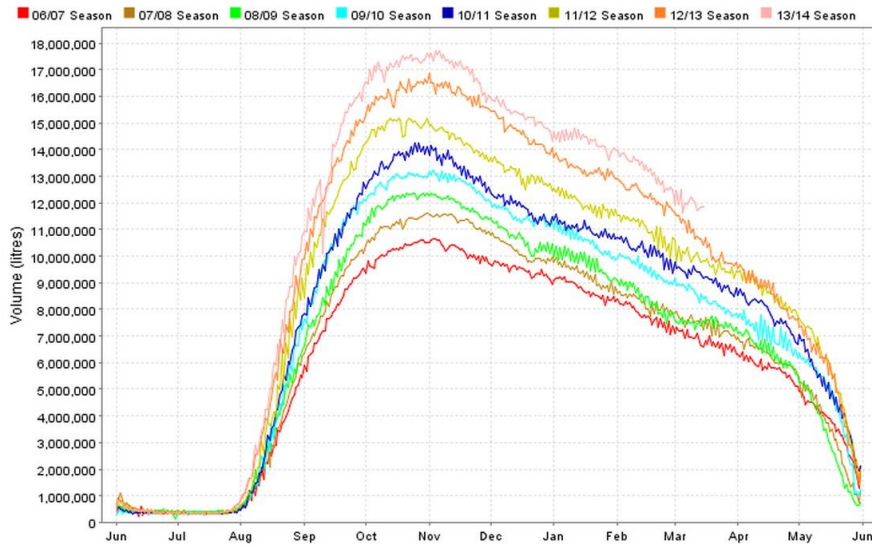
Environmental regulation specifically pertaining to the industry has been shaped by Regional Councils seeking to restrict environmental pollution, specifically the nutrient output of dairy farms in the light of trending farm system intensification. Regulation is being used to enforce best management practice at an on farm level with regard to nutrient losses and conservation of natural resource. Nutrient discharge allowances as already implemented in several regions (e.g. Manawatu & Canterbury), are likely to be the reality for the Waikato dairy industry moving forward. Dairy farmers are now tasked with lifting the overall environmental performance of their industry through optimising farm systems for maximum environmental and economic benefit within the limits imposed by Regional Councils. For the Waikato region, strict nutrient discharge limits are currently specific to sensitive catchments; they are however seen by regulators as effective in restricting the negative environmental impact of dairy farms.

The future of the dairy industry will be determined by the way in which dairy farmers can measure, adapt and improve environmental performance with regard to both real and perceived environmental performance. Achieving this requires an understanding of the comparative cost of compliance between farm systems. The aim of this research is to determine the comparative on-farm cost of environmental compliance with environmental regulations for different Waikato farm systems, based on a detailed analysis of specific environmental regulations and on farm practice.

## 2.0 The Dairy Industry

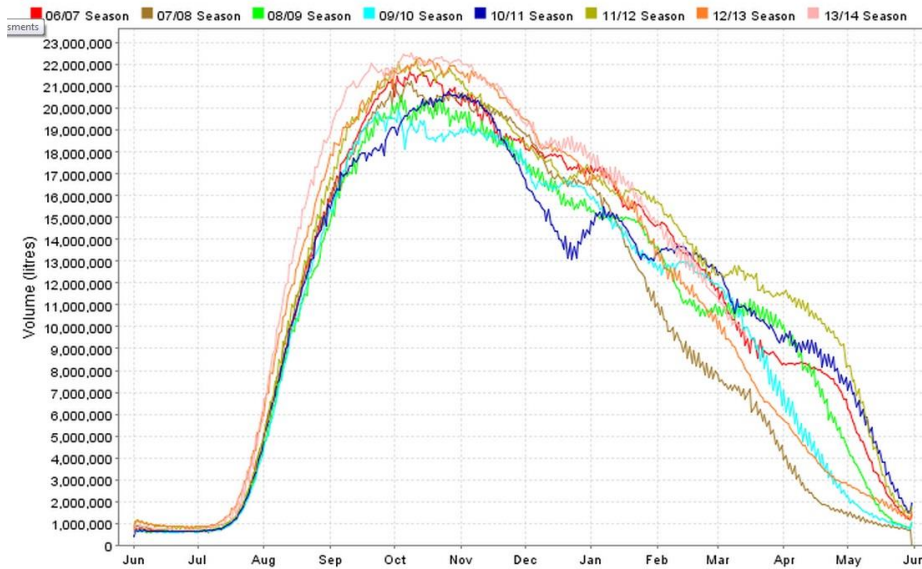
The dairy industry is a significant contributor to the New Zealand economy in the form of export receipts, regional economic and social development, tax revenue and employment (Ministry for Primary Industries, 2014a). The sector accounts for 26 percent of all merchandised exports, supports 35,000 jobs in addition to over 10,000 self-employed jobs, and is generating 2.8 percent of the national GDP (Schilling, Zuccollo, & Nixon, 2010). As a nation, the influence of dairy is such that an increase in the farm gate milk price of \$1 delivers an additional \$270 of benefit for every New Zealander (NZIER, 2010). Over the past decade the industry has grown in both scale and value within the economy (Anastasiadis & Kerr, 2013a; Coriolus, 2010; KPMG, 2013a). The growth has been based on improved farm productivity (NZIER, 2010), vertical integration of the value chain (Conforte, Garnevska, Kilgour, Locke, & Scrimgeour, 2008) and a rapid growth in demand for protein foods from emerging markets (ANZ, 2012).

In the 2012/13 dairy season, the New Zealand dairy industry processed 18.8 billion litres of milk from 4.78 million cows, up from 17.3 billion litres in the 2009/10 season (DairyNZ, 2013a; LIC, 2013). Growth in on farm productivity to fuel this demand has occurred in two key ways: through shifting dairy cows into previously non-dairying regions (Figure 2.1) and intensifying the existing dairy regions (Figure 2.2).



**Figure 2.1 Growth via expansion and conversion of land use –Central Canterbury**

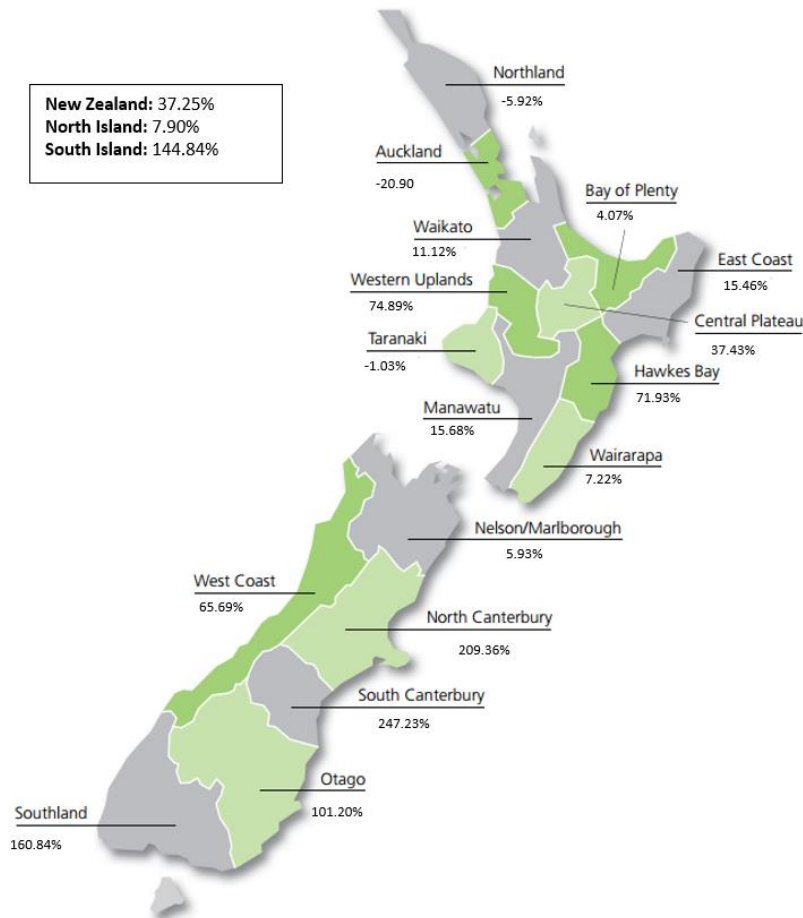
Source: Fonterra Co-operative Group (2014)



**Figure 2.2 Growth via intensification of existing dairy land - Waikato**

Source: Fonterra Co-operative Group (2014)

Figure 2.3 shows the percentage based change in cow numbers per region between 1991 and 2011. The most notable increases in cow numbers occurred in North and South Canterbury with an increase of 209 and 247 percent respectively. Nationally the dairy herd increased by 37.25 percent.



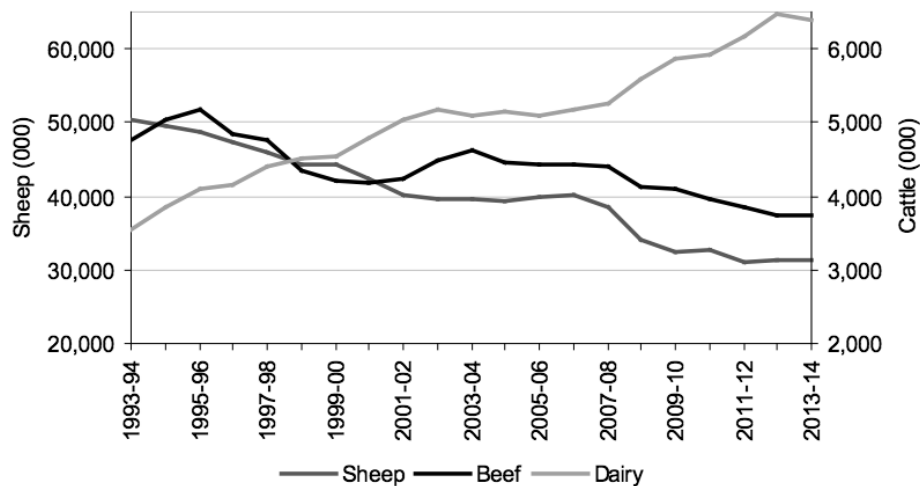
**Figure 2.3 Percentage change in cow numbers per region 1991 to 2011**

*Adapted from DairyNZ (2014) and McHaffie (2012)*

That stated, in the traditional Waikato dairying region of Matamata-Piako, the stocking rate has decreased over the last five years (from 3.22 to 3.13), but production of milk solids per cow has increased by 16 percent. In South Waikato, the stocking rate has also decreased marginally (from 2.98 to 2.97) but area has

increased 18 percent due to conversions around Tokoroa. Cow numbers have increased 20 percent and production of milk solids per cow has increased 18 percent.

The Land Use and Intensity report (Anastasiadis & Kerr, 2013a) indicates a similar trend of an increasing land area becoming part of the dairy platform, not just a growth in cow numbers at a national scale. The report details that between 1996 and 2008, the land used for dairying increased by 283,700 hectares. Figure 2.4 shows the way in which dairy has become the prominent land use within the past decade, with the increase in dairy cows inversely related to the sheep and beef population.

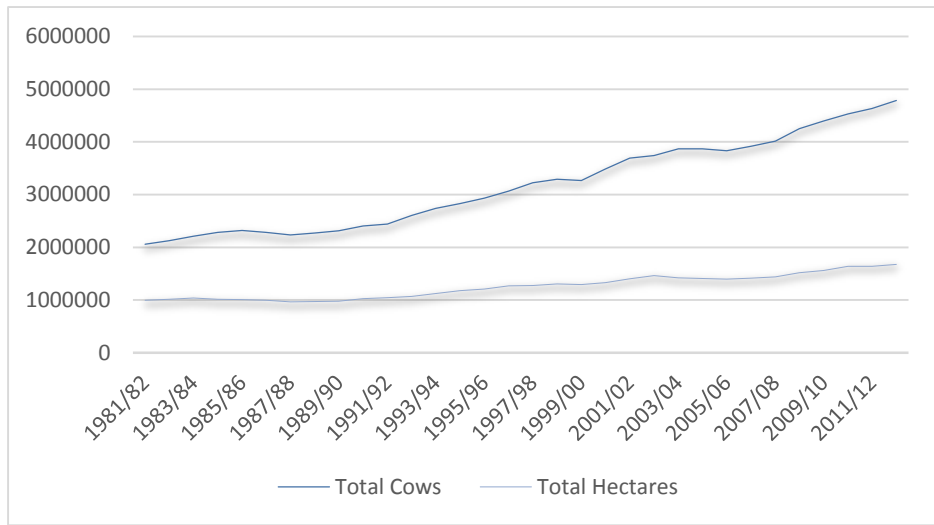


**Figure 2.4 Livestock numbers in New Zealand 1993/94-2013/14**

Source: Beef and Lamb New Zealand Economic Service Statistics New Zealand

Further the production per hectare (intensity) of all dairy land has increased in linear fashion for the same period (Figure 2.5). This stated, the supply of land suitable for dairying is inevitably constrained within New Zealand and further intensification scenarios similar to those adopted by progressive farmers will become standardised

throughout the industry as farmers continue to supply the global demand for dairy ingredients.



**Figure 2.5 Increase in cow numbers and effective hectares**

Adapted from DairyNZ statistics 2012/13

Monaghan’s analysis of the New Zealand dairy sector indicated the intensification of pastoral based farming systems has had an additive effect to the negative environmental impacts of dairy farming, namely water quality (Monaghan, 2008). The extent to which this has occurred as a function of dairy farm intensification has been reiterated by Wright (2013) who reported (from modelling) that there will be an increased loading of nutrient, sediment and pathogens in New Zealand waterways directly related to the increase of dairy farming’s physical footprint and intensity (Figure 2.3 & Figure 2.5). However, the modelling of Wright (2013) is built on the results of a previous model giving a significant margin of error within the data and extrapolated conclusions. Consequently, Wright (2013) temporally removed this report from the public domain to reassess the assumptions of the modelling undertaken. Naturally, with reporting showing an increased threat to water quality in New Zealand, government at both central and regional levels have

acted to guide policy with regard to environmental regulation in a bid to preserve the clean and green branding of the nation (Bell, 2012).

This has caused an increase in the regional application of regulation as local government pre-empt the decline in environmental performance, specifically water quality through a regulatory drive for sustainability in accordance with central government objectives regarding freshwater (New Zealand Government, 2011).

The scale and importance of the dairy industry in New Zealand means regulation has underpinned development to provide coordination and efficient outcomes (Cassells & Meister, 2001). The impact of regulation has both enabled and restricted growth within the industry to date, most notably the Dairy Industry Restructuring Act (DIRA). This legislation has benefited the industry through the formation of Fonterra ( a farmer owned dairy co-operative) as a dominant processor and marketer (Ministry for Primary Industries, 2013). In a period of growth and intensification, the industry has faced increased environmental regulation to protect the natural capital of dairy land (Cassells & Meister, 2001; Monaghan et al., 2007). It is likely regulation will continue to be used into the foreseeable future to improve environmental outcomes (Beukes, Romera, & Clark, 2014).

The interaction of the dairy industry with the environment has long been understood by those in the agricultural research area and to a similar extent by dairy farmers (Gauntlett, 2009; Ledgard, Crush, & Penno, 1998; McDowell, 2008). Dairy industry funded research and development to mitigate the negative environmental impacts has contributed to this knowledge and significantly improved on-farm performance over the previous two decades (Clark, Caradus, Monaghan, Sharp, & Thorrold, 2007; Monaghan, 2008). More recently, the Parliamentary

Commissioner for the Environment has indicated that the environmental performance of dairy has become of growing concern to the general public in the light of changes to land use and farm system intensification (Wright, 2013). Clear linkages are drawn between the recent increase of dairy farming and the declining quality of fresh water. Her report suggests the notion of environmental sustainability is now high on the agenda for all New Zealanders given the desire for recreational water use as well as maintaining tourism revenues (Wright, 2013). Recent surveys conducted by Fish and Game New Zealand and Lincoln University highlight the disconnect between society's perception of the dairy industry and the efforts and expense adopted by dairy farmers. The Fish and Game New Zealand (2014) survey suggested 55 percent of New Zealander's thought the environmental performance of dairy tarnished New Zealand's international reputation and 37 percent of respondents thought the economy was over dependent on dairy despite the stability and consistency it provides (Fish and Game New Zealand, 2014).

Internationally, New Zealand farmers are recognised for their innovation, production efficiency and sustainable production systems under a pastoral based farming model, most notably without direct economic subsidy payments (MacLeod & Moller, 2006). It is the pastoral farming model that drives the economic value component associated with 'brand New Zealand' dairy export (Marshall, Avery, Ballard, & Johns, 2012 ). An increasing global population has placed higher demands on protein-based foods. Further the growing wealth of consumers has installed a price premium on New Zealand products in recognition of our sustainable production systems. Increased global demand for dairy product has had a dramatic impact on the expansion of New Zealand's dairy industry through improving economic returns to farmers. New Zealand's share of exported dairy as

a percentage far exceeds the rest of the world's dairy producers. New Zealand exports 95 percent of production compared to just 25 and 20 percent for the Netherlands and California respectively (Moynihan, Holgate, & Crowder, 2014). Importantly, the shift in demand to emerging markets and the ability to capture more of the dairy value chain within these key markets has been a leading driver of success. Free trade agreements and increased globalisation has impacted the industry through a now diversified global export market of countries by both volume and value. One significant shift is the increase in powdered exports to China and the greater South East Asian market. This market has overtaken traditional markets of the west such as the UK and US markets by both volume and value. Overall, the value of dairy exports has increased 356 percent from \$2.5 billion to \$11.4 billion between 1992 and 2012 (Statistics New Zealand, 2013). With increased export market access the effective customer base of New Zealand farmers has grown, as have consumer demands for product specification and product 'sustainability'. For New Zealand's dairy exporters, managing the trade-off between the environment and economics is further complicated through the secondary trade-off between New Zealand regulatory limits and the standard of environmental performance expected by the end consumer (Moynihan et al., 2014).

Increasing the volume of output has been a focus within the industry as New Zealand seeks to keep up with growth in demand and to claim a dominant share of the global dairy market. Industry growth has built a stable operating platform where New Zealand dairy exporters are now responsible for over one third of all internationally traded dairy products. At the same time, both government and the dairy industry are aligned in seeking to grow the value of these exports, specifically a doubling of agricultural export value by 2025 as set out in the New Zealand

Government Growth Agenda (New Zealand Government, 2012). The aim of the Agenda is to improve both the incomes and wealth of all New Zealanders. To achieve this, a goal of increasing exports as a percentage of GDP from 30 percent to 40 percent by 2025 has been mooted (New Zealand Government, 2012). Given dairy exports form between 25 and 35 percent of the merchandised export receipt portfolio annually (Coriolus, 2010), there is significant reliance on the dairy sector to achieve this goal.

There is further industry-government agreement this growth must be founded within the framework of environmental regulation. Debate exists whether these outcomes are mutually exclusive given the increased regulatory drive for sustainability and the increasing cost of compliance faced by dairy farmers. The government's commitment to sustainably improving the performance of dairy has been realised through joint venture research and development funding under the Primary Growth Partnership (PGP). To date the dairy industry has received \$173 million dollars of co funding, the second largest PGP contribution behind the red meat sector (Ministry for Primary Industries, 2014b).

Increasingly, international markets and consumers are demanding greater sustainability measures to underpin the price premium commanded by 'Brand New Zealand' (Fonterra, 2013). Dairy farmers ensure the continued economic viability of New Zealand's protein production economy, the stewardship of natural resources based on farm, the protection or enhancement of other ecosystems influenced by agriculture and the provision of natural amenity and aesthetic qualities of the land (OECD, 1993). Baskaran, Cullen, and Colombo (2009) suggest a major problem for New Zealand society is how to weigh the economic benefits of increased intensification of dairy production against the costs of environmental degradation.

There is a common perception within the industry that economic and environmental performance are mutually exclusive (Baskaran et al., 2009; McDowell, 2008), however DairyNZ (2013c) and Gauntlett (2009) determine there are farm systems capable of both high levels of financial performance and environmental compliance.

## 3.0 Literature Review

### 3.1 Introduction

Research (both publically and privately funded) has informed industry and regulators of the environmental impacts of dairy and the suitability of regulation for differing farm systems. In 1998, Jarvis and Wilkinson reported that farmers faced few regulatory compliance cost items and for those who did have a particular compliance issue the cost was not substantial (Jarvis & Wilkinson, 1998). This is contrast to 2013 where farming within the limits of environmental regulation is identified as the new reality for New Zealand's dairy industry (Shadbolt & Valentine, 2013). Recent papers have reviewed the environmental impacts and available farm systems to mitigate the risks for dairying under the new regulatory framework (Bell, 2012; Clark et al., 2007; Journeaux, 2013). There is general consensus in this literature to suggest environmental regulation is beneficial to the industry's long-term success. However, Bell (2012) indicates there is a strong need to balance environmental provisions with maintaining output and productivity, that is the economic component of the farm system. A focus within the dairy industry has been on developing higher intensity farm systems (classified by the amount and seasonality of imported feed) (Hedley et al., 2006). This increased feeding and higher stock carrying capacity has been a leading driver for increasing the volume of milk produced per cow and per hectare. As farm systems have intensified, increased nutrient cycling as well as water quantity and quality issues have brought about the need for increased environmental regulation (Bell, 2012; Ledgard et al., 2006; Monaghan, 2008). With increased environmental regulation, there are options for dairy farmers to diversify their current farm system to a more

environmentally and economically efficient farm system. Decisions Support Systems such as OVERSEER® Nutrient Budgets (Overseer)(Wheeler et al., 2003) and DairyBase (DairyNZ, 2013b) are able to show both the environmental and financial implications of increased regulation. Initial modelling of farm system trade-offs by Doole and Romera (2014b) have shown the relationship between farming for maximum economic efficiency versus maximum environmental efficiency through changing farm systems. However, there is a need to interpret and analyse further data regarding compliant and economic farm systems within a comparative farm system framework. This literature review focuses on environmental regulation; dairy farm systems; and farm systems analysis as they pertain to New Zealand's pastoral dairy sector. A review of literature discussing the assumptions of Overseer nutrient modelling, farm financial analysis and cow housing systems is also included. The final section summarises key literature assumptions, identifies a clear gap within the literature and situates the research within the reviewed literature.

### **3.3 Environmental Regulation**

Agricultural sectors worldwide are facing increased environmental regulation (Moynihan et al., 2014). In New Zealand, management of environmental performance is the primary responsibility of the land manager (Valentine, Hurley, Reid, & Allen, 2007). Individual management actions dictate both the level of productivity and environmental impact of land use. "Dairy farmers have a crucial role in reinforcing the association of agriculture and the environment through their dual role and complementary responsibilities as producers of high quality food and as custodians of the land they farm" (OECD, 1993, p. 8). At the same time local and central government are tasked with ensuring suitable outcomes regarding

environmental impact thresholds and are therefore required to regulate land use. In the case of dairy this is conducted under the legislative framework, The Resource Management Act 1991 (the RMA).

For the dairy industry the potential range of environmental impacts is wide, and ranges from greenhouse gas impacts, to nutrient impacts on rivers, lakes and oceans as well as odour, noise and visual impacts on neighbours (Bewsell & Drake, 2008; Monaghan, 2008). There is industry wide consensus (DairyNZ, 2013c; DCANZ, 2013; KPMG, 2013b) that certain environmental regulation is of benefit to New Zealand dairy farmers in improving the natural capital of their land and setting guidelines for industry best practice. Increasingly, farmers are becoming aware of the impacts that their farming systems are having and how these systems can impact and affect others in the wider community (Ministry for the Environment, 2001). Regulation has been used rather than a voluntary compliance scheme given the high capital cost of infrastructure requirements (Clark et al., 2007). Further, Robson et al. (2012) suggests there is a need for limits and regulatory frameworks because they are the key, in combination with other complementary methods, to effective management of cumulative effects of natural resource management. “Establishing limits to resource use recognises that resources, in terms of both quantity and quality, have a finite capacity-for-use beyond which further use is unsustainable without resulting in harmful effects on the environment, values and other uses of the resource (Robson et al., 2012).

Environmental regulation can be formulated in three main ways. Through the setting of limits, creating price mechanisms or legislating specific practice change (NZIER, 2013). Doole and Pannell (2012) show the formulation and structuring of environmental regulation can have significant and varying production impact on-

farm when achieving the same environmental performance threshold. It is therefore essential to determine the desired environmental outcomes and develop regulation to achieve maximum environmental protection and minimum on-farm impact. The 1989 OECD report *Agricultural and Environmental Policies: Opportunities for Integration* concluded that integrated policy provides mutual benefit to the industries involved through enabling conscious trade-offs between competing agricultural and environmental objectives. The report suggested that integrated policy must fully account for the environmental considerations required by society at an early stage in the development of the agricultural policy framework (OECD, 1993). Within the New Zealand context it can be argued agricultural and environmental policy have historically not benefited from integration. Despite recent efforts of regulators and industry to integrate policy objectives, there is still public unrest (Fish and Game New Zealand, 2014). This sentiment can be attributed to the phenomena whereby perception is reality, with perception driven by misinformation. The divorce between public understanding and industry realities gives merit to the suggestion for early integration of policy objectives between agriculture and environment discussed by the OECD (OECD, 1993).

The economic impact of environmental legislation on industry and output is well documented (Doole, Marsh, & Ramilan, 2013; Gauntlett, 2009; Goodstein, 2011; Meyer, 1995). Few studies pertain to the agricultural sector. The reasons for this are that environmental provisions in agricultural legislation are often “vague subject to interpretation and lacking in concrete policy prescriptions” (Ballenger & Krissoff, 1996). Cassells and Meister (2001) and Kahn (1998) suggest that the impact and mitigation cost of non-point source environmental pollution is difficult to measure. For this reason it is much more difficult to implement economic incentives such as

per unit taxes or pollution permits (Kahn, 1998). One economic impact analysis specifically pertaining to the dairy industry was performed by Newman and Howard (2013). Their analysis determined reducing excessive nitrogen output for farm systems could be achieved at relatively low cost, however marginal abatement costs rose exponentially as reducing nitrogen leaching to low levels became a function of stocking rate. This directly impedes the farm systems productivity (Newman & Howard, 2013). Similar results were observed in the analysis by Neal et al. 2006 who found nitrogen based stocking rate restrictions had significant impacts on high input farming systems economic performance (Neal et al., 2006). NZIER modelling of nutrient cap policies with New Zealand's Southland region has indicated dairy will continue to be a more profitable land use than drystock or arable farming under caps at or above 15kg N lost per hectare annually (Kaye-Blake et al., 2013). Further understanding these mitigation costs will require collaboration as well as an increased capacity for research and development. Modelling techniques available to measure mitigation costs are limited due to the many differences in farming systems (Anastasiadis & Kerr, 2013b). Doole et al. (2013) found that 'uniform environmental policy measures' did not satisfactorily address the heterogeneity of different farm systems. Their study further found differentiated policy prescription regarding nitrogen leaching could lower the cost of compliance three fold, hence reducing the negative effect to individual farm balance sheets (Doole et al., 2013). This was supported by Kaye-Blake et al. (2013) which found within uniform nutrient caps, nitrogen was predominately the binding constraint and hence increased its significance to Regional Councils.

Modelling to quantify and predict the scope and cost of environmental regulation has shown high variation due to numerous modelling assumptions (Wright, 2013).

However the relevant studies (Bell, 2012; Journeaux, 2013), show New Zealand dairy farmers face rising costs of compliance as a proportion of farm incomes. It is found for off farm agribusinesses, the diversion of money and time into compliance activities means that fewer resources can be put to more productive uses, resulting in constraints to business growth (NZIER, 2007). The same applies to on farm businesses. “Getting the prices right” for agricultural inputs and outputs to reflect their full environmental and social cost better was identified by the OECD as critical to the success of environmental regulation over 20 years ago (OECD, 1993). Despite this, in the dairy industry there is disparity between the prices received for milk sold versus the rising cost of compliance. Cassells and Meister (2001) describe this as market failure.

The economic cost and complexity of environmental compliance has been the leading cause of tension between farmers and regulators (Monaghan et al., 2007). Compliance costs are localised, and many of the costs remain subtle, complex, long-term, and hard to quantify (Jay & Morad, 2007). Incompatibility with existing farms systems and an uncertainty about the perceived environmental benefits are causes of farmer concern (Monaghan et al., 2007). Kaine, Murdoch, Lourey, and Bewsell (2010) attribute the changing regulatory environment of the dairy industry to the reluctant nature of farmers toward compliance. Their study finds “attitudes and decisions are based on a systematic evaluation of context and available options regardless of environmental perceptions” (Kaine et al., 2010). The Ministry for the Environment (2001) report, *Managing Waterways On-farm* found the greatest reason for inaction is a lack of understanding about the impact of farming activities, such as the source of farm-generated contaminants and how they enter streams, rivers and drains. Further the report identified where farms had this

level of understanding their efforts toward environmental compliance were greatly increased (Ministry for the Environment, 2001). Volume 1 of the 2013 KPMG Agribusiness Agenda highlights inadequate local regulation and inconsistencies has significantly impacted the dairy industry's ability to commit to the long term business investments required to achieve compliance (KPMG, 2013b). Volume 4; Balancing the needs of the environment, communities and business goes further to suggest that well designed and consistent policy frameworks are critical to the long term development of a sustainable dairy industry with consensus that this would require more policy work to be undertaken at a national level (KPMG, 2013b). Davies, Kaine, and Lourey (2007) found that the majority of farmers believed they complied with the existing regulation, yet from a regulatory agency's perspective, farmer practices such as inadequate storage or application area for effluent posed a significant environmental risk. Historically a farmer's perception of environmental risk has not been aligned with the regulators assessment of the risk (Davies et al., 2007).

In the regulatory drive for sustainability there is a need to appropriately define sustainability and the required environmental outcomes. Smyth and Dumanski (1995) discuss a framework for sustainable land use which suggests sustainability as it pertains to modern agriculture encompasses five key elements. These are: maintain and enhance productivity, decrease risks to production, protect the potential of natural resources, be economically viable and socially acceptability.

Implementing sustainability at a collective level is most challenging, requiring consensus on how to define the relevant environmental stock in terms of both quality and quantity terms. Specifically the use of environmental performance indicators (OECD, 1993, p. 29). While the notion of sustainability as defined by

Smyth and Dumanski (1995) is widely accepted by the dairy industry, there is much debate as to the suitable measures of sustainability (Azzone, Noci, Manzini, Welford, & Young, 1996; Cornforth, 1999). Sustainability cannot be directly assessed. Explicit measures need to be identified (Hayati, Ranjbar, & Karami, 2011). McDowell (2008) has named these environmental metrics. A generally accepted measure for sustainability is in the use of environmental performance indicators (Cornforth, 1999; Parris, 1998). Environmental performance indicators must be functionally related to at risk parts of a system and sensitive to management actions (Cornforth, 1999). The current environmental performance indicator favoured by regulators is kilograms of nitrogen leached per hectare (kg N/ha) (Horizons Regional Council, 2010; Waikato Regional Council, 2010). Naturally, Wheeler et al. (2003) has shown kg N/ha leached to be a function of the farm system and resource efficiency.

The use of nutrient benchmarks is becoming increasingly common within the dairy industry. A study by McHaffie (2012) found the introduction of farming practices consistent with nutrient benchmarks has the ability to achieve sustainable farm systems within dairy intensive catchments, and hence for the national dairy industry.

### **3.4 Farm Systems**

Beukes et al. (2014) describes the pastoral dairy farm as a complex system where multiple physical and financial variables are interconnected often with nonlinear feedback loops. This provides a challenge for the management and design of efficient dairy farm systems. The past decade has seen a variety of adjustments to

farming systems to intensify the New Zealand pastoral farming model (MacLeod & Moller, 2006). Although still underpinned by pastoral grazing, farm systems are now rarely self-sufficient; rather they rely on additional feed sources to extend lactation beyond that dictated by seasonal pasture growth curves. Viable intensification of the New Zealand pastoral farming system has increased due to the availability of supplementary feed products and the desire to increase farm profitability (Newman & Savage, 2009). Traditionally the standard New Zealand dairy farm was characterised by low stocking rates and a self-sufficient supply of feed. Modern farm systems have increased the number of cows per hectare adding the need for supplementary feeding to fill seasonal feed deficits. Within the industry these are classified into farm systems (system 1 through systems 5) (Hedley et al., 2006).

System 1: All grass, self-contained – 10-15 percent of owner-operator herds. No cows grazing off the milking area.

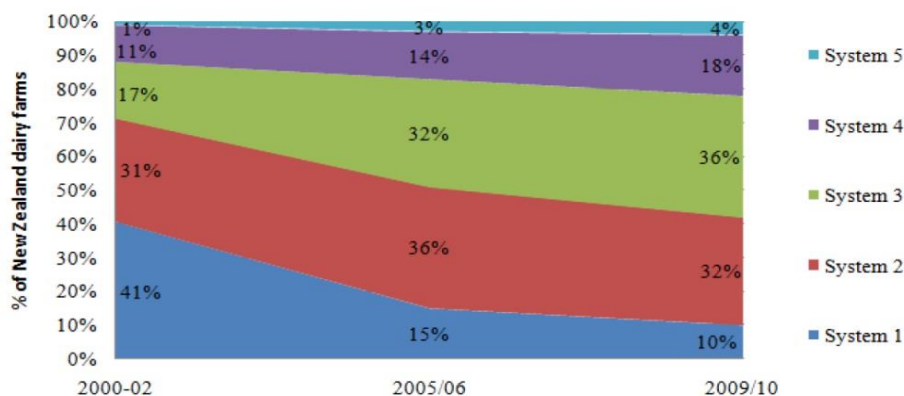
System 2: Dry cow feed purchased – 25-35 percent of owner-operator herds. Approximately 4-14 percent of total feed imported and fed to dry cows including dry cows grazing off the milking area.

System 3: Feed purchased for dry cows and to extend lactation – 35-40 percent of owner-operator herds. Approximately 10-20 percent of total feed is imported to the milking area.

System 4: Feed purchased for dry cows and to extend both ends of lactation – 10-20 percent of owner-operator herds. Approximately 20-30 percent of total feed is imported.

System 5: Feed purchased for year round feeding – 5-10 percent of owner-operator herds. At least 30 percent of total feed imported all year round including for dry cows

These classifications provide a broad grouping of similar farming operations, however, by nature farmers within these classifications have different variations of the farm system driven by available capital, soil type and farm business objectives. Key performance indicators have been developed to measure the efficiencies and performance of these farm systems, yet even these measures cannot fully account for the variation and individuality of the farm systems.



Source: DairyNZ Economics Group as acknowledged by Sinclair, 2011

**Figure 3.1 Distribution of New Zealand farm systems 2000-2010**

Figure 3.1 shows the decreases in system one farms of 75 percent. The largest growth over ten years was system five farms (300 percent) and system three (111 percent) (Greig, 2012). Modern farm systems have evolved as farmers have differing drivers of success, variable climatic and geographical constraints as well as different resource availability (Hedley et al., 2006). Economic conditions and relative input pricings have also been identified as a major determinant of farm system development (Greig, 2012). This has highlighted both the economic and biophysical components of implementing farm systems. Motivating factors for high

levels of intensification within a farm system are likely to be available sources of alternative feed, higher production per cow and per hectare as well as increasing land values which required higher economic returns (Sinclair, 2011). Hedley et al. (2006), considers a consistent benchmarking factor of the New Zealand pastoral model to be the quality and timing of imported supplement feed. The study classifies five farming systems ranging from no imported feed through to greater than 55 percent of the total diet year round feeding. Despite the wide spread uptake of system intensification, there has been little robust financial analysis regarding the financially optimal, most efficient farm system or the varying cost of compliance (Shadbolt, 2012).

Shadbolt (2012) concludes “there are low-input farms who achieve low cost of production through cost control (the numerator effect) and high-input farms who achieve it through improved outputs (the denominator effect)”. Shadbolt (2012) agrees with Langemeier (2010) and Ridler and McCallum (2014), who conclude that farms with a high asset turnover ratio\* are not necessarily those with high operating profit margin. (\*Total Revenue / Total Assets).

Hedley et al. (2006) suggested that while the higher input systems can provide more consistent production and a higher cash turnover, they may be more complex to manage. Specifically, the environmental impacts are shown to increase as greater nutrient cycling is a function of higher inputs and intensification (Ledgard et al., 1998; McDowell, Monaghan, & Carey, 2003; Monaghan, Paton, Smith, Drewry, & Littlejohn, 2005). Ledgard et al. (2003) concludes intensification of dairy farm systems has not always been accompanied by increased resource efficiency.

A notable impact of the regulatory drive for sustainable dairy farm systems is the need for infrastructure investment. Analysis of the economic costs involved in developing farm infrastructure shows there is a high cost to building sustainable dairy farm infrastructure and intensification of the farm system is often required to drive economic returns sufficient to cover the cost (Journeaux, 2013; NZIER, 2013).

Glasse, Mashtan, and McCarthy (2014) suggest recommendations to reduce N output must be considered within the context of the whole farm system. Their research indicates failure to do so risks the recommendations can lead to reduced profit, increased financial and business risk and no notable reduction in N loss. Moynihan et al., (2014) and DairyNZ (2014) suggests minor adjustments to the management and farm system can achieve increased environmental performance in the way of reduced N leaching by up to 5 kg per hectare. Park, Kingi, Morrell, Matheson, and Ledgard (2014) reinforce that where there is very little “low hanging fruit” in the farm system it is difficult for dairy farmers to meet a N discharge cap. Where larger reduction in N leaching are required, a significant shift in farming system is needed (Ledgard et al., 2006).

Gray, Dooley, and Shadbolt (2008) identify increasing consumer awareness of sustainable food systems and subsequent environmental regulation has brought increased variability on the financial performance of the dairy farm business. Optimising the dairy farm system to maximise the operating profit and minimise the cost of compliance will be a key focus of future farm system development (Clark et al., 2007).

### **3.5 Farm System Analysis**

In 2004, (Monaghan et al.) identified there were few tools available for dairy farmers and their consultants to predict how dairy farm systems respond to management changes from both an economic and environmental perspective. Despite the increasing importance of balancing the economic and environmental provisions of dairy, there are still only a limited number of tools to measure these factors as they relate to one another (AgResearch, 2014). The use of computerised modelling has been common in the dairy industry (Anderson & Ridler, 2010). Examples include UDDER (Monaghan et al., 2004), Whole Farm Model (Beukes et al., 2008) and Farmax Dairy Pro (Bryant et al., 2010).

Modelling - including physical, financial and environmental - of dairy farm systems is becoming more precise through demand from regulatory bodies, necessities from financial backers and the general industry trend for incremental performance adjustment. However, Ridler and McCallum (2014) suggest “recent analysis of farm performance is failing to accurately assess responses to resource use or to reliably predict future responses to the allocation of future resources”. This suggestion is caused in part by the reporting and analysis which utilises averaging of farm data and industry farm standards to predict future implications for development of regulatory standards.

Significant advances have been made in measuring environmental performance and economic performance separately – most notably Overseer Nutrient Budgets v6 as well as DairyBase and Farmax modelling tools. Given the available tools and their application, it is common for the analysis to be applied in isolation to the farm system. The result is that it is rare for a farm business to consider financial and environmental implications together (double bottom line analysis) (Monaghan et

al., 2004). Analysing dairy business requires understanding that dairy systems are both biological and economic in nature. Hence, increasing the farm output through milk solids per cow or per hectare lifts farm income helping to sustain the natural inflationary rise of input cost. However, profitability of the farm system, that is the margin between input and output per milk solid, remains critical to dairy farm businesses sustaining profit over a period of time. Profitability within the dairy business is required in recognition that the production of milk solids at the current level of output is at the expense of environmental quality which over time will need to be mitigated through internalising of environmental costs.

Given the importance of minimising environmental footprints and maximising profits within modern farming systems (Currie & Christensen, 2010), Doole and Romera (2014b) consider the multidimensional nature of farm systems and modelled the trade-offs between three drivers of pasture based dairy systems: profit, production and environmental footprint. It was found that naturally there is a clear link between production increase and environmental benefit however the implementation of nitrogen leaching limits to improve environmental footprint significantly reduced the available profit without additional infrastructure. Further, the importance of supplementary feeding within the farm systems as a tool to mitigate sensitivity risk to the payout was emphasised in alignment with the conclusions of (Shadbolt & Olubode-Awosola, 2013).

Farm systems analysis conducted by Dewes and Bolt (2012) attempted to measure the financial and environmental implications of dairy farms in the lower Waikato catchment. Findings showed over a three year period, farms within the trial experienced significant variation in climatic and market returns, plus experiencing

a 30 percent variance in pasture harvested and a 20 percent fluctuation in farm gate milk price.

Within DairyBase, there are over 30 measures of performance which give farmers benchmarking ability for physical and financial information. However the high number of key performance indicators make it difficult to assess farm businesses in absolute terms without the distortions of normalising data as a factor of cow numbers or farm size (Shadbolt, 2013).

A current issue for farm analysis is the lack of accurate record keeping on farm. There is a drive within the industry to improve on farm data collection through the use of Fonterra dairy diaries and data recording software. As with any modelling analysis, the result is dependent on accurate data input. Improving data recording processes on farm will be a key issue for farm analysis in the future. A second common issue for farm systems analysis is the repetition of data input into multiple models for multiple end uses. Currently, farmers are asked for nutrient management data from dairy companies, from Overseer nutrient budget analysis as well as through financial analysis such as Dairybase and annual accounting practices. Improving the way in which data is entered into modelling tools will be a determinant of successful farm analysis going forward.

### **3.6 Overseer**

A key tool for the dairy industry to model nutrient transfers is Overseer Nutrient Budgets (Overseer). Overseer was initially developed as a fertilizer recommendation tool by the Ministry of Agriculture and Fisheries (MAF) (Selbie,

Watkins, Wheeler, & Shepherd, 2013). Recent changes to environmental regulation and a wider range of options for on farm management practices have placed higher importance on the modelling and monitoring of nutrient transfers. To this end Overseer has undergone significant development work, shifting from a fertilizer recommendation tool to where it is now, a world leading model for nutrient budgeting (Edmeades, 2014; Wheeler et al., 2003). “Nutrient budgets are useful tools for assessing the sustainability of nutrient flows within a farm and for highlighting potential negative environmental impacts of nutrient use” (Wheeler et al., 2003, p. 191). More specifically, Overseer has the capability to model nutrient flows specific to individual ‘blocks’ within the whole farm, enabling users to accurately account for changes in management practices (e.g. effluent blocks) or changes in terrain and soil type. From a nutrient budget, a farm specific nutrient management plan can be drafted and implemented, detailing the current and proposed management of farm nutrient cycles. The Overseer model has enabled a progression in nutrient management decisions on farm through enabling farmers to understand total nutrient transfers better, not just information regarding maintenance fertilizer applications (McHaffie, 2012; Monaghan et al., 2007). Despite Overseer being a world class model, the complexity and inherent nature of modelling limit the application of Overseer for specific monitoring (Edmeades, 2014).

The Overseer model is now widely used by New Zealand’s fertilizer industry and by farmers to model the various nutrient cycling effects of farm management practices and to derive optimal maintenance nutrient recommendation. Similarly, there is increasing use of Overseer by Regional Councils with councils nominating Overseer as the way in which nutrients, specifically N losses will be derived and

monitored under restrictive nitrogen loss limits (e.g. Variation 5 Waikato, One Plan Horizons and Variation One Canterbury). The sources of uncertainty in Overseer are particularly relevant in the policy environment (Edmeades, Metherell, Rahn, & Thorburn, 2013). In this context, there is a need to recognise that although based on the best scientific information calibrated for specific areas, Overseer is still a modelling application and as such has a margin of error in proportion to that of the assumptions in entering data and the computing of data. Fundamentally, Overseer is a mathematical model which is used to describe the complexities of biological processes in agriculture, most of which vary seasonally e.g., soil moisture levels (Edmeades, 2014). In computing nutrient cycles through Overseer, the biological system variances require Overseer to make assumptions regarding the transfer of nutrients with regard to the farm specific soil type, management regime and rainfall etc. These assumptions have the ability to significantly alter the models output. For instance “the model assumes that good management practices such as those in the Fertilizer Code of Practice, Best Management Practices (BMPs) and Regional Council guidelines on effluent management, are followed” (Wheeler, Ledgard, & Monaghan, 2007). When these practices are not being followed, the model is likely to underestimate nutrient losses (Wheeler et al., 2007). For this reason the use of the Overseer model as a regulatory tool for specific nutrient limits is outside the core function of Overseer which is to ‘model’ the sensitivity of physical characteristics and management actions. The inherent value of Overseer in its intended context lies within the qualitative sphere where the sensitivity to management actions can be understood without concern for the absolute or quantitative aspects, which are demanded when applying overseer to a regulatory role (Edmeades, 2014). In essence, the absolute value for nutrient output under

certain farm management modelled through Overseer is irrelevant, the relevance of Overseer's output is the direction of change from the status quo and the significance of this change with regard to reducing the farm systems environmental impact.

Rowarth and Edmeades (2013) state it is important to recognise that the alternative to nutrient loss limits measured through Overseer would be restrictions on nutrient inputs, as has been demonstrated in Europe. Under such regulation nutrient inputs such as N brought in through fertilizer and feed would be capped, effectively limiting the freedom of farm systems which underpins the productivity of the current New Zealand dairy industry.

An issue for Overseer as an empirical model is in continuing to improve the assumptions and calculations of nutrient modelling whilst still maintaining a user friendly and practical interface (Shepherd & Wheeler, 2012).

### **3.7 N Cycling on Farm**

“The complex interactions of nitrogen in nature are usually described by the term ‘the nitrogen cycle’ ” (Keeney, Gregg, & Lynch, 1982). On farm management decisions at an individual farm level have a significant impact on the efficiency of nitrogen use and its incorporation into products. At a wider scale these decisions determine the extent of transfer of excess nitrogen to water or the atmosphere (Javis, Hutchings, Brentrup, Olesen, & van de Hoek, 2010). “Intensification of pastoral dairy systems in recent decades has raised concerns about the impacts on nitrogen losses to surface and groundwater (via leaching) and nitrous oxide (N<sub>2</sub>O) emissions” (De Klein, Monaghan, Ledgard, & Shephard, 2010, p. 14). Loss of nitrogen from dairy systems will always be greater than from a natural ecosystem due to the

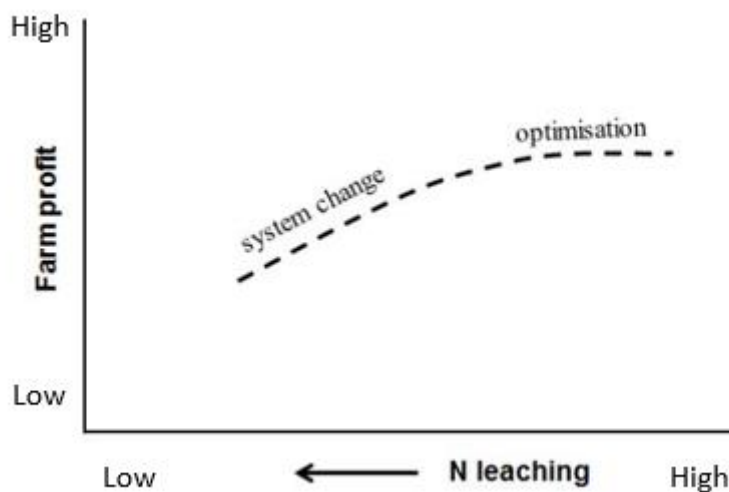
requirement of nutrient mobility in the production of food (protein) and fibre (Javis et al., 2010). The challenge for New Zealand dairy farmers is to maximise the production of food and fibre with minimal loss of nitrogen to both water and air.

Within modern New Zealand dairy systems, N inputs include biological fixation via clover, urinary deposits and N fertilizers, as well as farm dairy effluent and the nutrient value of supplement (Di & Cameron, 2000). Nitrogen removed from the pasture or outflows, are in the form of milk, meat, effluent transferred to walking tracks, as well as N loss to the atmosphere and leached (Ledgard, Penno, & Sprosen, 1999). Fundamentally, the issue for dairy with regard to the nitrogen cycle is the imbalance between nitrogen input and nitrogen output resulting in surplus and subsequent loss of nitrogen to both the atmosphere and predominantly fresh water bodies through N leaching (Ledgard et al., 1999). Farm gate N surplus is the term used to describe this imbalance between inputs and outputs of N on the farm (Dalley, Hunter, & Pinxterhuis, 2013). Beukes et al. (2012) found that farm gate N surplus is a useful tool for benchmarking the environmental performance of a farm system with regard to its efficiency and environmental loading. Within the typical New Zealand dairy system 95 percent of N leaching occurs as a function of urinary N deposition, relative to just 5 percent from N fertilizer and effluent inputs (De Klein et al., 2010). As such, the general increase of cows per hectare or intensification of dairy, without mitigation infrastructure is directly correlated with the amount of N leached as a function of increased urinary N deposition.

From an on farm management perspective there are actions which farmers can take to reduce N leaching. These include reducing N input and converting more N into product exported (Dalley et al., 2013). The use of farm infrastructure to intervene in the N cycle can reduce N leaching by up to 50 percent by removing cows from

the pasture, limiting the window in which cows are on the pasture to deposit N. Rather the urinary N is captured and reapplied to pasture at a controlled rate at a time when the soil can handle the increased N loading (C. Christensen, M. Hedley, M. Hanly, & D. Horne, 2012).

Figure 3.2 identifies the trade-off curve between farm profits and N leaching as shown by (McCarthy, Hutchinson, & Bowler, 2007). The graphical representation shows there are options for farms, although limited, to reduce leaching without reducing farm profitability. Such optimisation has been demonstrated by Glassey, McCarthy, and Serra (2013) through lowering stocking rate and maximising per cow production.

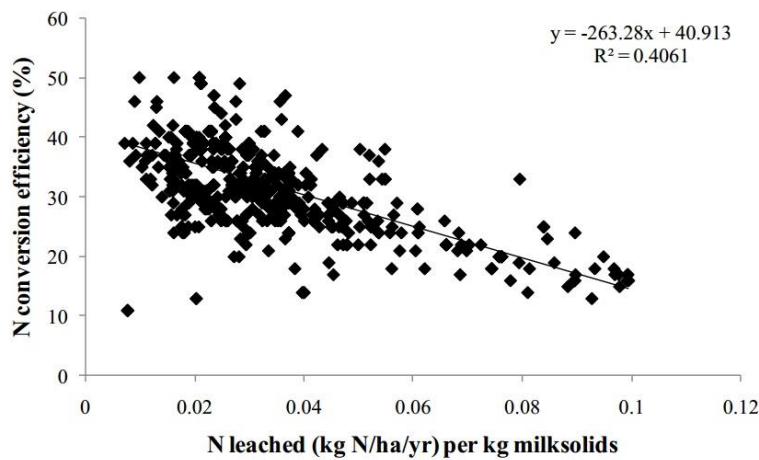


**Figure 3.2 Correlation between N leaching and farm profit**

Source: (McCarthy et al., 2007)

One particular measure of N cycling calculated in Overseer is N conversion efficiency, which is defined as product output N divided by N input (Wheeler, Power, & Shepherd, 2008). Naturally, N conversion efficiency can be increased by

improving the conversion of N inputs into N exported as milk or meat product (Ledgard, Penno, & Sprosen, 1997). Wheeler et al. (2008), calculated average N conversion efficiency for dairy farms to be between 15 and 45 percent. Within this range it was common for N conversion efficiency to decrease as N leaching per kgMS increased. (Figure 3.3)



**Figure 3.3 Correlation between NCE and N leached per kgMS produced**  
 Source: Wheeler, D., Ledgard, S., & Monaghan, R. (2007)

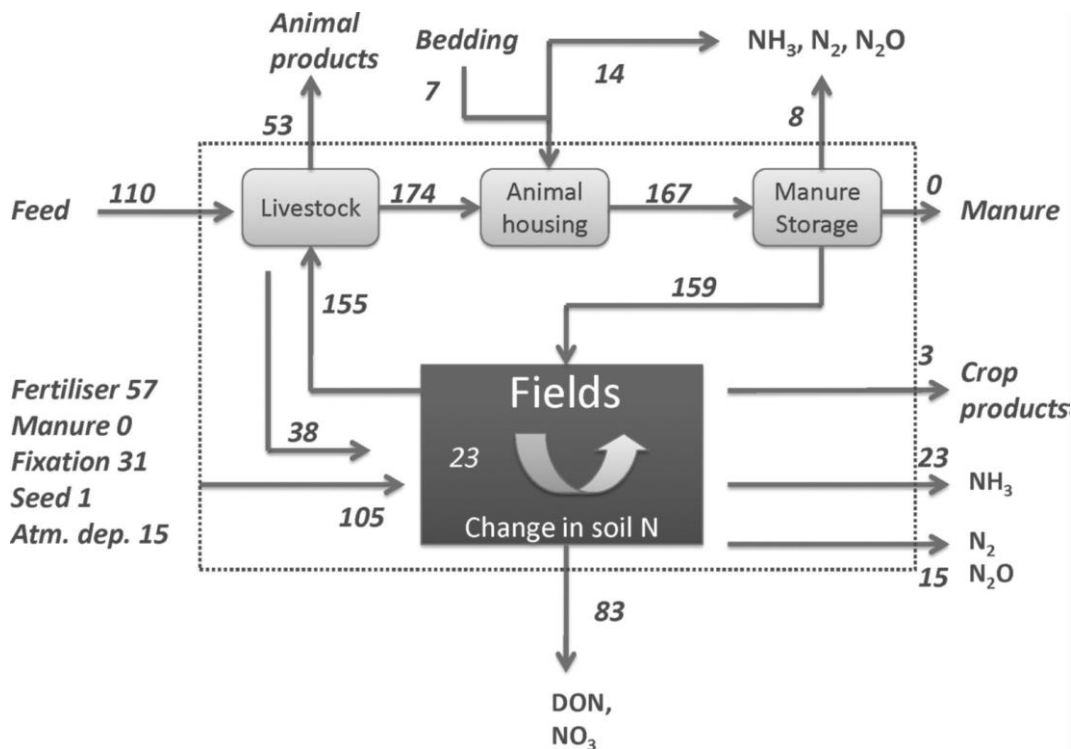
Within the current framework for measuring and monitoring loss of N to water, emphasis is placed on measuring the output of N leached expressed in per hectare terms e.g. KG N loss per Ha. An alternative measurement which incorporates the farms output productivity is measuring N lost per kilogram of milk solid produced e.g. KG N loss per kgMS. This expression has been referred to by Doole and Romera (2014a) as Nitrogen Leaching Efficiency (NLE) and expressed in kgMS per kg N lost. Currently not part of the Overseer model, the calculation is performed by dividing the per hectare N leaching data from Overseer by the kgMS per hectare production data. Essentially NLE measures the productivity of a farmer to

efficiently produce milk solids at the lowest nitrogen loss thus leveling the playing field between farm systems of different feed input intensity. Modelling by Doole and Romera (2014a) demonstrates that large increases in N leaching with intensification are offset by higher milk solid production to such a degree that NLE improves. N leaching increases by 37 percent going from farm system one to a system 5, but production increases by 56 percent. Accordingly, NLE increases by only 12 percent going from system one to system five. However, given that the scale (hectare) is a fixed variable, despite a comparative NLE, per hectare N losses have increased significantly and the net effect to waterways and the environment is worsened.

There are however certain cases which merit the use of NLE as an environmental performance indicator under a limits based regulatory environment. Working backwards from a catchment level, Regional Councils could effectively determine a level of N loss which can be tolerated at catchment level in which both the economic and environmental provisions were balanced and work back to allocate N loss rights. An example of this is the Rotorua Catchment where the Regional Council has indicated 450t of N entering the lake per year is an acceptable target for the catchment (Pauwell, F. February 2014 Pers Comm). From this target it would then be possible to include a tolerance for high intensity farming systems in which per hectare leaching was above the proposed blanket policy limits. In this case the NLE of the high input system would be more efficient than that of lower intensity systems which meet the requirements of per hectare N limits. In essence, this notion would encourage and reward the progression of farming systems for maximum productivity, however the major problem is that per hectare leaching is still comparatively high despite a lower or comparable NLE, therefore requiring a

lessor amount of land under higher output. This issue would require the allocation of polluter rights, most certainly under a grand parenting allocation scheme similar to that used in the allocation of water quantity.

Evidence of N conversion efficiency not correlated to N loss per hectare was demonstrated by Glassey et al. (2014). Their study shows a farm producing 1500kgMS per hectare using 5tDM/ha of maize can increase MS/ha by increasing the amount of maize silage fed to 20tDM/ha. NCE improves from 34 to 37 percent however the on farm N surplus/ha increases to 351kg N/ha from 212kg N/ha and N leaching increases from 48 to 113 kg N/ha. Despite a desirable increase in NCE, in net terms the farm has a higher N output which does not align with the Regional Council Regulation.



**Figure 3.4 The nitrogen cycle**  
Source: (Javis et al., 2010)

### **3.8 Cow Housing in New Zealand**

The increasing use of cow housing in New Zealand's dairy sector has resulted in an increasing amount of available literature with regard to both operational and economic considerations of cow housing. Recent studies include Christensen, Hanly, Hedley, and Horne (2011), Journeaux (2013) and Pow, Longhurst, and Pow (2014) which have analysed various components of cow housing with regard to cost, compliance and profitability.

By nature, farms as biological systems each have varied factors which determine the profitability of cow housing. These factors are varied farm by farm and region by region. For this reason, studies such as Journeaux (2013) have focused on particular regions within New Zealand and emphasised the variance between farm systems.

In quantifying the economic and operational benefits of cow housing systems there is much emphasis placed on best assumptions. This is because much of the measurement required is difficult and variable season by season (Shadbolt, 2012). The assumptions used in previous cow housing analysis have been shown to have a significant effect on the viability of the project. Assumptions such as a \$2000 per cow capital cost used in the Journeaux (2013) analysis showed that while cow housing can reduce nitrogen leaching problems, the farm has significantly increased risk regarding interest rates, milk price and feed input costs. Journeaux (2013) concluded farmers building housing infrastructure to mitigate environmental risk often intensified the farm system so as to manage the increased financial risk and therefore were no better off environmentally (Journeaux, 2013).

In New Zealand trials for integrating housing systems and the pastoral grazing model have shown significant reduction in N leaching (Christensen et al., 2011; Watkins & Shepherd, 2013). Duration Controlled Grazing is used to protect cows from climatic conditions, reduce treading (pugging) damage to pasture and soil, and minimise the loss of nutrients to waterways. Christensen, Hedley, Hanly, and Horne (2012) reported reductions in N leaching (up to 50 percent) were directly related to soil profile and annual rainfall

Adding profitable farm system infrastructure has been identified as an effective way to adapt a whole farm dairy system (Basset-Mens, Ledgard, & Boyes, 2009). New Zealand farm systems without suitable infrastructure or farm systems were exposed to greater risk and proved less resilient to farm systems with infrastructure to provide stability in the farm system (Shadbolt, 2013)

Within the general public of New Zealand there is a misunderstanding - (e.g. Kedgley (2014) describing factory farming) - as to the way in which cow housing has been integrated into New Zealand farming systems. The Kedgley (2014) descriptions of factory farming cows fails to comprehend the positive environmental outcomes proven in recent research from the adoption of cow housing systems.

There is consensus in the limited existing literature to suggest both the economic and environmental components of cow housing will add value to the New Zealand pastoral dairy model (Doole et al., 2013; Journeaux, 2013; Pow et al., 2014). Further research in cow housing is required to explore the complexities of regional analysis as well as sensitivity to farm scale.

### **3.9 Implications for this Research**

Dairy farming systems of all intensities under the New Zealand pastoral model can have negative environmental impacts through increased nutrient cycling and the subsequent loss of water and soil quality (Ledgard et al., 2003; Monaghan, 2008). There is industry agreement that environmental regulation is necessary to mitigate the negative impacts on-farm and to preserve the natural capital of the land (Clark et al., 2007). However, uniform policy prescriptions (Doole et al., 2013) are inefficient in achieving desired environmental outcomes (Doole & Pannell, 2012). These policies add significant cost to the farm business (Bell, 2012; Gauntlett, 2009). Journeaux (2013) shows certain on-farm investment to mitigate negative environmental impacts require high levels of investment and likely system intensification to recover the cost. With farm systems now widely classified by the amount and timing of imported feed (Hedley et al., 2006), there is a strong likelihood that different farm systems will incur varying cost of compliance by nature of the increased nutrient loading (Ledgard et al., 1998). The DairyNZ Strategy (2013) 'Making Dairy Farming Work for Everyone' details the strategy of dairy in the coming decade. The strategy is underpinned by sustainable development. Achieving sustainable development will require farmers to manage their cost of compliance.

There has been significant emphasis in the above mentioned literature to understand the impact of environmental regulation for the dairy industry as a whole. None of the research has referred to the cause and effect relationship between environmental compliance costs and the industry's classification of farm system intensification at an individual farm level. Despite a robust classification of farming systems in the literature (Hedley et al., 2006) etc., there are high levels of variation within a

farming system due to the seasonal weather variations and liquid markets for feed supply and farm gate milk price. The result is highly variable farm systems and a wide scope of management practices within the identified systems. These variances in farm management will naturally result in differences in environmental compliance cost. More so, individual decision making processes and preferences of the farmer will significantly influence the cost of compliance. However, there is a need to provide a distinction between compliance cost for low, medium and high levels of system intensification. Newman and Howard (2013) suggest understanding the different abatement cost curves for a wide range of farms is essential to any analysis of the economic implications of policy for dairy, specifically nitrogen leaching policy. Without proper understanding of the variability for the cost of compliance there is risk further regulation measures will add significant financial hardship to certain farm systems. Additionally there is little or no research as to determining an optimal farm system with regard to minimising the environmental impact and maximising the economic returns for a given dairy business. Determining the costs of compliance will provide individual farmers with an appropriate framework to adapt farm systems for compliance and to inform regulators, society and wider industry as to the implications of environmental regulation.

## **4.0 Methodology**

### **4.1 Introduction**

This research was undertaken to evaluate the on-farm financial implications of environmental regulations and the comparative costs of compliance for different farm systems. The aim was to understand the factors determining compliance costs, specifically the relationship between farm system, environmental performance and compliance infrastructure investment. The modelled cost of environmental compliance was used to identify appropriate farm decisions, regulatory frameworks and future implications for compliance in the Waikato dairy industry.

Regulation was evaluated for its suitability in addressing the environmental concerns as well as imposing the least economic constraint on the dairy industry. The cost of environmental compliance is measured as the direct cost to the dairy farmer through infrastructure investment as well as ongoing economic impacts to the farm business.

Multiple analysis methods including case studies and analysis of survey data have been used to demonstrate the economic and environmental components of compliance investment. Three average Waikato farm systems of low, medium and high input provide a comparative analysis of the economic and environmental characteristics of each farming system. These average Waikato farm systems were collated from data within DairyBase and analysed through both DairyBase and Overseer v6 Nutrient Budgets. Economic indicators such as operating profit as well as environmental performance indicators including total nitrogen loss per hectare and nitrogen loss per kilogram of milk solid were analysed on the basis of the

modelled results. The economic and environmental efficiency at an individual farm level was considered in order to inform the debate pertaining to limits based environmental policy.

Further modelling of a standardised Waikato farm system of 100 hectares was performed using Dairy Feed Planner and Overseer v6 under scenarios of low, medium and high input in order to show the true comparative economic and environmental implications of different farm system intensity. Scenario based analysis was used modelling the above standardised farm system under four identified scenarios to reduce N leaching. Dairy Feed Planner data was used to show the likely economic implications on operating profit for different farm systems as they move to environmental compliance under each of the four scenarios. A corresponding nutrient budget prepared through Overseer v6 was used to show the relative ratio of environmental performance to economic performance.

The real cost of environmental compliance for different Waikato farming systems was determined through a survey of Waikato farmers. The capital cost of recent farm system upgrades for compliance was measured as well as the cost of mitigating nitrogen loss to a required target. Comparative costs of compliance between farm systems were analysed as well as the incremental compliance cost of changing farm systems to achieve efficiency in compliance spending. Future issues and options for New Zealand dairy farmers determined from dairy farmers with regard to environmental compliance and continued profitability are discussed.

## **4.2 Paradigm**

A positivist research paradigm is used to analyse empirical observations and measures. This can be used to determine the relevant cost of compliance in both an exploratory and descriptive manner.

The positivist paradigm asserts the existence of one absolute, physical-material reality from which there are no variations (Patton, 1980). A significant amount of agricultural economic research is conducted from the positivist research paradigm e.g. (Doole & Pannell, 2012; Gauntlett, 2009; Shadbolt & Olubode-Awosola, 2013). A strength of the positivist research method is the rigor developed through tests of coherence, correspondence and clarity (Sterns, Schweikhardt, & Peterson, 1998). Initial selection of the positivist paradigm for this study is based on the three underpinning philosophical assumptions of positivism. These are the positivist ontology, epistemology and axiology stances (Blaikie, 2007; Crotty, 1998).

Positive ontology suggests that “reality exists ‘out there’ and is driven by immutable natural laws and mechanisms” (Zahra, 2006). Epistemology under the positivist assumptions is concerned with how the knowledge can be known (Creswell, 2012; Crotty, 1998). In the positivist paradigm, knowledge is seen to be derived from sensory experience by means of experimental or comparative analysis, concepts and generalisations of particular observations (Blaikie, 2007). Axiology is concerned with the values of the research. The axiological assumptions of the positivist paradigm state that the research topic is value neutral (Zahra, 2006).

Within the positivist paradigm it is assumed decision makers are rational and act in this manner (Morgan & Smircich, 1980). In the context of this research, the positivist research paradigm assumes every farmer will always act in the same

manner when presented factual data regarding environmental compliance. Kaine et al. (2010) describes that in reality this is not the case. Environmental compliance issues within the dairy sector are by nature emotive (Kaine et al., 2010). This is due largely to the intangible measurement of environmental performance and the negative financial impact of compliance on farm businesses. Consequently, research involving the cost of environmental compliance cannot be classified as value neutral.

According to (Burrell & Morgan, 1994, p. 24) “to be located in a particular paradigm is to view the world in a particular way”, commonly there is more than one usable research paradigm (Schultz & Hatch, 1996).

For this reason, a post-positive research paradigm allows for comparable rigor generated by the ontological and epistemological assumptions of positivist research whilst also allowing for a more realistic consideration of the emotive value component within environmental agricultural economics. The post-positive method is reductionist (Creswell, 1994), in that it reduces ideas to that of a hypotheses or proposition.

When considering the axiology component of this research, the subjective opinion and view point of the regulator versus the regulated will have an impact on the research outcomes. There is a need to consider the bias in data collection methods and data origins. The post-positive paradigm is accommodating of these influences however another paradigm that could inform this research is the pragmatic paradigm (Creswell, 1994). The pragmatic paradigm is underpinned by the three research assumptions. These are, problem focused, pluralistic and real-world practice centred (Creswell, 2009). With a pragmatic approach, emphasis is placed

on the research problem and all methods for answering this are used (Rossman & Wilson, 1985). The pragmatic paradigm is considered best for mixed methods research (Tashakkori & Teddlie, 2003) where both the qualitative and quantitative data are used to provide validity to the analysis. The pragmatic paradigm is underpinned by the collection and analysis of qualitative data before the quantitative data (Creswell, 1994). Pragmatism draws on many ideas including using “what works,” using diverse approaches, and valuing both objective and subjective knowledge (Cherryholmes, 1992). Tashakkori and Teddlie (2003) have formally linked pragmatism and mixed methods research arguing through methodological research that the research question should be of primary importance over the method and the research paradigm.

#### **4.3 Research Design**

A mixed methodology research design was used due to the quantitative and qualitative nature of the data required in this research area. Specifically an exploratory mixed method design was used where qualitative data was gathered and analysed prior to commencing quantitative data collection. Using an exploratory design, the qualitative data collected informed and justified the collection and analysis of quantitative data. This is opposed to a concurrent mixed methodology where both quantitative and qualitative data are collected and analysed at the same time or an explanatory design which collects quantitative data before qualitative data. An exploratory design was selected to provide greater validity to the research analysis and is fitting with the assumptions of a pragmatic research paradigm. Further, the exploratory design involves both an inductive and deductive research design. A top down approach using deductive reasoning gathered through

qualitative data collection is used to provide a foundational framework for the research free from bias. This was used to inform the quantitative analysis which involves a bottom-up interpretation of on farm data. The sections below discuss specific data collection and analysis technique.

#### **4.3.1 Case Study**

Within the agribusiness research field, traditional research design, including the use of surveys and archive data analysis, are at times limited in their applicability and scope (Sterns et al., 1998). This is a reflection of the complexities and variation within the industry, specifically farm systems, and the necessity to detail all underlying assumptions when analysing a particular component of a farm system Doole et al. (2013). Overcoming the limitations of traditional research design can be achieved through the use of case studies. The case study research method is of high value within New Zealand's agricultural industry given the innovative thinking and willingness to share information between primary industry participants (KPMG, 2013b). Detailed case analysis can be conducted where all assumptions and complexities are covered in depth giving the end research high credibility and ensuring it is applicable to those within the industry (Sterns et al., 1998). Further, case study research design becomes beneficial when used to cover multiple cases and draw cross case conclusions (Yin, 2009). Yin (2009) proves the validity of case study research suggesting that researchers can make analytic generalisations from the findings of case studies through detailed comparative analysis.

The complexity of environmental compliance costs and farm systems favour case study as the primary research design in this study. This research uses case studies of three farm systems to analyse the financial and environmental performance of different farming systems under existing environmental regulation. The three case

studies have been chosen to represent varying levels of dairy farm system intensification as described by (Hedley et al., 2006). Kennedy (1979) suggests successful selection of case studies involves selecting for cases with a wide range of comparable attributes yet a number of unique features to differentiate the case. The case study will analyse the financial cost of environmental compliance for a low input farm (System 1 or 2), a medium input farm (System 3) and a high input farm (System 5).

Cross case analysis was used to show the financial similarities, efficiencies and overall performance of the farm systems. Specifically Dairy Feed Planner performance measures, both physical and financial, were analysed as well as a corresponding environmental performance analysis using Overseer modelling. Data was collected through document analysis, interviews and survey.

#### **4.3.2 Document Analysis**

Specific data required to address the research question is found within the regulatory documentation provided by Regional Council and the associated commentary by lobby groups and industry bodies. Document analysis is carried out to evaluate existing environmental legislation pertaining to the dairy sector and the rationalisation for implementation. Discourse analysis forms a significant part of the qualitative research analysis given the changing nature of terminology used within the relevant documentation. Specifically, the use and definition of ‘sustainability’ within the regulatory documentation is notably different to that used by industry. Discourse analysis is used to determine where the change in terminology has occurred and whom it was influenced by.

### **4.3.3 Interviews**

The interview process is beneficial to small scale research projects such as a case study and provides a rich data source (Drever, 1995). Semi structured interviews conducted with industry experts from both on and off farm were used to gather the scope of environmental regulation for the dairy industry and to build a framework of relevant issues in which the industry is currently facing. Candidates for interview were selected for their merit and scope of understanding in the area of environmental compliance and regulation. An equal selection of both the regulator and regulated perspective is sought to ensure a fair balance in data collected. Semi structured interviews maximise the generalisability and scope of data collected allowing the participant to expand on relevant issues while maintaining a uniform focus for cross interview analysis. Content analysis was undertaken to analyse interview transcripts. "Content analysis classifies textual material reducing it to more relevant manageable data" (Weber, 1990, p. 5). The interview process provides further validity to the research, specifically to the qualitative analysis. The interview process was performed in two stages. An initial round of interviews were conducted following document analysis. The data collected was informative for both the case study analysis and development of a relevant survey. Axiological issues concerning data interpretation and bias can be eliminated through a second stage of interviews with the same candidates. These interviews were used as a means to check analysis conclusions and interpretations with both farmers and industry.

### **4.3.4 Survey**

A comprehensive survey to investigate the variance in compliance cost would provide an effective data source to determine how these costs compare between

individual Waikato farm systems. Further an indicative range for the infrastructure investment requirements could be summarised in gathering a range of farmer responses. In 2014 James Stewart of Federated Farmers initiated a survey on environmental compliance cost to all dairy farmers in the Manawatu region. Response rates were recorded as 165 from 918. (Stewart, 2014). Similar data pertaining to the Waikato region has not been collected before. However, the scope and variation within the data collected would not provide rigor given the wide variation of farm systems and on farm practice, hence limiting the validity of a wide spread survey for the purposes of determining the comparative cost of compliance. Further, gaining access to a large number of farmers who are already under pressure from industry organisations to provide data would yield poor survey response. A common difficulty conducting data collection via survey within the agricultural industry is gaining participant (farmer) response. Similar research using survey method has indicated poor response rates below 35 percent (Bensemman, 2012; Shadbolt & Olubode-Awosola, 2013). Typically the response rate for agricultural surveys via web, phone or post is too low to validate and provide sufficient data for the purposes of research. Identified reasons for this include the seasonal workload requirement of dairy farmers narrowing the collection time frame, high demand for information on farmers from existing research organisations (DairyNZ, Seed and fertilizer companies etc.) and difficulty in obtaining the correct information required. Improvement in the commonly observed response rate can however be achieved through thorough targeted research design as well as limiting the length of surveys to a manageable scale.

The above limitations of a wide spread survey limit this method of data collection as the primary method of obtaining data for the purposes of this research. Despite

this the survey method has merit in showing a cross section of participating farmers and extrapolating a realised cost of compliance for farmers in line with the key research objectives.

A survey of limited length with easily answered questions was presented to selected owner operator farmers in the Waikato Regional Council catchment. Surveys were distributed in both hard copy (in person) and electronically (via email). Results of these selected questions are used to provide information on owner operator dairy farmer's attitude towards environmental compliance and an indicative financial cost associated with installing compliance infrastructure.

Questions within the survey were asked directly to farmers in the face to face setting so as to ensure responses were fit for purpose and further that the data collection process from presenting the survey through to having data was effectively immediate. Further, using the survey questions as a point of discussion, general comments regarding compliance cost were mentioned in greater detail than what could be provided on a written survey form. This data was recorded as 'general comment' and was strictly qualitative data collection used to inform the quantitative analysis.

Information regarding the survey was presented to participants prior to the survey and the survey was commenced with fully informed consent. Participants had the option to receive an aggregated data summary of the surveyed information via email upon completion of the research.

## **4.4 Farm Analysis**

### **4.4.1 DairyBase**

DairyBase is an industry funded venture through DairyNZ which provides a platform to benchmark farm physical and financial data. “The aim of DairyBase is to standardise terminology used in physical and financial reporting within the dairy industry and to ensure consistency in calculations for key performance indicators such as Return on Assets (ROA) and Operating Profit (OP)”. It provides the industry with a database that could provide relevant industry statistics (DairyBase, 2014)

DairyBase operates free of additional charge as an optional tool for farmers and consultants to measure and benchmark performance. By nature, those farmers investing time and resource into DairyBase for benchmarking purposes are generally performing higher than the industry averages. This to a certain extent leads to a skewed data set when looking at national or regional industry statistics. That stated, DairyBase is the only comprehensive, standardised and regular measure of both physical and financial data farm data. Validation of the data reported within DairyBase is achieved through comparison to the dairy industry statistics generated by DairyNZ. Upon analysis it is clear there is a correlation between the Waikato DairyBase data and the Waikato data presented within the dairy statistics therefore positively validating the data to be used within this analysis.

Data collected from DairyBase is shown to be correlated to the data published within the DairyNZ economic survey and the DairyNZ statistics. One statistical difference is in the analytical approach used by the two services. DairyBase is a business analysis tool and as such measures the performance of dairy businesses where one entity can own multiple dairy supply numbers. This is contrasted to the

DairyNZ dairy statistics and DairyNZ economic survey which are compiled on a per supply number basis.

#### **4.4.2 Dairy Feed Planner**

Dairy Feed Planner is a Microsoft Excel based farm systems modelling tool designed to measure the biophysical and financial implications of dairy farming systems. The model uses published dairy production science from DairyNZ to record, analyse and forecast the variable drivers of a dairy farm system. Dairy Feed Planner is a transparent model whereby the user can clearly see the assumptions and calculations used to model the farm system. Within this research Dairy Feed Planner is used to model case study farm systems under a base scenario and four alternative scenarios for reducing N leaching. The biophysical and financial implications of each scenario for a low, medium and high input farming system are measured.

To model farm systems consistently through Dairy Feed Planner a standardised set of operating assumptions were followed. All financial modelling was performed using an average milk solid payout of \$6.50 per kgMS. The price of purchased feed was held constant at \$0.30 per kgDM for Palm kernel, \$0.33 per kgDM for maize silage and \$0.27 per kgDM for pasture silage. Pasture growth rates were assumed to be the Horsham Downs average pasture growth rates as reported by DairyNZ.

#### **4.4.3 Climatic variances**

Within the New Zealand pastoral based farming system, farm performance season to season is dictated by climatic conditions and the farm systems ability to withstand these seasonal variances. Most notably New Zealand farm systems are dependent on consistent rain fall.

Recent drought conditions in the 2012/13 dairy season increased on farm demand for external feed sources. The extent of the drought in key dairy regions forced farmers to import feed significantly above that common in a typical season. Under the strict classification of farm systems (Hedley et al., 2006), very few farmers remained within their standard farm system in this year. For this reason, analysis of standardised farm systems will be based upon data relating to the 2011/12 dairy season.

#### **4.4.4 Regional analysis**

Given varying soil conditions, specific natural resources, social and cultural influences, the impact of environmental regulation on a dairy farmer is varied from region to region. Although each regions regulation is underpinned by the National Policy Statement for Fresh water, the specific environmental performance indicators and policy prescriptions are implemented by each Regional Council. For the purposes of analysing the cost of compliance, this research focused farms within the Waikato region where the same regulatory requirements are set equally across all farms.

#### **4.5 Methodology Summary**

The aim of this research is to determine the comparative cost of environmental compliance for New Zealand dairy farm systems. A multi-paradigmatic approach is undertaken using both a post-positive and pragmatic research paradigm. This is justified through the axiological component of environmental agricultural economics and the need to consider the subjective implications of environmental regulation. The complexity of New Zealand farm systems is best analysed through the use of case study design. A multi case approach is used to compare and contrast three farm systems of low, medium and high input. Both quantitative and qualitative data will be collected for the basis of this analysis through an exploratory mixed methodology.

## **5.0 Environmental Regulation**

The limited availability of natural resources and the need to ensure their sustainability has been the key driver of increased environmental regulation in New Zealand (Doole et al., 2013; Moynihan et al., 2014; Valentine et al., 2007). Due to the scale and nature of the dairy industry, much of the increased regulatory constraints are relevant at an on-farm level. Therefore, these regulations require understanding and importantly action from the dairy industry and individual farmers to become compliant. Water quality and allocation regulation forms the majority of environmental regulation for dairy farmers. By nature, the negative environmental impacts of dairy are intangible and challenging to measure, adding to the difficulty in both proving the necessity for regulation and the benefits once implemented. This chapter discusses the legislative framework in which environmental regulation is administered as well as the justification and specific implications of existing regulation for dairy farmers.

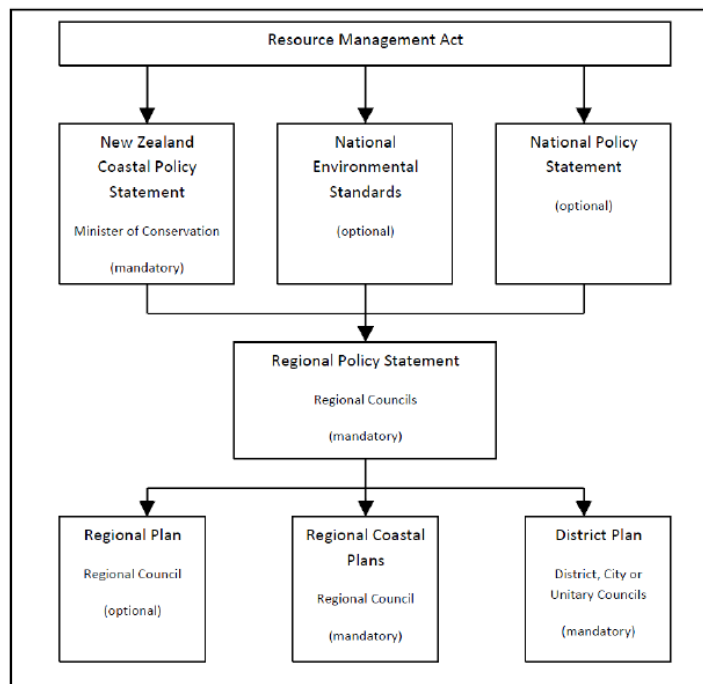
### **5.1 The Resource Management Act (1991)**

Within New Zealand, the Resource Management Act (RMA) is the main body of legislation which sets out how to best manage the interaction of society and industry with the environment. When enacted in 1991, the RMA replaced 78 statutes and regulations whilst amending others to form a single piece of legislation with regard to the management of land, water and soil within New Zealand. The core objective of the RMA 1991 is to ensure the sustainable management of all natural and physical resources. Sustainable management is defined by the RMA 1991 in section 5(2) as “managing the use, development and protection of natural resources in a

way or at a rate which enables people and communities to provide for their social, economic and cultural wellbeing and for their health and safety while...”

- a) Sustaining the potential of natural and physical resources (excluding minerals) to meet the reasonably foreseeable needs of future generations;  
and
- b) Safeguarding the life-supporting capacity of air, water, soil and ecosystems;  
and
- c) Avoiding, remedying or mitigating any adverse effects on the environment.’

As a large and overarching legislation, the way in which the RMA (1991) is broken down and managed by central and local government is important. Figure 5.1 details the framework through which the RMA (1991) is implemented.



**Figure 5.1 Framework for implementing the Resource Management Act (1991)**  
Source: McHaffie 2012

The RMA (1991) classifies the interactions of society and industry with the environment into six categories: permitted, controlled, restricted discretionary, discretionary, non-complying and prohibited. Rules within regional and district plans determine the classification of each activity, such as disposal of farm dairy effluent to land, on a case by case basis. Resource consents are required for controlled, restricted discretionary, discretionary and non-complying activities. Naturally, resource consents may not be granted for prohibited activities. The process for obtaining resource consent includes a full assessment of effects of the proposal on the environment within the above sustainable management framework. “When considering applications for resource consents, the focus is on evaluating the 'actual and potential effects on the environment of allowing the activity’” (Environmental Defence Society, 2014).

Under the RMA 1991, enforcement mechanisms are granted to regional and local authorities. Such measures include enforcement orders made by the environment court at a regional level or abatement notices at a local level. In the case of the dairy industry, there is emphasis placed on local regulators to work with farmers on farm to prevent such issues worthy of enforcement via abatement notice. As the dairy industry transitions from a non-controlled industry to a highly regulated industry there has been lenient enforcement of regulation from regional authority. Increasingly, understanding of the regulatory environment by industry and sufficient abatement periods will see an increased pressure placed on dairy farming to adhere to full compliance standards with the full force of any penalty imposed for those who have not yet actioned changes to their farm system.

## 5.2 National Policy Statement

“National policy statements enable central government to prescribe objectives and policies on resource management matters of national significance” (Environmental Defence Society, 2014). Such statements guide subsequent decision-making under the RMA 1991 at the national, regional and district level. As defined within the RMA 1991, a National Policy Statement can be used to provide general direction or to impose nationwide limits and restrictions.

A recent and significant National Policy Statement which is driving increased regulation for the dairy industry is the National Policy Statement for Freshwater. Through the National Policy Statement (NPS) for Freshwater 2011, central government have issued the revised call for regional authorities to monitor with consistency and clarity the quality and quantity of all freshwater as dictated under the Resource Management Act 1991. The NPS for Freshwater 2011 has imposed a national requirement for the monitoring and restricting of non-point and point source pollution of fresh water bodies as well as restricting the amount of water able to be abstracted from rivers, lakes and aquifers. Notably, a core objective of the NPS for Freshwater is to manage water quality and quantity in a manner which fosters future economic growth (New Zealand Government, 2011). Within this regulatory framework there is scope for each regional council to implement catchment specific plans which best integrate the needs of water users, society and other regional objectives with the objectives of the NPS. Under the NPS regional councils are required to have limits regarding quantity and quality in place by 2015, or formally set out a program to have such limits in place by 2030. As a result of this regional flexibility, the dairy industry nationally is in a position where

environmental regulation, specifically environmental thresholds are varied by region and by enforcement date.

### **5.3 Waikato Environmental Regulation**

Within the Waikato region, environmental regulation is administered through the regional plan as a function of the RMA and NPS for Freshwater. When compared to other New Zealand regions, the Waikato region has moderate environmental controls with nitrogen limits pertaining to only specific and sensitive catchments. This stated, the implication of strict regulation in both Canterbury and Horizons region will significantly influence further development of such policy for the Waikato region. With the central government requirement for cleaner water under the NPS, a limits based regulatory framework will be the reality for dairy across the region. Currently Waikato has regulation in place to monitor water takes from surface and ground water through Variation 6, the correct storage and application of effluent as well as catchment specific nitrogen leaching limits through Variation 5. The following evaluates such policies and discusses the on farm implication with regard to management and farm profitability.

### **5.4 Variation 6**

“The Waikato Regional Council considers the promotion of water use efficiency to be an important resource management issue. Decisions by councils regarding water takes are becoming increasingly focused on promoting the efficient use of water. That is, ensuring that when water is allocated it is for a justifiable purpose and the quantity taken represents a reasonable allocation for the proposed use.”

Variation 6 pertains to the allocation of fresh water within the Waikato region. The variation became operative on Tuesday, 10 April 2012 as a result of an Environment

Court hearing in which the court ruled to uphold the proposed changes to water policy in the Waikato region (Environment Court, 2011). The Variation 6 water policy has several factors that have imposed changes to dairy farming businesses in the Waikato. Variation 6 states “any taking of ground water for the purposes of milk cooling and dairy shed wash down is a controlled activity” and subject to new regulation. New regulation under the variation allows dairy farms to take 15 cubic metres of water a day for use in the dairy shed, anything above that requires resource consent. A key implication of the new regulation is the way in which WRC will determine water allocation per farm over and above the 15 cubic meters. The variation states “the net amount of ground water taken is proven to be the same or less as was occurring prior to October the 15<sup>th</sup> 2008”. This quantity will be determined based on a water volume per cow basis. The volume per cow is set at 70 liters. Using these figures, all dairy farms carrying over 215 cows will be drawing more than the 15 cubic meters and therefore subject to the application for water consent. In order to gain access to this water allocation, Waikato dairy farmers are to file an eight page water allocation application form. This information is processed under the RMA. An initial deposit of \$500 dollars is required on submission to council. An unspecified value will be further billed to farmers. Industry data suggests 3500 of the region's dairy farmers will be required to gain consent for their dairy shed water take before January 1, 2015. Dairy farmers will need to comply with the above dates so as to avoid increased processing cost and the risk of failing to achieve compliance.

A second implication of the variation is riparian Vegetation Management. For the many farms which take surface water for use in the milk cooling or wash-down, the variation requires a fencing and planting plan as part of the initial consent process.

Waikato Regional Council has made exemptions to assist farmers, suggesting all fencing to be completed within three years to a permanent standard and vegetation planting to be commenced during the 15 year duration of the consent. The rationale behind this aspect of the regulation is sound in that fencing and planting excludes stock from waterways, thus reducing pollution from stock and improving overall water quality. However this imposes several costs and ongoing issues for farmers. It is estimated that the cost of permanent fencing is \$8 per meter.

## **5.5 Variation 5**

Variation 5 is a catchment specific regulation regarding the water quality of Lake Taupo in the southern Waikato catchment. Lake Taupo is New Zealand's largest lake and is regarded highly for its natural capital including clear water quality and biodiversity.

A nutrient budget prepared for the lake Taupo catchment has estimated the loading of N from both natural and human sources to be 1360 tonnes per year (Waikato Regional Council, 2010). Studies regarding water quality and nutrient output have determined that a minimum 20 percent reduction in nitrogen output is required within the catchment to ensure water quality is maintained at current levels (Hamilton & Wilkins, 2004). This is due in part to the time delay between land and lake.

Variation 5 is Waikato Regional Council regulation drafted under the Waikato Regional Plan. The variation was proposed in 2005 and became operative in July 2011 in accordance with core regional and central government objectives under the National Policy Statement for Freshwater. The objective of Variation 5 is to avoid catchment-wide increases of nitrogen leaching from surrounding land uses.

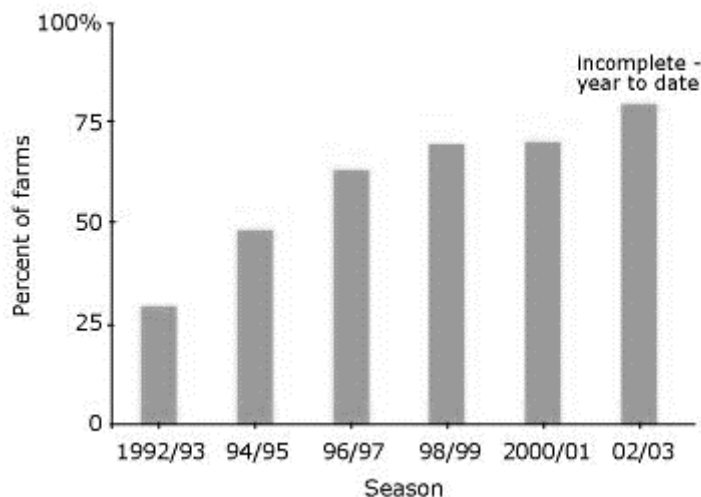
The primary regulatory measure under Variation 5 is the necessity for all farming activities within the catchment to gain resource consent through the use of annual nitrogen leaching limits termed Nitrogen Discharge Allowances. Under variation 5, agriculture and specifically dairy becomes a consented activity requiring farmers to seek approval for a consent to continue farming. Within this consent process, farmers will be required to prove their farming operation abides within the acceptable Nitrogen Discharge Allowance.

Nitrogen Discharge Allowances are calculated via grand parenting based on the single year between 2001 and 2005. For the year selected nutrient budgets determine a level of N output with regard to the stock units farmed from which the allowance is granted. Nitrogen Discharge Allowances, once granted are tradable units between farms. That is if a given farm decides to alter current practices so that nitrogen loss is below the level consented, the farm can sell the discharge allowance to another farm within the catchment. Further, leasing of discharge allowances is another form of transaction associated with the allowances for farmers to balance the needs of their farm and their financial situation under restriction.

The implementation of Variation 5 in the Taupo catchment is serving to both mitigate nitrogen leached to the lake as well as giving the Regional Council scope to establish a successful nitrogen discharge allowance policy. The learnings and efficiencies of Variation 5 will likely shape the implementation of all future discharge policies in the Waikato region.

## 5.6 Effluent Storage and Application Requirements

The management of farm dairy effluent is a high priority for farmers and regulators seeking to lift the environmental performance of the dairy industry. In the Waikato 90 percent of farms discharge effluent to land in compliance with the permitted activity rule. The remaining 10 percent of farms hold current consent to discharge treated effluent to a water body (Waikato Regional Council, 2014a). Historically, effluent management in the Waikato has been via discharge to water. Figure 5.2 shows the progression of Waikato farms moving to land based disposal of effluent.



*Figure 5.2 Percentage of Waikato farms with discharge to land*  
Source: (Waikato Regional Council, 2014a)

From a practical perspective, district councils have authority under the RMA to control the location and guidelines for effluent storage facilities. Furthermore, from the food safety aspect of dairy effluent treatment, dairy companies such as Fonterra are active in setting standards for farmers with regard to both storage and application of effluent.

Heubeck, Nagels, and Craggs (2014) found a large variation in on farm effluent volume between similar farming systems. Their report concludes different on-farm

management techniques have a greater influence the volume of effluent produced, the quality and overall environmental impact than cow numbers. An implication of this is the incorrect use of stocking rate, cow numbers or farm size as a proxy to determine effluent storage.

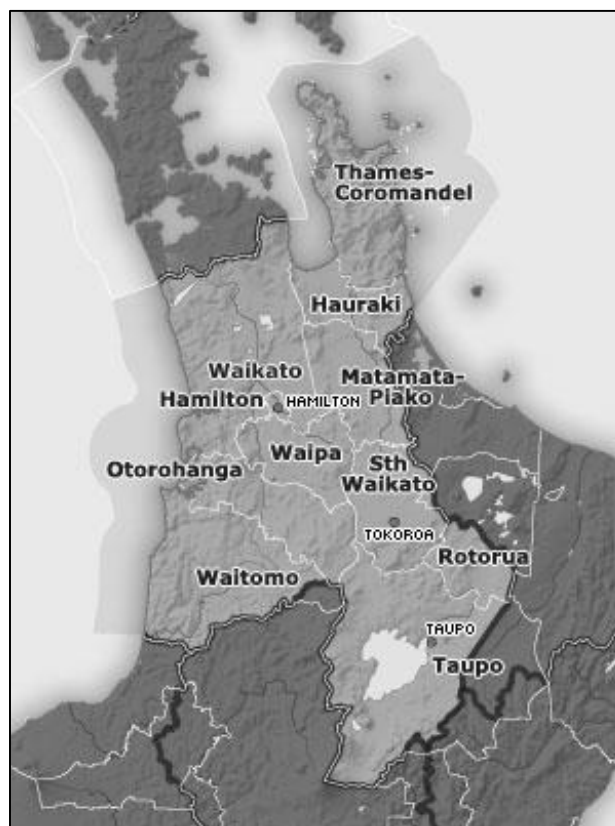
The specific regulations regarding effluent as set out by the Waikato Regional Council state, "...no more than 150 kilograms of nitrogen can be applied per hectare per year". Each effluent application must not be more than 25 millimeters deep. For effluent applied at 25mm being 0.04 percent nitrogen, the 150kg per hectare target is reached with 1.5 applications. Further all ponds and storage facilities must be proven to be sealed and guaranteed to not leak.

Regarding the application of effluent to land, the regulation stipulates effluent must not run off the land into waterways. Further effluent must not pond on the land surface after application. The farmer/contractor must spread effluent and sludge in a way that reduces odour and spray drift and have a contingency measures in place in case there is prolonged wet weather or a pump breaks down. If asked by Waikato Regional Council, the person or contractor applying the effluent must be able to show that they have met the above conditions.

A lack of existing effluent infrastructure on Waikato dairy farms has caused a significant emphasis from Regional council to get farmers compliant with the applicable guideline.

## 6.0 Waikato Farming Systems

The Waikato region covers an area of 2.5 million hectares (Figure 6.1) (Waikato Regional Council, 2014b). Within this area are nationally significant and sensitive natural resources with over 100 lakes, including New Zealand's largest lake, Lake Taupo. Additionally the Waikato River spans the length of the region, notably through key dairy farming areas. Average annual rain fall ranges from 900mm through 1600mm across the region.



*Figure 6.1 Map of the Waikato Region*

The Waikato region has New Zealand's highest concentration of dairy cows at 24.6 percent of the national herd. Across the region there are 3,554 dairy herds, 30 percent of the national herds. The average Waikato herd size is 323 cows (2012/13 season). These statistics represents smaller herd sizes and more individual suppliers when compared to other large dairy regions such as North Canterbury with just 788

herds and an average herd size of 791 cows. (DairyNZ, 2012). The Waikato has the highest number of owner operator herds at 33 percent of total herds in the region compared to just 9 percent and 10 percent in Canterbury and Southland respectively. Comparatively, the Waikato region has the highest stocking rate for the North Island at 2.94 cows per hectare, however it is below the Canterbury average of 3.5 cows per hectare. Overall, Waikato dairy farmers occupy 390,211 hectares of land. For an individual region this is a significant amount of land and almost 100 percent more land than the next largest dairying region of Southland. The implication of this large area from a regulatory perspective is the challenge of introducing per hectare nutrient benchmarking. In net terms the Waikato region as a catchment is dealing with significant nutrient transfer volumes. From a regulatory perspective, the greater number of individual farm in the Waikato region requires further effort and management of the compliance process as a greater number of individual farmers move to comply with the regulation. A further implication with smaller Waikato farms is the relative cost of compliance spend in relation to the farm value and the loss of economies of scale to implement suitable mitigation infrastructure. Farmer demographic and business ownership structure are also defining factors to the profile of Waikato farming business when considering the implications for compliance. Farm ownership within the Waikato is predominately family farming businesses with farmers generally in an older age bracket when compared regions such as Canterbury with a high representation of larger corporate ownership businesses and a younger farmer demographic.

The following details the physical and financial characteristics of a low, medium and high input average Waikato farm system. (Refer table 6.1, 6.2 & 6.5)

### **6.1 Low input ( DairyNZ System 1 & 2)**

Low input farming systems are classified by DairyNZ as either a system one or system two. System one farms are termed all grass farms implying no additional feed is used to supplement the cow's diet. Further that none of the herd is grazed off the milking platform during winter months. Dairy statistics suggest system one farming systems are 10 to 15 percent of owner operator farms nationally. Increasingly, systems one farming operations are declining due to the opportunity cost of increased production through supplementary feeding as well as significant difficulties maintaining the system through severe weather events and loss of pasture by infestation through pest such as Black Beetle.

System two farms represent 22 to 27 percent of owner operator herds nationally. Within this system, additional feed is purchased to cover a deficit in pasture supply over winter months. Approximately 4 to 14 percent of the total diet consists of imported feed and is fed to dry cows only, including dry cows wintering off the milking platform.

The average "low input" Waikato dairy farm is 121 hectares in size and has 17 ha of dairy support block. Notably, 43 percent of the milking land area is identified as being at a different height to the milking shed. Peak cows milked are 353 cows giving a stocking rate of 2.9 cows per hectare. Farm milk solid production totalled 131,316 milk solids, or 372 milk solids per cow. Average milk solids per cow per day totalled 1.4 solids for 259 days in milk. N applied per hectare is 113 kg/N or 245 kg of urea fertilizer. Aggregate financial data for the low input systems within the North Island show operating expenses of \$4.44 per kilogram of milk solid. Per hectare operating expenses totalled \$4,020 and expressed per cow \$1,561. For the 2011/12 dairy season the above cost structure gave low input farms an operating

profit of \$2.82 per kilogram of milk solid produced, and a \$2,551 per hectare operational surplus. Naturally, the variability in earnings for low input systems is greater as a function of seasonal variation. Comparing between the 2011/12 dairy season and the severe drought of 2012/13, operating profit for low input systems fell by an average of 30 cents per kilogram of milk solid after factoring for payout variation. This is compared to only an average 20 cent per kilogram drop in operating profit for medium and high input North Island systems.

### **6.2 Medium input (DairyNZ System 3)**

System three farms, described as medium input farms are the most common dairy system in New Zealand representing 35-40 percent of owner operator farms. Within a system three farm, approximately 10-20 percent of the total feed is imported into the milking area and used to extend lactation beyond that dictated by the pasture growth curve as well as for wintering dry cows.

In the Waikato, the average system three farm determined from a sample of 33 farms in the 2011/12 season was 147 hectares. System three farms were identified as having significantly less area available as dairy support block as a percentage of the milking platform when compared to both low and high input farm systems. A similar stocking rate to low input systems of 2.9 cows per hectare is observed for the system three farms. Gains in production from imported supplement feeds lift production per cow to an average production of 388 kgMS per cow and 1,141 kgMS per hectare. This is an increase from the low input system of 4 percent and 5 percent respectively. Nitrogen used per hectare was 122kg annually, 8 percent above the

low input systems. Imported feed eaten in a medium input system is 1.9 tons per hectare of 663kg per cow. Most significantly, system three farms have greater dependence on on-farm dry matter production through crops. System three farms have greater areas in grazed winter and summer crops as well as harvested crop. The net result of this area out of the grazing platform is an increase in effective stocking rate. This is generally noted with 5 percent less of the effective farm area being harvested for hay or silage. For the average Waikato medium input farm, kilograms of milk solid produced per full time labour equivalent is 10 percent higher compared to lower input farms at 58,000 kgMS. Financial benchmarking of 129 North Island medium input farms shows operating expenses of \$4.81 per kilogram of milk solid, an 8 percent increase in cost from low input systems on a per kilogram of milk solid basis. Operating expenditure per hectare of \$4,920 represents a 22 percent increase compared to low input farms. Per cow operating expenses increased 14 percent moving between a low input system to a medium input system. Profitability with the 2011/12 season at a \$6.70 milk price show operating profit of \$2.48 per kilogram of milk solid produced, \$2,533 operating surplus per hectare and a per cow profit of \$913. Notably this represents a worse state of profitability compared to low input systems, whereby the additional price of feed inputs exceeded the marginal revenue generated through milk production. Operating profit for the medium input system was 12 percent, 1 percent and 8 percent lower respectively across per kilogram of milk solid, per hectare and per cow measures.

### **6.3 High Input (DairyNZ Systems 4 & 5)**

High input systems encompass DairyNZ classified systems four and five. High input farms are generally classified as intensive by nature of the greater production and greater stocking rate achieved with additional feeding practices.

System four farms represent 20-25 percent of owner operator farms nationally. In this system, imported supplementary feeds are used to extend both ends of the lactation creating high volumes of shoulder milk.

For a system five farm, at least 30 percent of the cow's diet is imported supplementary feeds. Supplement is fed year round to boost production and condition score. System five farms represent 7-12 percent of owner operators nationally. At this level of input it is common for these farms to operate autumn calving or split calving systems. Further, diet is often manipulated to optimise the nutritional requirements of the cows.

High input farms within the Waikato are generally larger farms combined with a larger area for a support block. High input farms necessitate investment in feeding infrastructure such as concrete feedpads or housing. This enables a higher stocking rate of 3.2 cows per hectare. By nature, this stocking rate and heavier cows, liveweight per hectare increases to 1,530kgs up from 1,330kgs in both low and medium input systems. With a higher stocking rate, greater use of nitrogen fertilizer is required to maintain the pasture component of the diet. Nitrogen fertilizer use was 135kgN/year for high input farms compared to 113 and 122kgN/year for low and medium farms respectively. Production within high input systems is significantly increased to 1,404kgMS/ha and 445kgMS/cow. At this production

level, cows in a Waikato system five farm milk 92 percent of their bodyweight. The average level of supplement imported is 4.8 tons per hectare, 138 percent greater than in a system three farm. Of note, a 30 percent reduction in area harvested for hay or silage occurs in a high input system as there is a closer correlation between pasture supply and demand. Financially, higher input systems have a 33 percent increase in total operating expenditure per hectare however per kgMS this increase is only 4 percent. Operating profit increases 24 percent per hectare compared to the medium input system however analysed per kgMS, operating profit dropped 4 percent compared to the average system three farm.

Table 6.1 Multiple year, multiple system: physical benchmark

Waikato Region	Units	Low Input		Medium Input		High Input	
		42 Farms	34 Farms	33 Farms	51 Farms	33 Farms	45 Farms
		2011/12	2012/13	2011/12	2012/13	2011/12	2012/13
<b>Farm physicals</b>							
Milking platform	ha	121.4	171.4	147.9	212.5	202	130
Support block eff.	ha	17	29.7	6.9	11.3	32.3	24.8
Percent of farm at different height to dairy		43%	26%	13%	15%	31%	21%
Peak cows milked		353	478	434	573	640	430
Stocking rate	cows/ha	2.9	2.8	2.9	2.7	3.2	3.3
Average cow liveweight	KG	458	462	458	466	484	484
Liveweight/Ha	KG	1332	1290	1345	1256	1529	1599
Nitrogen applied per year	KG	113	117	122	138	135	141
<b>Production</b>							
Milk solids/ha	MS/ha	1083	809	1141	911	1404	1426
Milk solids/cow	MS/cow	372	290	388	338	445	432
Milk solids/ha to 31st Dec	MS/ha	633	581	687	342	801	908
MS as % of Liveweight		81%	63%	85%	73%	92%	89%
10 day peak per cow	MS/Cow	1.9	1.84	1.9	1.95	2.01	2.01
Average milk solid per cow per day	MS/Cow/Day	1.4	1.3	1.5	1.5	1.7	1.9
Days in milk per cow	days	259	218	262	224	256	231
<b>Feed</b>							
Pasture & crop eaten		13.5	11	12.3	10.2	12.6	12
imported supplement eaten	t DM/ha	0.8	0.8	1.9	2.2	4.8	5.7
imported supplement eaten	kgDM/cow	289	301	663	806	1525	1725
Farm area in grazed winter crop	ha	1	6.6	2.6	1	11.4	2.6
Farm area in grazed summer crop	ha	3.2	2.9	7	3.3	8.5	3
Farm area in harvest crop	ha	2.5	1.8	3.3	5.2	3.6	5
Percent of farm harvested for hay or silage		25%	15%	20%	13%	14%	10%
<b>Labour</b>							
Cows per Labour unit	cows/FTE	147	165	155	174	187	143
MS/Labour Unit	kg/FTE	54,753	47,802	60,262	58,647	62760	61,815

Table 6.2 Multiple year, multiple system: financial benchmark

North Island	Units	Low Input		Medium Input		High Input	
		119 Farms	25 Farms	129 Farms	70 Farms	33 Farms	56 Farms
		2011/12	2012/13	2011/12	2012/13	2011/12	2012/13
<b>Farm Financials</b>		\$	\$	\$	\$	\$	\$
Milk price	<b>\$/kgMS</b>	6.69	6.20	6.71	6.33	6.82	6.43
Gross Farm Revenue	<b>\$/kgMS</b>	7.40	6.80	7.29	6.92	7.38	6.99
Total Operating Exp.	<b>\$/kgMS</b>	4.44	4.89	4.81	5.03	4.99	5.23
Total Operating Exp.	<b>\$/ha</b>	4,020.00	4,072.00	4,920.00	5,065.00	6,564.00	6,233.00
Total Operating Exp.	<b>\$/cow</b>	1,561.00	1,525.00	1,774.00	1,764.00	2,135.00	2,174.00
Operating Profit	<b>\$/kgMS</b>	2.82	1.91	2.48	1.88	2.39	1.76
Operating Profit	<b>\$/ha</b>	2,551.00	1,588.00	2,533.00	1,896.00	3,153.00	2,098.00
Operating Profit	<b>\$/cow</b>	991.00	595.00	913.00	660.00	1,026.00	721.00

Table 6.3 Operating profit per hectare for Waikato farm systems

Operating profit per hectare in \$								
	Best	95th	75th	Mean	25th	5th	Min	SD
Low Input	2833	2366	2025	1646	1266	925	466	829
Medium Input	2751	2129	1735	1363	989	602	-43	944
High Input	3180	1953	1366	927	487	-94	-1286	1441

Source: Principals of System Intensification, DairyNZ 2013

#### 6.4 Financial Sensitivity Analysis of Farm System Variables

Monte Carlo simulations of Waikato farming systems by Hedley, Glassey, Fisher, Newman, and Taylor (2014) show the large variance in farm financial data indicating the sensitivity of farm systems to the physical variables and the contribution that management ability makes to the farm systems results. This analysis further justifies the assumption that farms within the DairyBase data set a generally performing above the financial mean and are more commonly operating within the 75<sup>th</sup> - 95<sup>th</sup> percentile. Maximum operating profit per hectare is generated from the high input system, however the variance between the highest and the 95<sup>th</sup>

percentile demonstrate the increasing number of variables contributing to the profit. With regard to system intensification for financial efficiencies, A farmer with high management ability will profit moving from a medium input system to a high input system, however when moving from a low input system to a high input system will lose profitably. For a farmer operating at the ‘average management ability’ a significant loss in profitability is noted when moving between systems.

The implication of this for environmental compliance and the investment required to meet regulation means changing farm system by increasing the intensity to cover cost can result in a net loss of profitability if management ability is not factored into the calculation. Further, this simulation shows similar operating profits are achievable regardless of the farm system, in that a low input system is capable of returning comparative if not higher operating profits up to the 95<sup>th</sup> percentile. With regard to environmental performance, this analysis indicates there is scope for increased profitability and reduced impact by lowering the intensity of farm system.

Further this operating profit data is supported by analysis of Return on Assets (ROA) for Waikato farming systems, where Monte Carlo simulations using the same variables indicated higher return on assets for the low input farming system.

Table 6.4 Return on asset (percent) for Waikato farm systems

%	Best	95th	75th	Mean	25th	5th	Min	SD
Low Input	4.34	3.59	3.07	2.49	1.92	1.40	0.72	1.26
Medium Input	3.88	3.01	2.45	1.93	1.39	0.85	0.00	1.32
High Input	3.99	2.50	1.75	1.19	0.62	-0.12	-1.50	1.79

Source: (Hedley et al., 2014)

Table 6.5 Comparative system benchmarks 2010/11 season

Waikato Region	Units	Medium Vs. Low System %	High Vs. Medium System %
<b>Farm physicals</b>			
Milking platform	ha	22	37
Support block eff.	ha	-59	368
Percent of farm at different height to dairy		-70	138
Peak cows milked		23	47
Stocking rate	cows/ha	0	10
Average cow liveweight	KG	0	6
Liveweight/Ha	KG	1	14
Nitrogen applied per year	KG	8	11
<b>Production</b>			
Milk solids/ha	MS/ha	5	23
Milk solids/cow	MS/cow	4	15
Milk solids/ha to 31st Dec	MS/ha	9	17
MS as % of liveweight		5	8
10 day peak per cow	MS/Cow	0	6
Average milk solid per cow per day	MS/Cow/Day	7	13
Days in milk per cow	days	1	-2
<b>Feed</b>			
Pasture & crop eaten		-9	2
imported supplement eaten	t DM/ha	138	153
imported supplement eaten	kgDM/cow	129	130
Farm area in grazed winter crop	ha	160	338
Farm area in grazed summer crop	ha	119	21
Farm area in harvest crop	ha	32	9
Percent of farm harvested for hay or silage		-20	-30
<b>Labour</b>			
Cows per Labour unit	cows/FTE	5	21
MS/Labour Unit	kg/FTE	10	4

North Island	Units		
<b>Farm Financials</b>			
Milk price	\$/kgMS	0	2
Gross Farm Revenue GFR	\$/kgMS	-1	1
Total Operating Expenses	\$/kgMS	8	4
Total Operating Expenses	\$/ha	22	33
Total Operating Expenses	\$/cow	14	20
Operating Profit	\$/kgMS	-12	-4
Operating Profit	\$/ha	-1	24
Operating Profit	\$/cow	-8	12

## 7.0 Waikato Farm Systems – Nutrient Modelling

### 7.1 Introduction

Farm nutrient budgets were carried out using Overseer for the three average Waikato farm systems; low, medium and high input as defined in the above DairyBase analysis. The same input standards within Overseer have been used across each of the three farm systems. The resulting nutrient budget provides a comparative analysis for determining the nutrient efficiency of each farm system and the ability to benchmark performance across a range of environmental performance indicators. Efficiency of nitrogen cycling for the farm system is the primary measurement considered due to its use by several Regional Councils in a regulatory role. Measures include N leaching, N leaching efficiency, N conversion efficiency and N surplus. A sensitivity analysis shows the variation in nitrogen performance indicators over three typical Waikato soil types as well as the influence of variation in terrain.

The combined assessment of land with regards to soil type and terrain is best measured using land use capabilities (LUC) (Lynn et al., 2009). The LUC index ranges from LUC1 through LUC8 with LUC1 highly desirable as flat land with no climatic constraints through to LUC8 being steep terrain, high climatic constraints and limited applicability to dairy. This analysis considers the LUC from LUC1 through LUC4 a reflection of land predominantly utilised by dairy within the Waikato.

## 7.2 Assumptions

As a mixed model combining both mechanistic and empirical aspects (Rowarth & Edmeades, 2013), there is a clear need for accuracy in data input as well as in the back calculation assumptions of the model for Overseer outputs to have any degree of usefulness. Within Overseer multiple variations of “decision rules” (Pellows et al., 2013) can be used to drive a particular range of outputs. In this analysis, the default values were chosen, then change was made in one area of the model using the assumptions of scenarios typical of a Waikato farm while all other values were left the same. The results explore the sensitivity of both physical characteristic and management actions (Overseer inbuilt assumptions) to various data input fields with regards to N loss to water and N efficiency. Recognising that Overseer will model N lost through multiple channels, this analysis is concerned only with N lost to water, due to the emphasis of local government in monitoring and limiting the loss of N through leaching. The following assumptions have been followed with consistency across each of the average Waikato farm systems to provide accuracy in the results.

Input data required for the Overseer model was retrieved from Waikato DairyBase data (Table 6.1) and is gathered for the 2011/12 dairy season. DairyBase provides details of effective area, terrain, stocking rate, production, lactation length, nitrogen applied as well as supplementary feeding. Where required data for Overseer was not available through the DairyBase reports, data was generated from built in default values within Overseer combined with data from DairyNZ dairy statistics for the Waikato region. Where no published data regarding averages were present, a best practice, best management scenario was used consistently to enter farm data for the three farm systems.

Sandy Loam, Peat and Clay based soils were modelled to give a range of soils typical of Waikato dairying land. Typical soil test values have been used for each farm scenario and populated using the default settings of Overseer. No lower soil profile characteristics were defined. Drainage characteristics for the soils were assumed to be well draining with occasional susceptibility to pugging. No artificial drainage such as mole and tile was used in this analysis.

Modelling the sensitivity to terrain is carried out for flat, rolling and easy hill contours with the exception of peat soils which are predominately of flat to rolling contour within the Waikato.

Initial climate data input assumes the nearest New Zealand town is Hamilton with an estimated distance to the coast of 80km. Annual average rain fall is set as 1250mm with low potential evapotranspiration (PET).

Modelling of the high input farm requires the addition of dairy infrastructure such as a feed pad to enable the high levels of feed input. An open concrete feed pad with cleaning via scraping was added into the modelling of the high input farm with sump and spray facilities used for the all farm dairy effluent generated. It was assumed cows were on the feed pad for two hours per day year round to receive the supplementary feed.

The effluent system modelled in the analysis was set for all three systems as a sump and spray irrigate system as opposed to holding pond facilities. Currently 90 percent of 4,600 Waikato farms discharge effluent to land in compliance with the permitted activity rule. (Waikato Regional Council, 2014a). It is assumed effluent is applied to 20 percent of the farm area at an application depth between 12 and 24mm. Importantly, this effluent area (20 percent of milking platform) is modelled in

Overseer as a separate 'block'. This enables the analysis to determine the nutrient loading specific to the application of effluent. Restricted nitrogen fertilizer was modelled for the effluent area in accordance with best practice and N input being no more than 150kg N per hectare including both N applied as effluent or Urea.

It is assumed the nitrogen fertilizer applied as recorded in DairyBase occurred in four applications, September, November and December and April with a maximum per application N loading of 46 kg per hectare (100kg Urea).

Modelling assumes no irrigation is used due to low number of farms with irrigation in the Waikato and the increasing water allocation restrictions under Waikato Regional Council Variation 6. The use of DCD nitrate inhibitor is excluded due to these products being currently unavailable to the market. No wetlands were modelled on the farms. Finally it was assumed that all cows are wintered on the milking platform and once a day milking is used only to dry cows off.

The N specific results of each farms nutrient budget are detailed in table 7.1.

Table 7.1 Overseer modelling of average Waikato farm systems

Low Input		KG N loss per Ha			NLE kgMS/Ha per kg N Loss/Ha			N conversion Efficiency %			Farm N Surplus kg N/ha/yr		
		Terrain			Terrain			Terrain			Terrain		
		Flat	Rolling	Easy Hill	Flat	Rolling	Easy Hill	Flat	Rolling	Easy Hill	Flat	Rolling	Easy Hill
Soil Type	Sandy Loam	33	28	28	32.81	38.67	38.67	33	33	32	170	176	179
	Peat	27	26		40.11	41.00		34	33		169	174	
	Clay	29	22	21	37.340	49.220	51.57	34	33	33	169	174	177
Medium Input		Terrain			Terrain			Terrain			Terrain		
		Flat	Rolling	Easy Hill	Flat	Rolling	Easy Hill	Flat	Rolling	Easy Hill	Flat	Rolling	Easy Hill
Soil Type	Sandy Loam	30	27	27	38.00	42.00	42.00	35	34%	34	168	173	176
	Peat	26	26		43.88	43.88		35	34		166	171	
	Clay	28	22	21	40.75	51.00	54.33	35	34	34	166	171	174
High Input		Terrain			Terrain			Terrain			Terrain		
		Flat	Rolling	Easy Hill	Flat	Rolling	Easy Hill	Flat	Rolling	Easy Hill	Flat	Rolling	Easy Hill
Soil Type	Sandy Loam	35	33	33	40.11	42.54	42.54	35	35	35	199	204	207
	Peat	31	33		45.29	41.29		36	35		195	203	
	Clay	32	27	26	43.87	52.00	54.00	36	35	35	196	199	201

### 7.3 Overseer Output

In modelling three Average Waikato farm systems, the comparative N loss results between farms using theoretical Waikato farm system data are consistent with expectations based upon existing research e.g. (Ledgard et al., 1998) in that as stocking rate and feed input increase, the environmental impact monitored through N cycling performance indicators increases. Notably, the nitrogen leaching efficiency, that is the milk solids produced per kg of N lost, increases in linear fashion as the farm system moves from low to high input, thus reflecting the efficiencies of higher input feed systems with regard to output. However there is a notable increase in total farm N surplus per hectare moving from a low to a high input system.

The results from this analysis do deviate from what is expected with regard to the comparisons between the low and medium input systems. In this analysis, N leaching for the medium input system was below the level noted for the low input system. This is a reflection of the input data collected through DairyBase and can be attributed to the relatively low average stocking rate for a medium input system as noted in table 6.1 and further the use of maize silage as a low protein feed relative to grass. These results do however indicate that in certain scenarios as modelled above, medium input systems are more efficient at converting input N into product N and as a result leach a lesser amount of N when compared to low input systems.

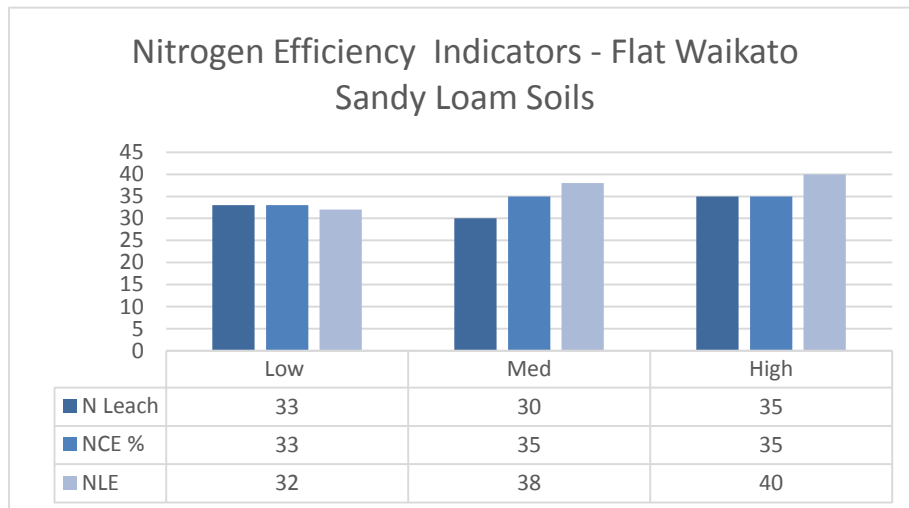
In analysing the average farm systems, N leaching declined across all farm systems as terrain moved from flat to rolling and flat to easy hill country. This is consistent with expectations in that rolling and easy hill country is less susceptible to N leaching as a result of soil characteristics and interaction with the water table.

Results of the sensitivity analysis show soil type to have a lesser impact on N lost to leaching as the farm system becomes more intensive. For a low input system the sensitivity to soil type between the three soils was 6 kg N/ha difference (range 27-33). This result contrasts with both the medium and high input systems where the difference in kg N/ha leached is 4 kg for each system.

The use of a dairy feed pad as modelled for the system four and five high input farm limited the increase the N leaching despite the increase of N imported to the farm system through supplementary feed. The use of a feed pad was modelled for an average of two hours use per day, capturing a portion of the high N concentration effluent, and hence N, previously deposited on the pasture. The even distribution of this effluent through a spray and sump system reduces the N leaching potential associated with concentrated deposits from the cow within the paddock and therefore reduces N loss for the farm system. Total N loss per hectare does not increase significantly for the high input system when moving from medium input to high input.

### 7.3.1 Sandy Loam Soils

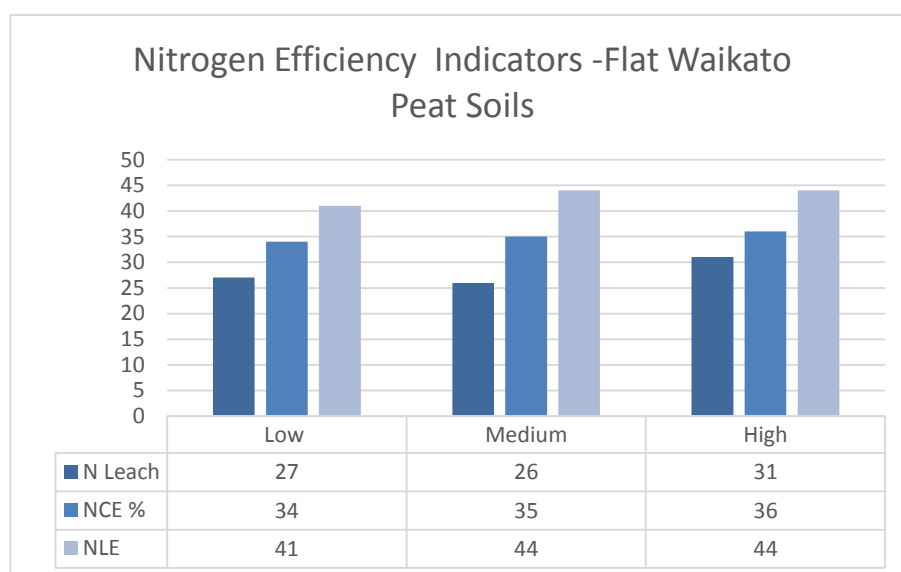
For flat sandy loam soils the comparative N leaching between low (33), medium and high input (35) systems was just 2 kilograms of N per hectare. The low input system produced 32 kgMS per kg of N leached while the high input system produced 40 kgMS. The comparative efficiency between the low intensity and medium intensity system was eight kgMS per kg N leached while between the medium and high input system only two kgMS. Overall the farm N surplus increased from 170 kg N hectare per year under a low input system to 199 kg N per hectare per year under a high input system.



**Figure 7.1 Nitrogen efficiency indicators - sandy loam soils**

### 7.3.2 Peat Soils

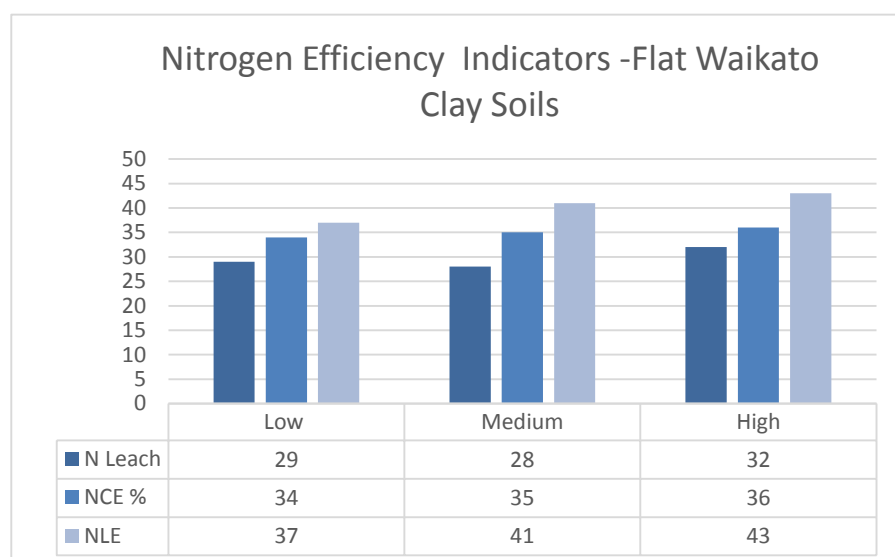
The Waikato Peat soils gave significantly lower levels of N leaching across all three farm systems. In peat soil the variability in N leaching was just 5 kg between low, medium and high input systems. Similar to the sandy loam, leaching decreased under a medium input system comparative to the low and high input system. Nitrogen leaching efficiency increase consistently as system intensity increased from 40 in the low input scenario to 43 in a high input system. This is reflected in the nitrogen conversion which increases linearly moving from a low to high input system indicating the efficiency gain through balancing diet using low protein feeds. Farm N surplus per hectare increased from 170 kg to 195 kg, however not to the same extent as under sandy loam soils.



**Figure 7.2 Nitrogen efficiency indicators – Peat Soil**

### 7.3.3 Clay Soil

For clay soil profiles, nitrogen losses under each farm system were above losses in peat soils, yet significantly below sandy loam soils. Notably, in modelling clay soils the range between nitrogen losses was the least, increasing by only three kilograms of nitrogen per hectare when moving from a low to a high input system. By nature of stable leaching rates and comparative farm system output, the nitrogen leaching efficiency increases significantly from 37 to 43 kgMS per kg nitrogen lost moving between a low and a high input system.



**Figure 7.3 Nitrogen efficiency indicators – Clay Loam Soil**

## 7.4 Financial, Physical and Environmental

The comparative profitability with regard to environmental performance of Waikato farm systems can be shown through operating profit as a function of N leaching. Expressed as dollars per hectare, the profitability per unit of N leaching ranges from \$82.29 per kgMS to \$92.74 for the average Waikato farm system.

Table 7.2 Summary of operating profit versus Nitrogen efficiency

		Low	Medium	High
Operating Profit	\$/kgMS	\$2.82	\$2.48	\$2.39
Operating Profit	\$/ha	\$2,551.00	\$2,533.00	\$3,153.00
Operating Profit	\$/cow	\$991.00	\$913.00	\$1,026.00
OP/N leaching	\$/kgMS	\$82.29	\$87.34	\$92.74
N leaching	kg/ha	31.00	29.00	34.00
NLE	kgMS/kgN leached	34.5	39.5	41.5

While the efficiency with regard to profit increases in a linear fashion indicating high input systems are desirable, the total N leaching per hectare is comparatively three kg/ha (10 percent) higher - being worse for the environment.

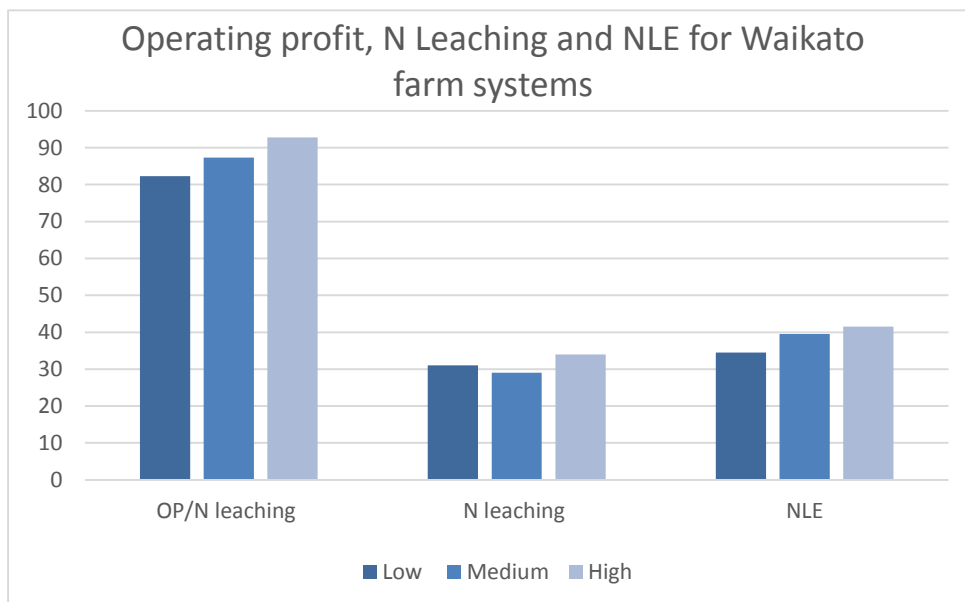


Figure 7.4 Operating profit versus N leaching

Table 7.3 Summary statistics for average Waikato farming systems

	<b>Low Input</b>	<b>Medium Input</b>	<b>High Input</b>
<b>N leached /ha</b>	22	33	30
<b>Stocking Rate</b>	2.9	2.9	3.2
<b>Nitrogen Used</b>	113	122	135
<b>Operating Expenses/ha</b>	\$4,020	\$4,920	\$6,564
<b>Operating Profit/ha</b>	\$991	\$913	\$1,026

The relative cost associated with moving the above analysed average farm systems to full compliance is assumed to be similar for each of the farm systems. The range in N leaching between the average low and high input systems 10 kg N indicating the mitigation strategies involved in reducing N leaching on each of the farm systems would incur a similar cost. Based on the financial information, the cost is most likely to impact on the business of the low and medium input systems as the relative operating profit per hectare is lower under these two farm systems.

## **8.0 Comparative Nutrient Modelling – The Same Farm with Varied Intensity**

An understanding of the average Waikato farming systems with regard to nutrient output shows there is a general link between farm system intensity and the rate of N leaching. To further understand the implications of farm system intensity on environmental performance there is a need to model nutrient outputs for a given physical farm under three scaled scenarios of low, medium and high input to give a truly comparative analysis of the nutrient losses and therefore a measure of environmental performance. To demonstrate the sensitivity of nitrogen leaching as a proxy for environmental performance of different intensity dairy farm systems a sensitivity analysis has been performed using the same physical farm under the parameters of three different farm systems of low, medium and high input. The results demonstrate the efficiency and performance of each farm system and the variances in farm system performance.

Table 8.1 details the standardised farm parameters and assumptions used to model the three farm systems. A farm system, being 100 hectares of Horotiu Silt Loam has been modelled under three scenarios of 290, 350 and 410 cows representing stocking rates of 2.9, 3.5 and 4.1 cows per hectare. Supplementary feed input has been altered for the systems to give supplement feed as a percentage of total diet of 5 percent, 20 percent and 35 percent respectively to fit within the Hedley et al. (2006) farm system descriptions of low, medium and high input. The comparative stocking rate (kg Liveweight/ tDM available) has been maintained consistent across the three systems ranging between 90 and 95.

Table 8.1 Standardised farm system parameters

	Low Input	Medium Input	High Input
<b>PHYSICAL</b>			
Farm Area	105	105	105
Effective	100	100	100
Contour	Flat	Flat	Flat
Soil Type	Horotiu Silt Loam	Horotiu Silt Loam	Horotiu Silt Loam
Rainfall	1250	1250	1250
Irrigated	None	None	None
Nitrogen Applied	120	150	150
<b>INFRASTRUCTURE</b>			
Feedpad- Concrete	No	yes	yes
Effluent	Sump and Pump	Sump and Pump	Sump and Pump
<b>ANIMALS</b>			
Peak cows Milked	290	350	410
Stocking Rate	2.9	3.5	4.1
CSR	92	95	90
Cow Breed	Crossbred	Crossbred	Crossbred
Cow Liveweight	470	475	485
Replacement Rate	23 %	23 %	23 %
Proportion Spring Calving	100 %	100 %	100 %
<b>FEED</b>			
Pasture grown	15000	15000	15000
Nitrogen Response Rate	10:1	10:1	10:1
Pasture grown with N	16200	16500	16500
<b>IMPORTED SUPPLEMENT t DM/ha</b>			
<b>PKE</b>	0.8	1	3
Maize Silage		2	4
Grass Silage		1	1.7
% of feed imported	5 %	20 %	35 %
<b>PRODUCTION</b>			
<b>Milk solids</b>	110,200	140,000	184,500
kgMS/Ha	1102	1400	1845
kgMs/Cow	380	400	450
MS as a % of LWt	79%	82%	90%

## 8.1 Financial Modelling

Modelling of the base farm scenario through Dairy Feed Planer gives physical and financial implications of the base scenario farm under the low, medium and high input systems. Table 8.2 details the results of Dairy Feed Planner modelling. The results are consistent with trends noted in the earlier data collected and analysed through DairyBase.

Table 8.2 Financial modelling of standardised farm system

	Base Scenario		
	Low	Medium	High
<b>Operating Revenue</b>	\$741,054	\$904,996	\$1,207,505
<b>Operating Costs</b>	\$417,263	\$514,078	\$698,380
<b>Feed Costs</b>	\$39,850	\$135,733	\$276,658
<b>Profit</b>	\$283,941	\$255,184	\$232,468
<b>Return/ Ha</b>	\$2,839	\$2,552	\$2,325

Operating revenue was reported as a function of milk revenue at a \$6.50 payout and livestock income. Revenue increases significantly between the farm systems from \$741,054 to \$904,996 and \$1,207,505 for the low, medium and high input system respectively. Operating cost was assumed to be \$3.82 for the low and medium input system and \$3.89 per kgMS for the high input system resulting in operating costs of \$417,263, \$514,078 and \$698,380 for the systems respectively. Notably the increased production achieved as the systems intensified was at the expense of purchased feed. This resulted in an exponentially increasing feed bill moving between the farming systems. Feed cost based on current 2014/15 real costs totaled \$39,850 for the low input system, \$135,733 for the medium input system and \$276,658 for the high input system. Operating profit therefore was a reflection of

feed cost and reversed the trend noted with increasing revenue. Operating profit reported per hectare totaled \$2,839 for the low input system, \$2,552 for the medium input system and \$2,325 for the high input system.

## 8.2 Nutrient Modelling

Environmental performance modelling of the same farm under three different system intensities produced results similar to modelling of the average Waikato farm systems in that increases in the physical stocking rate resulted in higher N leaching. Unlike the average farm systems modelled in chapter seven, this analysis has modelled a farm in the upper limits of its respective system grouping. In relation to the Hedley et al. (2006) classification, the farm systems in this analysis relate to a system two, a high system three and a system five. Table 8.3 details the N specific results of the nutrient modelling.

Table 8.3 Nitrogen efficiency results of comparative system analysis

	<b>Low</b>	<b>Medium</b>	<b>High</b>
<b>N Leached</b>	32	43	47
<b>NCE</b>	34 %	32 %	34 %
<b>NLE</b>	34.43	32.55	39.25
<b>N Surplus</b>	170	231	273

This analysis shows that the low input system resulted in the lowest N leaching per hectare at just 32 kg N per hectare per year. Further, the low input system had an N conversion efficiency of 34 percent equal to the high input system, further demonstrating the efficiency of low input systems at converting N input to milk solids. Nitrogen leaching efficiency was 34.5 milk solids produced for every kg of

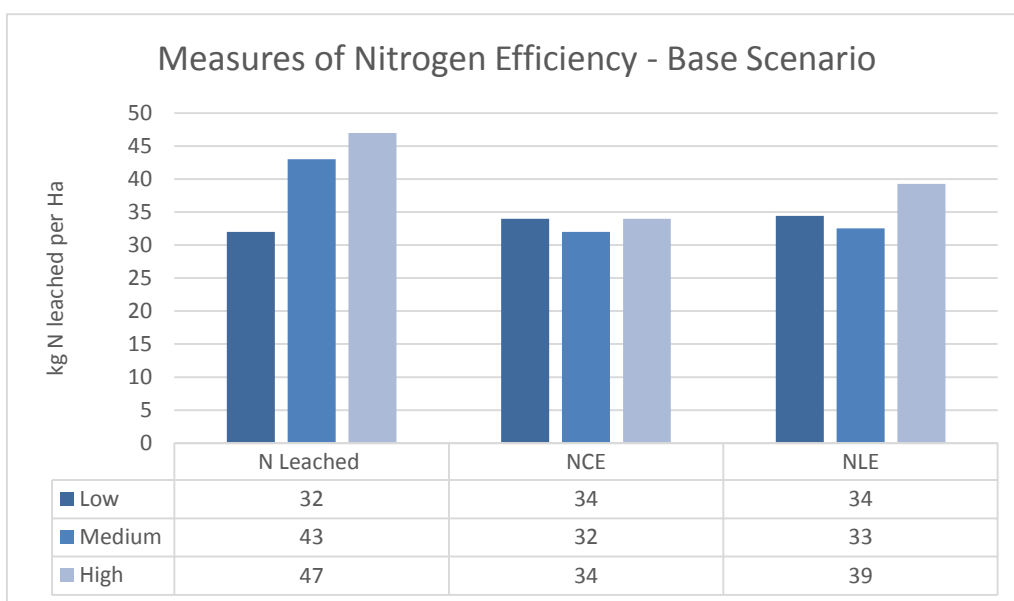
N leached. The lower stocking rate of 2.9 cows per hectare limits the system through both concentrated N urine spots and lower N fertilizer input. Overall the farm N surplus for a low input scenario was just 170 kg N per hectare per year.

Comparatively, increasing the stocking rate and feed accordingly to 3.5 cows per hectare and 20 percent imported feed, the N leaching increased to 43 kg N leached per hectare. While the comparative stocking rate remains unchanged, the physical increase in cow numbers results in an increase of 11 kg N loss per hectare compared to the low input system. Notably, the medium input scenario was modelled with a concrete feed pad to allow for the increased volume of supplementary feeding. The use of a feedpad to capture and control the distribution of effluent significantly limits the N output. This result deviates from the average medium input farm previously modelled where N leaching was favourable against the low input system, despite including a feed pad within this analysis. This demonstrates the scope of each system and the proportional effects of stocking rate within the medium input system. Both N conversion and NLE fell under the medium input system to 32 percent and 32.5 milk solids respectively. The increase in N input to the system combined with lower N conversion results in an increased farm N surplus of 231 kg per hectare per year.

Adding a further 60 cows to the farm system increased the stocking rate to 4.1 cows per hectare. A corresponding increase in supplementary feed inputs to 35 percent of the diet maintained the comparative stocking rate between 90 and 95. A concrete feedpad was used in this scenario to enable the volume of feed to be consumed. N leaching modelled for the high input scenario is 47 kg N per hectare. Comparatively this was only 4 kg of N per hectare more than under the medium input scenario however, milking 60 more cows. This reflects the environmental efficiencies with

regard to N cycling gained by feeding lower protein feeds such as maize silage as well as the further benefits of capturing effluent for controlled distribution on a feed pad. By nature of high milk solid production, NLE was the highest of all the input scenarios at 39 milk solids per unit of N input. This enables an N conversion efficiency of 34 percent. Farm N surplus lifted by 42 kg N per hectare to 273 kgs. Although still a substantial difference, the comparative change between a medium and high system of four kg N is significantly less than the difference between a low and a medium system which increases by 11 kg N loss per hectare. Despite the efficiencies achieved with the high input system when measuring milk solid output, the net nitrogen surplus per hectare was 103 kg higher under the high input system.

Figure 8.1 summarises the results of the comparative farm system analysis using the key performance indicators for farm nitrogen efficiency. This analysis has shown a uniform correlation between the systems with regard to NLE despite the significant increase in N leaching. This demonstrates the increased milk solids moving from a low input scenario to a high input scenario are being produced at no greater environmental efficiency.



**Figure 8.1 Comparative N modelling of same farm system intensified**

Table 8.4 Summary of comparative farm system

	<b>Low</b>	<b>Medium</b>	<b>High</b>
<b>Return per Hectare</b>	\$2839	\$2552	\$2325
<b>N Leached per Hectare</b>	32	43	47
<b>OP per kg N leached</b>	\$83	\$59	\$49
<b>NLE</b>	34	32	39
<b>N Surplus</b>	170	231	273

## **9.0 Options for Mitigation- The Cost of Compliance**

In the Waikato region, environmental regulation to date has been concerned with the correct treatment and disposal of effluent and sufficient storage capacity. Aside from sensitive catchments such as the Lake Taupo catchment, policy in the region does not yet legislate for nitrogen discharge allowances. With the political landscape becoming more concerned with water quality and environmental protection, there are strong indications that Waikato farming systems will have to account for nitrogen losses from their farm system as part of regulation. There is a likelihood that these losses will be restricted from current (unlimited) levels. Applying nitrogen leaching limits as in the Horizons and Canterbury region is a tool available to the Waikato Regional Council which would assist in their objectives under the National Policy Statement for Freshwater. The following analyses the financial and environmental implications of increased N loss limiting regulation for Waikato farming systems.

### **9.1 Scenarios for Reducing Environmental (N) Impact.**

Significant amounts of research has been focused on determining mitigation options for nitrogen leaching e.g. (Basset-Mens et al., 2009; De Klein et al., 2010; Doole et al., 2013; Glassey et al., 2013; Howard, 2013).

This analysis focused on four previously identified N mitigation strategies for nitrogen leaching within the literature and applied them to the modelled standardised farm systems of low, medium and high input.

The four strategies are:

**Scenario (1)** Decrease stocking rate

**Scenario (2)** Build increased effluent storage and expand application area

**Scenario (3)** Winter grazing herd through sensitive N leaching months

**Scenario (4)** Build a covered feed pad or cow housing shelter

The four identified scenarios are modelled using Overseer v6 and Dairy Feed Planner to determine the implications on N leaching as well as operating profit. Sensitivity analysis is used to show the extent to which each scenario impacts on farm operating profit at varying levels of farm gate milk price payout.

## **9.2 Scenario 1) Decrease Stocking Rate**

The effect of stocking rate on environmental performance has been estimated by modelling the average and high performing Waikato farm systems of low, medium and high input. Historically, high stocking rates have been encouraged to improve pasture utilisation per hectare as well as milk solid production per hectare (Glasse et al., 2013; Van Bysterveldt, 2014). The appropriateness of such high stocking rates are now being questioned under the premise of increased whole farm environmental impact. Decreasing the stocking rate is often proposed by regulators and by critics of intensive dairy with regard to nitrogen leaching limits and the negative impact of high stocking rates on the environment.

A reduction in stocking rate of 0.4 cows per hectare (40 cows) has been modelled across each of the farm systems. Under this scenario there is a one off capital financial benefit from the sale of cows to reduce herd size. Farm productivity metrics are reduced, a reflection of farming fewer cows. That stated, there are significant reductions in N leaching which improve the environmental sustainability and compliance of the destocking scenario.

### **9.2.1 Low Input**

A decrease in stocking rate from 2.9 cows per hectare to 2.5 cows per hectare for the low input farm results in a reduced N leaching of 15 percent from 32 kg N to 27 kg N leached per hectare. As noted within the average farm system analysis, 2.9 cows per hectare is a common stocking rate in the Waikato region. This analysis shows that for many of these farms a severe decrease in stocking rate will only reduce N leaching by just 5 kg of N or 15 percent.

Financially, operating revenue falls 6 percent as a function of lower milk solid production. A net reduction in operating cost of 4 percent is achieved. Notably, less feed pressure on farm results in significantly lower requirement for purchased feed and reduces feed cost by 36 percent. Overall profitability is reduced by 6 percent through destocking the low input system. Change in operating profit per hectare per kilogram of N leaching reduced was -\$38 per kg N reduced.

Table 9.1 Financial results of low input system destocking

	<b>Destocking</b>	<b>Change from base scenario</b>
<b>Operating Revenue</b>	\$690,950	-6.76 %
<b>Operating Costs</b>	\$400,551	-4.01 %
<b>Feed Costs</b>	\$25,450	-36.14 %
<b>Profit</b>	\$264,950	-6.69 %
<b>Return/ Ha</b>	\$2,649	-6.69 %

### 9.2.2 Medium Input

For the medium input farm stocked higher at 3.5 cows per hectare, decreasing the stocking rate 0.4 cows per hectare to 3.1 cows per hectare results in a reduction of N leached by 9 kg N, from 43 kg N to 34 kg N per hectare. This represents a 21 percent decrease in leaching, a greater reduction than modelled through destocking the lower input farm.

Financially, removing 40 cows from the medium input system relieved feed pressure to an extent where the remaining cows were able to consume a higher amount of feed grown on farm, and decreased the cost of feed for the whole farm system. Operating revenue falls 5.8 percent as a function of lower production, however there is a greater reduction in farm operating cost (6 percent) and feed costs (23 percent). This gives an overall lift in profit per hectare of 4 percent.

Table 9.2 Financial results of destocking medium input system

	<b>Winter Grazing</b>	<b>Change from base scenario</b>
<b>Operating Revenue</b>	\$852,406	-5.81 %
<b>Operating Costs</b>	\$483,222	-6.00 %
<b>Feed Costs</b>	\$103,800	-23.53 %
<b>Profit</b>	\$265,384	4.00 %
<b>Return/ Ha</b>	\$2,654	4.00 %

### 9.2.3 High Input System

For the high input farm stocked at 4.1 cows per hectare a reduction to 3.7 cows per hectare results in a decrease in N leaching by 23 percent to 11 kg N per hectare. N surplus per hectare is also reduced by 36 kg to 237 kg per hectare.

Financial modelling shows operating revenue falls by 6.72 percent, however there is also a 6.93 percent reduction in operating cost. Combined with a 16 percent fall in feed cost the total profit for destocking the high input farm system is increased by 5 percent to \$2459 per hectare.

Table 9.3 Financial results of high input system destocking

	<b>Winter Grazing</b>	<b>Change from base scenario</b>
<b>Operating Revenue</b>	\$1,126,315	-6.72%
<b>Operating Costs</b>	\$649,998	-6.93%
<b>Feed Costs</b>	\$230,392	-16.72%
<b>Profit</b>	\$245,925	5.79%
<b>Return/ Ha</b>	\$2,459	5.76%

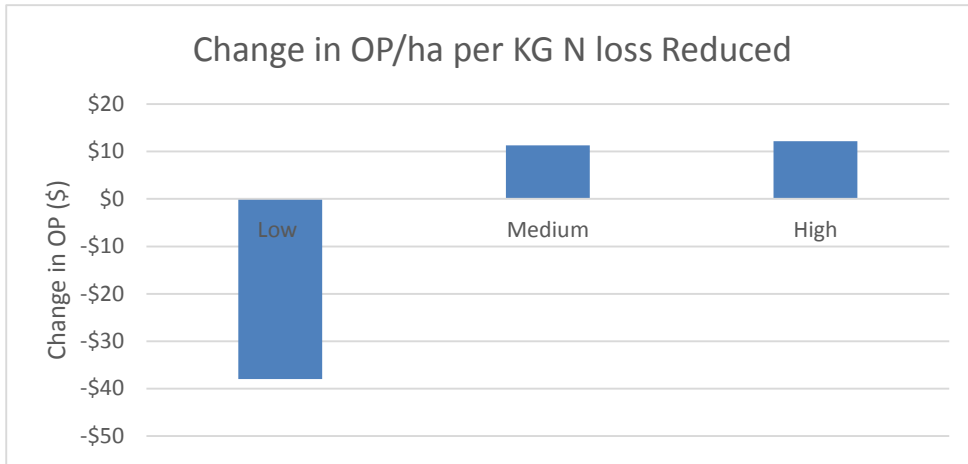
#### 9.2.4 Summary of Destocking Scenario

Modelling of destocking (often resented by industry because farm productivity is lowered) shows that it is possible to increase efficiency by reducing N leaching and increasing economic return per hectare. For the three farm systems modelled, destocking by 0.4 cows per hectare resulted in an average reduction in N leaching of 20 percent. Table 9.4 details results of nutrient modelling across each of the farm system intensities. Notably the range of N leaching between the low medium and high input systems is reduced to just nine kg N per hectare compared to 15 kg N under the base farm scenarios.

Table 9.4 Nutrient modelling for destocking scenario

	<b>Low</b>	<b>Medium</b>	<b>High</b>
<b>N Leached</b>	27	34	36
<b>NCE</b>	32	34	35
<b>NLE</b>	38	37	47
<b>N Surplus</b>	156	194	237

The financial implications measured through operating profit per hectare were positive for two of the farm systems under a destocking scenario. Both the medium and the high input system benefited from lower total feed cost, lower total operating cost and therefore increased operating profit. Figure 9.1 shows the cost or benefit per hectare for every kilogram of N leaching mitigated when destocking the farm system by 0.4 cows per hectare. For the low input system, each kg of N loss mitigated resulted in a decrease in operating profit per hectare of \$38. In comparison, the medium and high input systems gained \$11 and \$12 per hectare per unit of N mitigated respectively.



**Figure 9.1** Change in profit per hectare, per KG of N mitigated by destocking

### **9.3 Scenario 2) Build Effluent Storage & Expand Application Area**

In the Waikato, effluent storage has been a focus of dairy companies, councils and farmers in the move to ensure compliant sustainable farm systems. The environmental concern from regulators and dairy companies is that saturated soils over winter months do not have the capacity to absorb nutrients within the effluent and as such causes leaching and surface run off. Minimum storage requirements are the main way in which regulators have imposed requirements on farmers to improve effluent infrastructure. Effluent pond storage requirements are calculated as a function of soil type, annual rainfall, contribution area and estimated water use per cow. Efficient dairy effluent storage is calculated using the Pond Storage Calculator, a model which accounts for each of above factors as well as the farm system parameters. Available area for application of effluent to land is increased to show the N leaching reductions achieved through increasing available area.

Overseer analysis was performed for the three farm systems with the assumption of increasing the available effluent area to 40 hectares representing 40 percent of the effective milking platform (a 50 percent increase from the base farm scenario). Increased effluent area enabled low rate applications to <12mm applied. Further to increasing the available area a lined storage pond was added to enable no application of effluent during periods of high leaching risk. The cost of extending the effluent area is assumed to be \$1000 per hectare giving a total cost of \$20,000 for each system. Cost to build a lined effluent pond is assumed to be \$30,000, \$40,000 and \$50,000 for the low medium and high input system respectively noting the relative volumes of effluent produced. No change in farm operating profit is modelled. It is assumed the nutrient value of effluent remains the same.

### **9.3.1 Low Input**

Through extending the effluent area and storage capacity, N leaching for the low input system was reduced by 6 percent from 32 kg N per hectare to 30 kg N per hectare.

Initial installation cost of the upgraded effluent system totals \$50,000, being \$20,000 of effluent network extension and \$30,000 for the new holding pond. Per hectare the initial cost is \$500. Using the above modelled two kg reduction in N leaching, increasing application area and building holding pond storage has a capital cost of \$250 per kg N loss mitigated.

### **9.3.2 Medium Input**

With a higher stocking rate and increased feed input, the nutrient concentration of effluent was higher than that of the low input system. For this reason, extending the effluent area by 20 percent to 40 hectares and adding storage facilities reduces the nitrogen leaching by 10 percent to 39 kg N per hectare from 43 kg N per hectare. Total cost for the new effluent system is \$60,000 including \$20,000 for increased area.

### **9.3.2 High Input**

For the high input system, N leaching reduced 11 percent to 42 kg N per hectare. This was achieved because the volume and nutrient concentration produced by a greater number of cows had a larger impact on the N leaching under the base scenario than was apparent with lower stocking rates for the low and medium input systems. The financial cost of implementing effluent storage and application scenario was \$70,000 for the high input system.

### 9.3.4 Summary of Increasing Effluent Storage and Application Area.

Increasing both the effluent storage facility and the application area is a suitable N leaching mitigation option where a small reduction in N leaching is required for compliance. Nutrient modelling shows an average reduction in N leaching of 8.7 percent from the base scenario.

Financially, the capital investment into effluent storage is large compared to the environmental benefits received by the farm system. However, it must be noted that proper storage of effluent is increasing as a proxy measure of environmental performance by the general public as well as by dairy companies. The opportunity cost for not investing in correct storage and application is likely to increase as the use of fines and the threat of dairy companies refusing to collect milk becomes common practice.

Table 9.5 Nutrient budget results for increasing effluent area and storage

	<b>Low</b>	<b>Medium</b>	<b>High</b>
<b>N Leached</b>	30	39	42
<b>NCE</b>	36	34	36
<b>NLE</b>	36.47	34.33	41.88
<b>N Surplus</b>	154	210	255

### **9.4 Scenario 3) Winter Grazing Herd**

Grazing dry cows off the milking platform during the winter months can make a significant impact to the nutrient losses of the farm. The impact of effective stocking rate on potential N leaching occurs as a function of urine patches (Dalley et al., 2013). During winter months, dry cows held on a long rotation are grazed using break fencing. The effective area per cow is reduced reflecting the reduced feed requirement and for pasture management. As a result, urine patch concentration is increased. Further, the winter weather compounds the noted effects with high soil moisture levels adding to the mobility of nitrogen within the soil. Therefore, removing the herd from the milking platform is one option to mitigate this risk. However, in wintering cows off the dairy platform, while the farm specific N leaching is able to be reduced, at the cows winter grazing location there is still an N footprint. Removing cows is an effective strategy to reduce individual farm N leaching, however farms are in reality exporting the N leaching to another farm. Further considerations of a winter grazing strategy include the relative cost of feed and the high cost and stress of trucking/ moving in calf cows. Results of winter grazing nutrient budgets are detailed in Table 9.9.

#### **9.4.1 Low Input**

For the low input farm system, removing cows over the winter for the month of June is shown to reduce N leaching by 3 kg N per hectare a total reduction of 9 percent. The modelled N leaching under the winter grazing scenario is 29 kg of N per hectare. Farm N surplus is reduced from 170 kg to 163 kg per hectare.

Financially, modelling the winter grazing scenario through Dairy Feed Planner resulted in higher cost of purchased feed in the form of winter grazing, higher

operating cost and the same annual milk solid production resulting in a static operating revenue.

Table 9.6 Financial results of winter grazing scenario – Low Input

	<b>Winter Grazing</b>	<b>Change from base scenario</b>
<b>Operating Revenue</b>	\$742,952	0.26%
<b>Operating Costs</b>	\$415,851	-0.34%
<b>Feed Costs</b>	\$58,307	46%
<b>Profit</b>	\$268,794	-5%
<b>Return/ Ha</b>	\$2,688	-5%

The increase in feed cost is equal to 46 percent compared to the base scenario. This increase results in a 5 percent reduction in profit to \$268,794 or \$2,688 per hectare.

The modelled reduction in operating profit per hectare of 5 percent represents a loss of \$151 per hectare. Given that nutrient modelling shows a three kg reduction in N leaching per hectare, the cost to operating profit per kg of N leaching reduced is \$50.

#### 9.4.2 Medium Input

For the medium input farm with a higher stocking rate, removing all cows from the platform makes a marginal difference of 1 kg per hectare of N leached compared to the low input system. Total N leaching was reduced from 43 kg per hectare to 39 kg per hectare.

Similar to results observed in modelling the low input system, the medium input system incurs increased feed cost for no additional revenue (Table 9.7).

Table 9.7 Financial results of winter grazing scenario – Medium Input System

	<b>Winter Grazing</b>	<b>Change from base scenario</b>
<b>Operating Revenue</b>	\$905,973	0.11%
<b>Operating Costs</b>	\$511,813	-0.44%
<b>Feed Costs</b>	\$144,700	6.61%
<b>Profit</b>	\$249,460	-2.24%
<b>Return/ Ha</b>	\$2,495	-2.23%

Winter grazing for the medium input farms 350 cows resulted in an increased feed cost of 6.61 percent to \$144,700 annually. Operating revenue and cost remain static resulting in a 2.23 percent reduction in profit to \$249,460.

Profit per hectare falls against the base scenario by \$57 per hectare to \$2,495. For the reduction in N leaching of 4 kg per hectare, the cost per kg of N leaching mitigated was \$14.25.

#### 9.4.3 High Input

Under a high input system, the winter grazing scenario reduced N leaching by 4 kg N per hectare to 43 kg. This is a reduction of 8.5 percent from the base scenario. Farm N surplus is lowered by 10 kg to 263 kg. Both the nitrogen conversion efficiency and nitrogen leaching efficiency are increased to 35 and 41 respectively.

Financially, the cost of winter grazing increases feed cost by 4.6 percent to \$287,960 annually. As a result farm profit is reduced by 4.3 percent to \$223,994. The reduction in profit per hectare to \$2,240 represents a loss of \$99 per hectare. Cost per kg of N leaching reduced is therefore \$24.75.

Table 9.8 Financial results winter grazing scenario – High Input System

	<b>Winter Grazing</b>	<b>Change from base scenario</b>
<b>Operating Revenue</b>	\$1,210,921	0.3%
<b>Operating Costs</b>	\$698,968	0.1%
<b>Feed Costs</b>	\$287,960	4.1%
<b>Profit</b>	\$223,994	-3.6%
<b>Return/ Ha</b>	\$2,240	-3.7%

#### 9.4.4 Summary of Winter Grazing Scenario

Winter grazing the whole herd off the milking platform for the month of June reduced N leaching by up to 4 kg of N per hectare. The cost of winter grazing is modelled through increased annual feed cost. For no extra milk solid production the scenario incurs a seasonal net cost equal to the value of feed. As such the cost to reduce N ranges between \$14 and \$51 per kg N loss reduced (Figure 9.2). The comparative cost of compliance using a winter grazing strategy is far greater for the low input system than it is for the high input system. This cost can be attributed to the low baseline leaching for the low input scenario as well as the higher feed cost as a percentage of revenue.

Table 9.9 Nitrogen efficiency metrics- Winter grazing scenario

	Low	Medium	High
<b>N Leached</b>	29	39	43
<b>NCE</b>	35	33	35
<b>NLE</b>	37.72	34.33	41.74
<b>N Surplus</b>	163	233	263

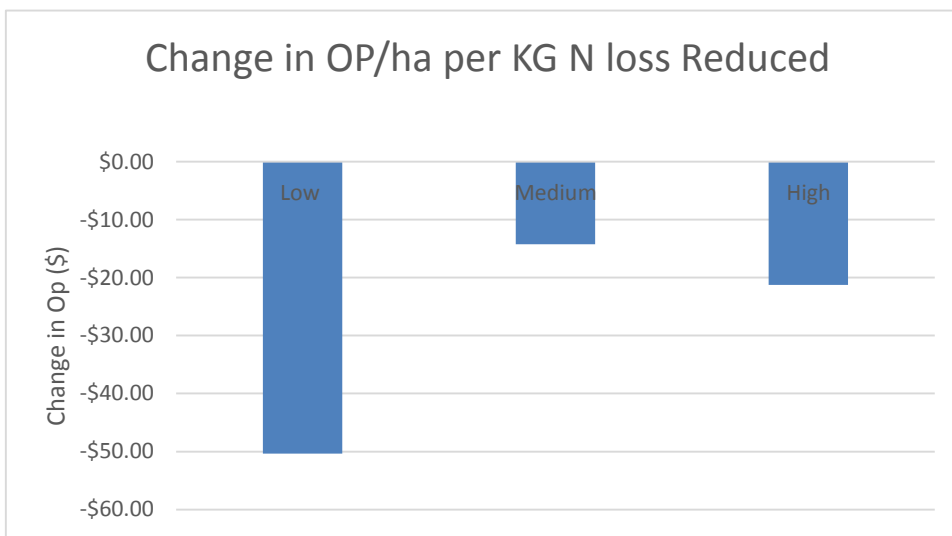


Figure 9.2 Change in operating profit - Winter grazing scenario

#### **9.5 Scenario 4) Build Covered Feedpad or Cow Housing**

Increasingly, cow housing systems are being included in farm systems as they are capable of reducing farm environmental impacts as well as maintaining or increasing the profitability of the farm system. Housing cows for compliance works on the principle of duration controlled grazing. Within a duration controlled farm system, cows are allowed to graze pasture only for the time it takes them to reach optimum residual (Christensen et al., 2011). In months sensitive for nitrate leaching, the grazing window can be as little as four hours. Under this system, cows are removed from the pasture to the housing facility where they are kept sheltered, fed and most importantly, their effluent is captured in a controlled environment. In Dairy Feed Planner the use of a cow housing system is modelled for the low, medium and high input farm. Assumptions of the housing scenario include increased opening cow condition, a reduced average walk to the cowshed, reduced wastage of feed, higher feed conversion efficiency and increased pasture grown. The corresponding nutrient budget prepared through Overseer is based upon a concrete floored housing system. For the purposes of this comparative analysis, only the impact on farm operating profit is considered. The capital cost assumptions with implementing cow housing are discussed in-depth in chapter 10.

### 9.5.1 Low Input

For the low input system, a cow housing facility is modelled to reduce N leaching by five kg per hectare, being the largest reduction scenario equal to destocking. The modelled N leaching of 27 kg per hectare is a reduction of 15 percent from the base scenario of 32 kg per hectare.

Operating revenue is increased 3.16 percent through increase milk solid production. A small increase in operating cost is recorded as a function of both higher production and maintaining a housing facility. Notably, the feed going into the system was better utilised through reducing wastage. Given the low volume of supplement feed in the low input system, better utilisation results in a 24 percent reduction in feed costs. Operating profit is increased to \$3,084 per hectare, a 9 percent increase.

Table 9.10 Financial results of cow housing –Low Input System

	<b>Cow Housing</b>	<b>Change from base scenario</b>
<b>Operating Revenue</b>	\$764,470	3.16 %
<b>Operating Costs</b>	\$417,552	0.07 %
<b>Feed Costs</b>	\$30,475	-24 %
<b>Profit</b>	\$308,442	9 %
<b>Return/ Ha</b>	\$3,084	9 %

### 9.5.2 Medium Input

Nutrient modelling of a cow housing scenario for the medium input system shows a reduction in N leaching of 10 kg N per hectare equivalent to a 23 percent reduction from the base medium input farm scenario. N leaching is reduced from 43 kg per hectare to 33 kg per hectare. This reduction shows that the addition of farm

infrastructure and adapting the farm system to suit, it is possible to substantially reduce N leaching.

Importantly, the financial performance of the medium input system with a cow housing scenario is improved from the base scenario, proving both environmental and economic performance can be increased. Operating profit has increased from \$2,552 per hectare to \$2,807 per hectare, an increase of \$255 per hectare or \$255,000 for the whole farm system.

Table 9.11 Financial results cow housing – Medium Input System

	<b>Cow Housing</b>	<b>Change from base scenario</b>
<b>Operating Revenue</b>	\$928,896	2.64 %
<b>Operating Costs</b>	\$513,691	-0.08 %
<b>Feed Costs</b>	\$134,403	-0.98 %
<b>Profit</b>	\$280,722	10.01 %
<b>Return/ Ha</b>	\$2,807	9.99 %

### 9.5.3 High Input

For the high input system, a cow housing scenario is modelled to reduce N leaching by seven kg N per hectare. This reduction is less than that modelled for the medium input system as a result of high stocking rate and the volumes of effluent generated. With a housing facility, N leaching falls from 47 kg N to 40 kg N per hectare representing a decrease of 15 percent.

Financial modelling of the high input system with housing facilities showed an increase in operating revenue, driven from greater production as a result of increased feed utilisation. There was no material change in either operating cost or feed cost. Operating profit is therefore increased 14 percent from the base scenario to \$2,654. The increase in operating surplus for the whole farm system is equal to \$329 per hectare or \$329,000 for the farm.

Table 9.12 Financial results –High Input System

	<b>Cow Housing</b>	<b>Change from base scenario</b>
<b>Operating Revenue</b>	\$1,238,443	2.6 %
<b>Operating Costs</b>	\$698,425	0.0 %
<b>Feed Costs</b>	\$274,596	-0.7 %
<b>Profit</b>	\$265,423	14.2 %
<b>Return/ Ha</b>	\$2,654	14.2 %

#### 9.5.4 Summary of Cow Housing Scenario

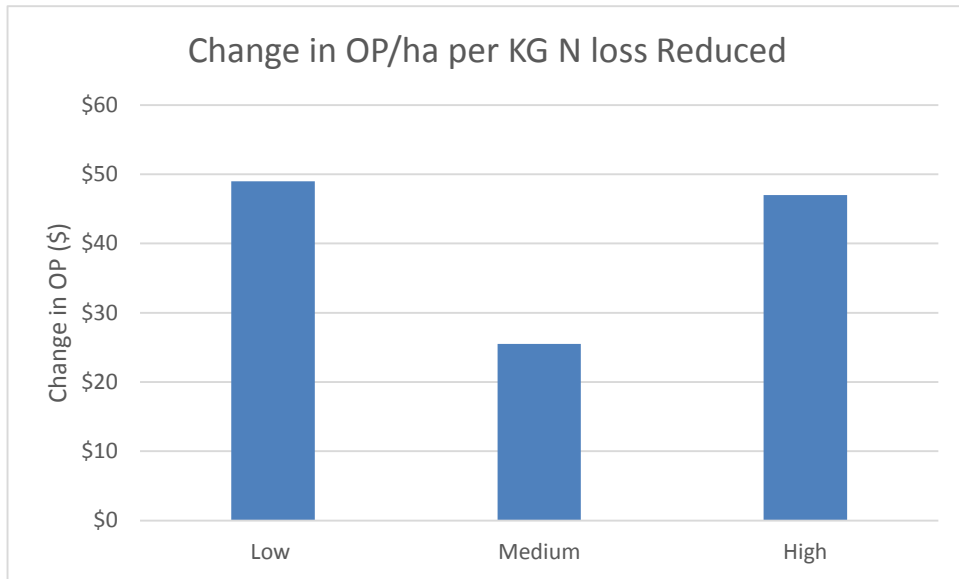
Cow housing is the only scenario of the four modelled to show a significant reduction in N leaching above 10 percent, and demonstrating the ability to lift financial performance. Across each of the farm systems, average reduction in N leaching was 18 percent. The average increase in operating profit is modelled as 10.9 percent. Table 9.13 shows a summarised nutrient budget across each farm system. With the cow housing system, N leaching increases linearly from the low through high input systems reinforcing the link between stocking rate and N leaching.

Table 9.13 Nutrient budget for cow housing scenario

	<b>Low</b>	<b>Medium</b>	<b>High</b>
<b>N Leached</b>	27	33	40
<b>NCE</b>	28	29	31
<b>NLE</b>	40.52	40.58	44.88
<b>N Surplus</b>	199	247	291

Financially, operating profit is increased for each of the farm systems. The average increase in operating profit per hectare was 11 percent ranging from 9 to 14 percent between the low and high input system respectively.

When considering the financial implication per kg of N leaching mitigated, the cow housing system gives a change in operating profit per kg N mitigated of \$49, \$26 and \$47 for the low medium and high input system respectively being the highest of the four scenarios modelled (Figure 9.3).



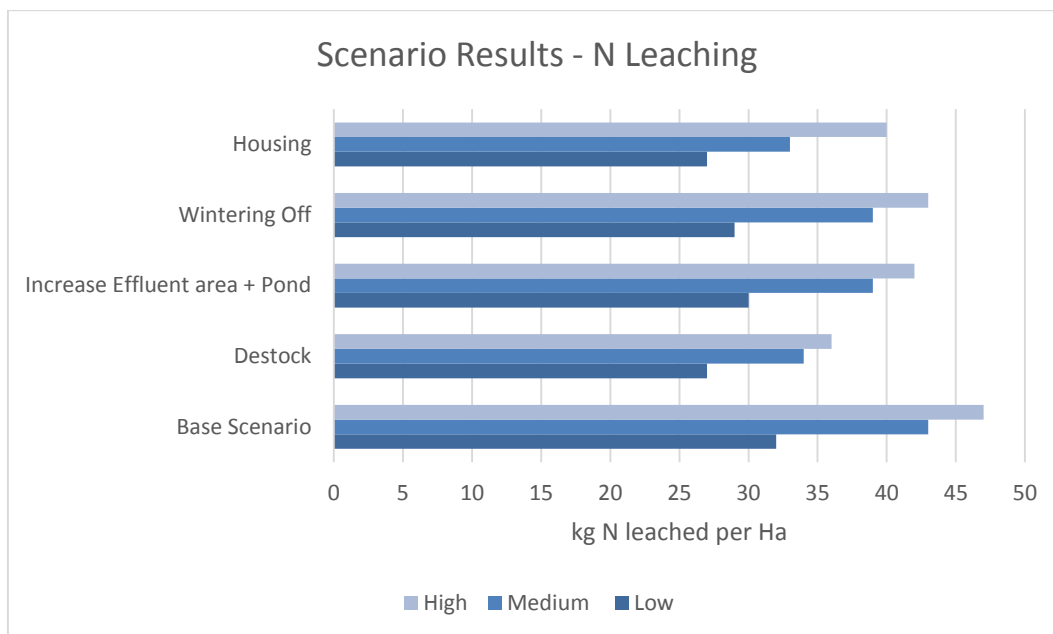
**Figure 9.3** Change in profit per hectare, per kg of N mitigated through cow housing

## 9.6 Implications of Scenario Analysis

In modelling the four identified scenarios for their financial and environmental implications it is clear that reductions in N leaching for farm environmental compliance are able to be achieved through both farm management practice and additional farm infrastructure. Despite all scenarios reducing N leaching, the degree to which each scenario must be implemented varies to achieve acceptable environmental performance under limits based regulation. The financial viability as measured through operating profit per hectare had a large dependence on the farm system intensity. The following summarises both the financial and environmental implications across the four scenarios.

### 9.6.1 Environmental Performance

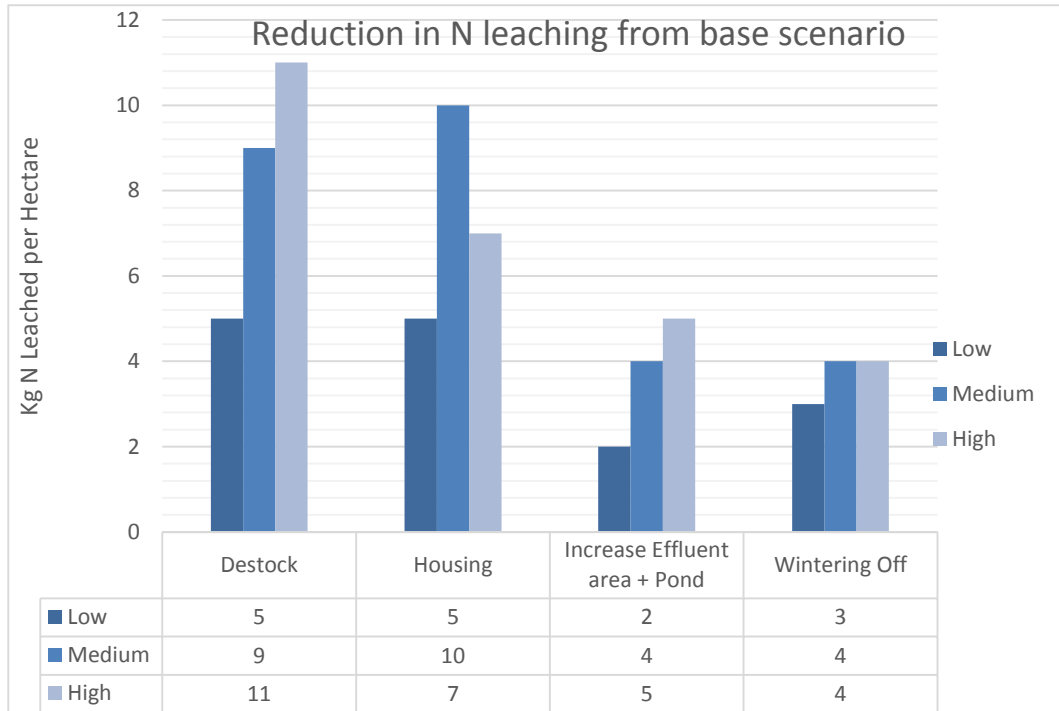
In all scenarios, N leaching was reduced from the base farm scenario. Figure 9.4 shows that the maximum modelled N leaching was 47 kg per hectare under the high input system base scenario. Of the four scenarios modelled, reductions in N leaching were varied however both housing and destocking provided the minimum leaching achieved being 27 kg per hectare.



**Figure 9.4 Scenario results N leaching**

A summary of the N leaching reductions is shown in figure 9.5. Both destocking, a farm management action and cow housing, a farm infrastructure investment result in the highest reduction in N leaching compared to the base scenario. Notably, scenarios of increasing effluent area and wintering off provide significantly less scope to reduce N leached.

The modelled scenarios for reducing N leaching can be summarised by two groupings. Destocking and cow housing reduced N leaching by 20 percent and 18 percent respectively, while effluent infrastructure and winter grazing reduced leaching by 8 percent and 9 percent respectively. Overall reductions in N leaching are summarised in Figure 9.5 and expressed as a percentage from the base scenario in Table 9.14



**Figure 9.5 Reduction in N leaching**

**Table 9.14 Percentage base change in N leaching**

Change From Base Scenario	%	%	%	%
	Low	Medium	High	Average
<b>Destocking</b>	15.63	20.93	23.40	19.99
<b>Cow Housing</b>	15.63	23.26	14.89	17.92
<b>Increase Effluent Area + Pond</b>	6.25	9.30	10.64	8.73
<b>Wintering Off</b>	9.38	9.30	8.51	9.06

The base scenario with regard to N leaching and existing infrastructure is a major determinant as to which mitigation scenario to use so as to achieve compliance. Where relatively low reduction is required, increasing effluent area and pond, as well as wintering off provide possible strategies. However to achieve a significant reduction in N leaching similar to the reduction required by the base farm scenarios

in this analysis, a more significant mitigation is required such as destocking or cow housing.

In all scenarios modelled, the medium and high input farm systems resulted in larger reduction in N leaching measured in kg per hectare. This is due to the relatively low N leaching of the low input farm system in the base scenario and the difficulty in reducing low N leaching rates further without significantly compromising economic performance.

### **9.6.2 Financial Performance**

Measuring the financial implications of each mitigation strategy is best considered through the change in operating profit per hectare. In three of the four modelled scenarios there are significant changes to the farm with regard to management and therefore changes in operating revenue and cost. For the scenario of increasing effluent area and storage it is assumed there is no material impact on operating profit.

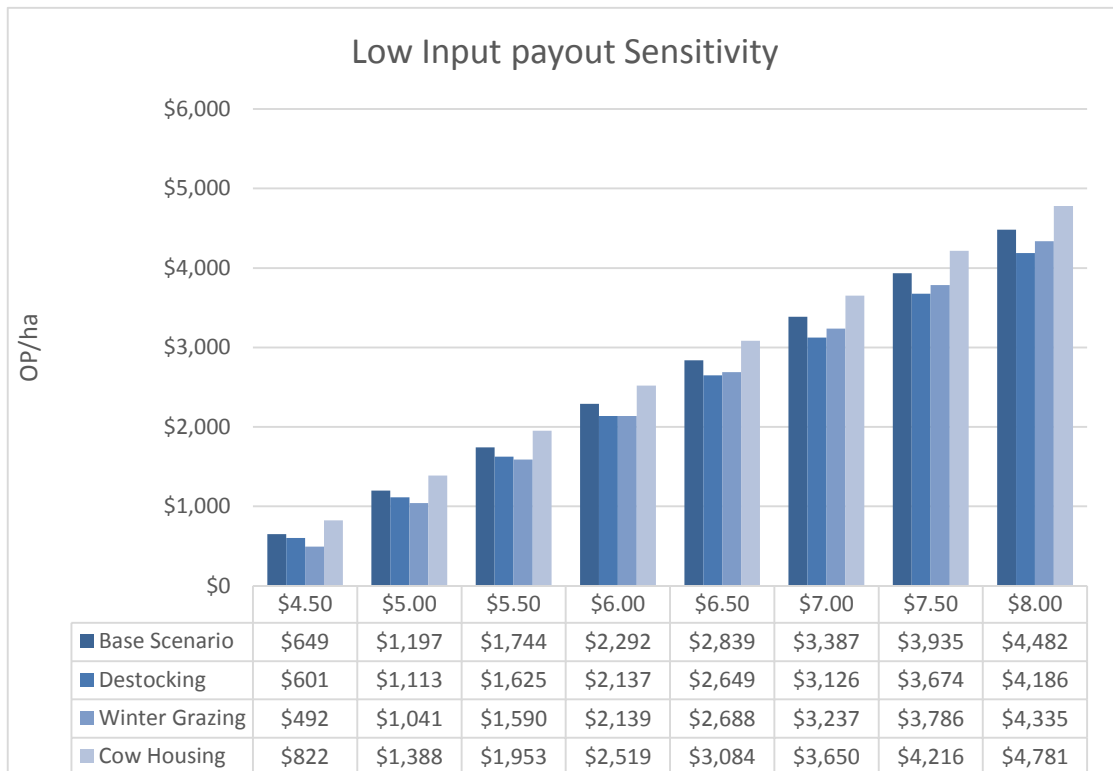
Mitigation scenarios are assessed against a base scenario for operating profit of \$2,839, \$2,552 and \$2,325 for the low, medium and high input farm respectively.

It must be noted, farm operating profit per hectare is the expression of operating revenue less farm working expenses. Operating profit does not consider outstanding tax, interest or depreciation charges accumulated. Average increases or decreases in operating profit per hectare were 1.02 percent, -4 percent and 11 percent for the destocking, winter grazing and cow housing scenario respectively.

## Sensitivity to payout

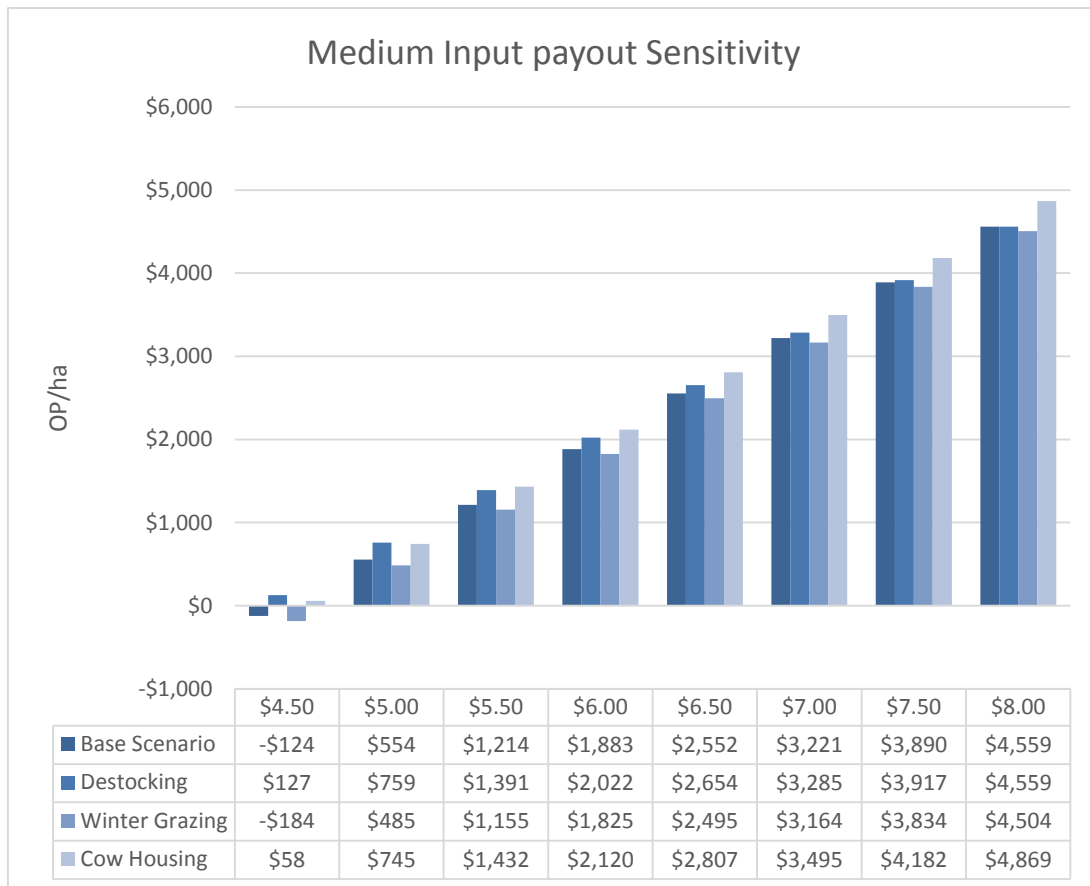
For each of the scenarios where change in operating profit was reported, the relative profitability of the given scenario is altered by the milk price payout. Sensitivity modelling has been used to show the breakeven point and comparative profitability determined through operating profit per hectare. Analysis is provided for the low, medium and high input farm systems respectively modelled at milk prices of \$4.50 through \$8.00 per kgMS

For the low input farm system, all scenarios resulted in a positive operating profit per hectare. With the profits modelled there is evidence to show each scenario under a low input farm system is capable of meeting non-farm working expenses and recording a positive net profit.



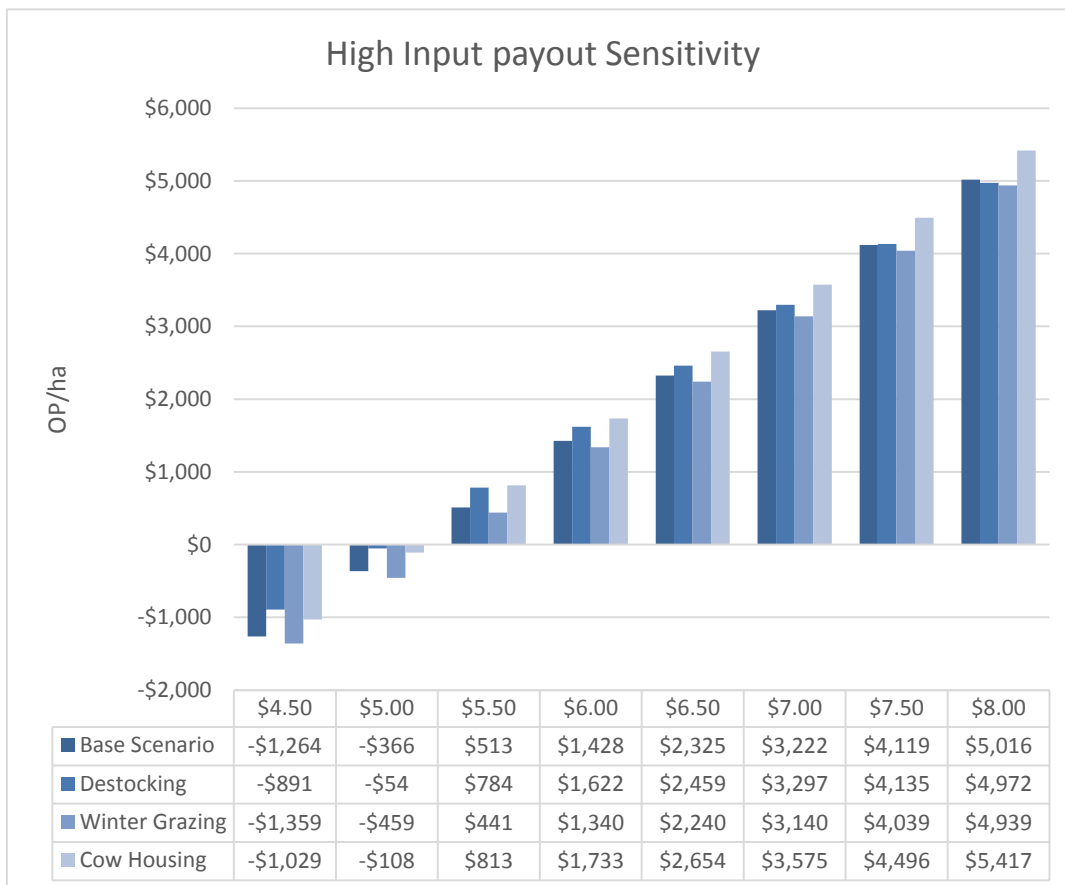
**Figure 9.6 Sensitivity to payout- Low input system**

Modelling the medium input system, sensitivity to payout shows that at a \$4.50 payout the base scenario and the winter grazing strategy incur negative operating profit. Further, the low levels of return noted at both \$4.50 and \$ 5.00 indicate after including non-farm working expenses each scenario has very low net profitability.



**Figure 9.7 Sensitivity to payout- Medium input system**

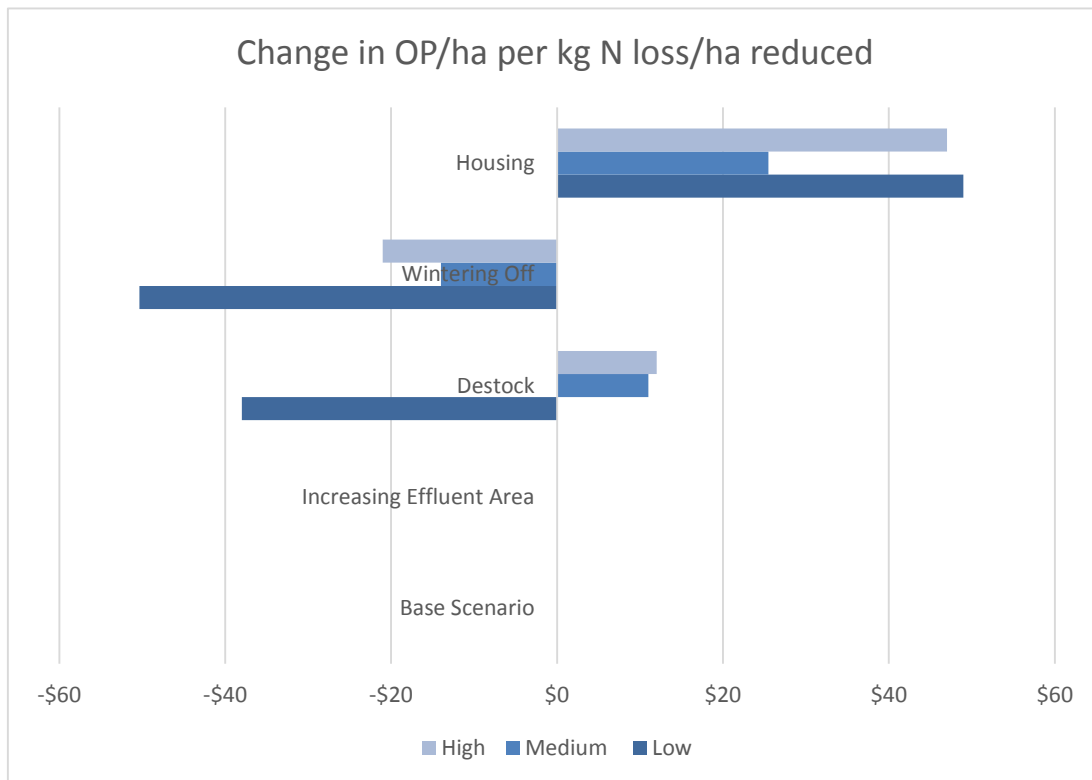
Considering the high input system, modelling shows the relative breakeven from an operating profit perspective is between \$5.00 and \$5.50. However, when modelled with a high payout of \$8.00, the high input system records significantly higher operating profit levels. Despite the capacity for higher returns in high payout years the long term profitability (capable in other systems) is not achieved at the current long term average milk price.



**Figure 9.8 Sensitivity to payout- High input system**

## Cost of reduction per unit of N

An expression of the cost of compliance for each farm system is the change in operating profit per hectare noted for every kg of N leaching mitigated. Figure 9.9 shows the comparative changes in operating profit as a function of N leaching giving both an economic and environmental measurement. Destocking and cow housing, identified as the ‘large reducers’ are shown to have a positive effect on operating profit for every kg of N mitigated against the base scenario. An exception to this is shown for the low input system destocking scenario whereby reducing the already low levels of leaching through decreasing stocking rate has a significant negative impact on operating profit for every kg of N leaching mitigated. For the winter grazing scenario, the increase in farm working expense for little increase milk revenue results in a negative change in operating profit for each kg of N mitigated.



**Figure 9.9 Change in profit per ha, per kg N loss/ha reduced**

## **9.7 Conclusion**

The comparative analysis of mitigation options across low, medium and high input systems gives evidence to show there is no one fit system for compliance. The cost of mitigation options becomes inefficient where small reductions in N leaching are achieved as shown through the moderate reducing scenarios. Efficient reduction in N leaching, these being reductions greater than 10 percent and improved operating profit, can be achieved through destocking and cow housing.

Across all farm systems modelled the cow housing scenario is shown to provide both high economic and environmental performance. That stated, there is a high capital cost to implementing cow housing infrastructure and the capacity for farmers to implement a housing system is no always evident.

The following chapters provides in-depth analysis of implementing a cow housing facility for a specific farm system taking into account the full cost to the farm system and providing rationale for the suggested benefits.

## 10.0 Cow Housing Implementation Case Study

### 10.1 Introduction

The previous analysis shows that cow housing infrastructure is one farm system where both environmental performance can be improved by greater than 10 percent and economic returns can be increased. Implemented correctly, cow housing systems turn the requirement for environmental compliance from a cost to a benefit. In New Zealand, cow housing systems are relatively new when compared to European dairy systems. As such there is a need to model the implementation of various housing systems under scenarios of scale and system intensity. There is existing research which details the implementation of cow housing for small and medium dairy farms similar in scale to typical Waikato farms (Journeaux, 2013; Macdonald, Scrimgeour, & Rowarth, 2013). This chapter details a case study analysis of building cow housing for large scale farming in the Taharua catchment. The Taharua catchment is a small yet sensitive catchment with regard to the environment near Taupo New Zealand. Taharua catchment includes three large scale farms including Shanghai Pengxins Taharua Dairy Unit.

Taharua Dairy Unit is a large scale dairy farm milking approximately 2300 cows owned by the Shanghai Pengxin Group (SPG) of China. As a large scale dairy unit Taharua represents a significant investment on behalf its owners SPG and as such the annual performance is critical to the economic success of the SPG New Zealand venture. Taharua is now managed through a joint venture company between Shanghai Pengxin Group and Landcorp Farming Limited called Pengxin New Zealand Farm Management Limited (PNZFML).

In farming Taharua, Landcorp have noted the performance of Taharua is below that of the remaining SPG farms and the performance of Landcorp Farming's nearby Pastoral dairy complex. The poorer performance can be attributed to topographic, climatic, infrastructure and genetic constraints faced in running the farm.

Further, the environmental performance of Taharua Dairy Unit is now of primary concern to Landcorp and SPG as increased regulation pertaining to farming in the Hawkes Bay Taharua catchment becomes applicable to the farm. More so, several consent conditions granted through the Overseas Investment Office require Taharua to operate in an environmentally responsible manner.

It is in the best interest of both SPG and Landcorp as PNZFML to consider possible strategies in optimising Taharua farm for greater productivity through increased milk production whilst limiting or minimising the environmental impact of the farming operation in accordance to regulation under the Overseas Investment Office and Regional Council. Opportunities to achieve improved performance include the investment in farm infrastructure. Cow housing has been identified as a possible strategy to improve both per cow and per hectare productivity whilst minimising the environmental effects (N leaching) of potential system intensification.

This case study is concerned with the economic and environmental optimisation of Taharua farm through cow housing. Modelling of the farming system through Overseer and a discounted cash flow model is used to quantify the respective changes arising from optimisation of farm infrastructure to house cows off pasture.

## **10.2 Background:**

### **10.2.1 Physical Description**

Taharua farm is located off the Napier-Taupo Road at an altitude of 660 meters above sea level. The farm is of considerable size at 1790 hectares of which 1250 are effective hectares. Currently the farm spring milks approximately 2300 cows through two milking facilities. In addition, harder hill country is used to graze carryover stock for the SPG group farms.

Formerly part of the Crafarm group, the difficulties of dairy farming Taharua are well publicised with severe cases of environmental neglect and animal welfare leading to the eventual sale by receivership to SPG. Weather conditions and the subsequent pasture growth curve currently have an over proportionate influence on farm performance compared to other farms within the group managed by Landcorp. The altitude of Taharua is responsible for much of the adverse weather with snow and temperatures below freezing point common throughout the winter. Given the scale of Taharua, the noted effects of weather and follow on cow and pasture condition have a significant effect on overall productivity.

Current milk production levels are below 300 kgMS per cow giving approximately 500 kgMS per hectare. Days in milk are comparatively low and are dictated by calving spread, historically late planned start of calving and poor pasture growth through the second half of the milking season. Operating at the current scale, small incremental changes to these key performance indicators have a significant effect on the financial performance and hence viability of the farm. For example, a change of 10 kgMS per cow results in +/- \$162,500 in revenue calculated at a \$6.50 per kgMS payout.

Winter grazing is a core strategy employed by the farm to manage low winter pasture growth rates as well as to minimise the effect of stocking rate on N leaching through the winter months. Approximately 2000 of Taharua's cows are wintered off the platform at neighboring properties where they are fed winter crop and silage. This incurs significant cost the farm business, however under current infrastructure and regulatory conditions is essential to the running of the farm. It is also noted that while wintering off reduces the farm specific nutrient budget the N loss is exported to other farms giving the same net effect to the catchment.

Taharua is located within the Hawke's Bay Regional Council (HBRC) catchment and as such falls under the HBRC land use and freshwater management plan with regard to environmental regulations. The Taharua farm is one of three large scale dairy farms within the catchment. There has been clear linkages made between the increased dairy activities in the catchment with the declining water quality measured throughout the wider Mohaka catchment. In response to rising nitrogen loss and increased nitrate measurements in fresh water streams, the HBRC have regulated a regional resource management plan to be developed with stakeholders in the catchment to manage the impacts and risks to water from the land. This includes regulating intensive land use (dairying) in the Taharua catchment to restore water quality within the Taharua headwaters.

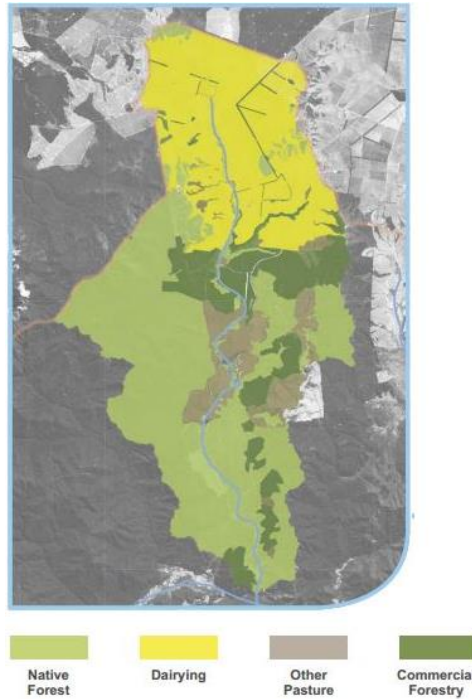
### 10.3 Hawkes Bay Region- Environmental Policy

Taharua catchment is a small 13,500 hectare catchment at the beginning of the Mohaka River 30 kilometres south east of Taupo (Figure 10.1 - Farm located in box). Based on pumice soils, the Taharua catchment is a tributary to the iconic Mohaka River. Development of the catchment began in the 1980's when central government facilitated clearing of native vegetation through development encouragement loans (Powell, 2011). Today the catchment includes land under commercial forestry, native forest, dairy farming as well as sheep and beef operations. A tourism operation and a large scale drystock unit as well as the SPG farm are all foreign owned, representing 50 percent of the catchment under foreign ownership. Figure 10.2 details the relative land area of each activity within the



catchment.

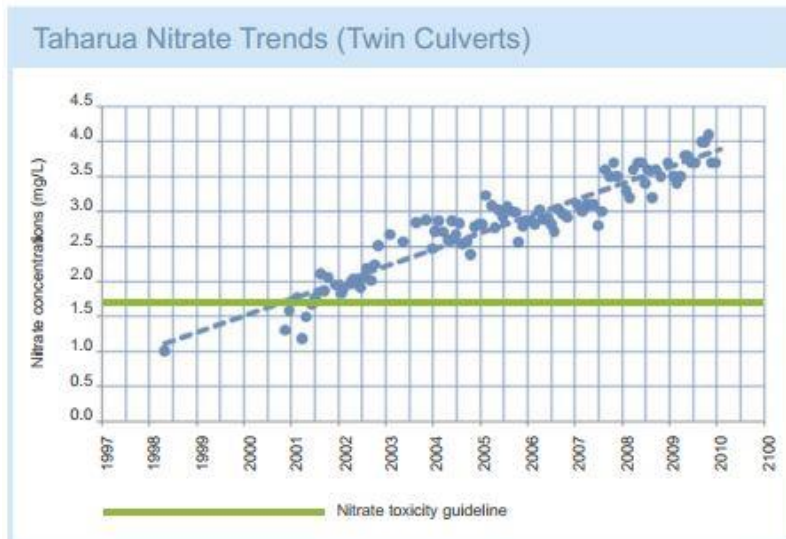
**Figure 10.1 Outline of Taharua sub catchment**



**the Mohaka region**

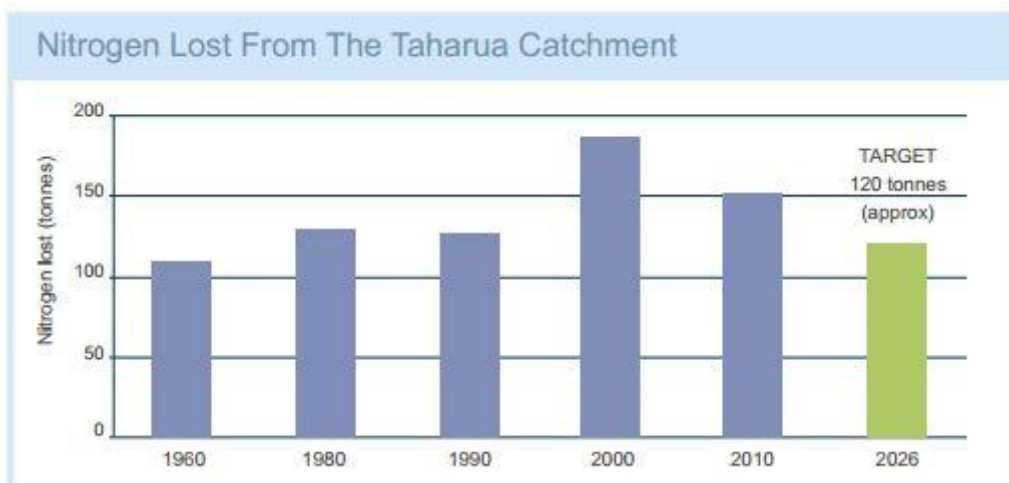
**Figure 10.2 Land use in the Taharua Catchment**

Dairy within the region has intensified from one farming operation in 1989 to the current three farms. Whilst the total number of farms is not significant compared to other sensitive catchments, the scale of the farms involved is significant. Dairying in the catchment covers 35 percent of the land area. The SPG property is one of these three farms. Notably, there has been a corresponding increase in the nitrogen loading recorded in the catchment. Figure 10.3 shows the annual measurement of nitrate loading in the catchment with a linear increase noted compared to the stable nitrate toxicity guideline of 1.5mg/L.



**Figure 10.3 Nitrate measurements in the Taharua Catchment**

Total nitrogen lost reflects the increased measurement of nitrate in the water. In the period between 1960 and 2010 total nitrogen lost increase 45 tonnes, to 150 tonnes. Notably in the year 2000 a total of 180 tonnes of nitrogen was lost (Table 10.4). The significant increase can be directly attributed to the increase in dairy activity within the region at the same time.



**Figure 10.4 Total nitrogen lost in the Taharua Catchment**

#### **10.4 Methodology: Assumptions for Cow Housing Analysis**

Financial analysis of implementing a cow housing system is performed over a 30 year period using net end of year cash flows discounted at 6 percent. The profitability of a cow housing scenario is measured against the current base farm system. End of year cash flows are calculated using the following assumptions of the annual costs and benefits.

##### **10.4.1 Costs**

(See appendix 4)

The cost associated with the cow housing facility were

1. The initial build cost of the housing structure and connected infrastructure
2. Increased feed cost
3. Increased tractor/ feeding out cost
4. Cost of repairs and maintenance to the housing facility
5. Borrowing and repayment costs

##### **10.4.1.1 Initial cost of the wintering facility**

The cost to build cow housing systems in New Zealand range from \$900 per cow to \$7000 per cow. This represents the numerous options ranging from a covered feed pad to an elaborate free stall barn. Free stall barns range from \$1800 to \$7000 per cow and incorporate full housing, feeding and effluent facilities. Herd Home structures are a common housing used in the Waikato region and incorporate a clear roof over a slatted floor effluent system. The cost of a Herd Home ranges between \$1800- \$2000 per cow. Soft floor standoff such as the Redpath can be constructed

for \$1000 per cow and incorporates a clear roof with ongoing cost to replace the woodchip bedding at intervals between 12 and 24 months.

For this analysis a hybrid design facility has been modelled at a cost of \$1350 per cow incorporating feeding, loafing standoff and effluent capture. This represents the need for a substantial feeding platform whilst at the same time being suitable to winter a majority of the cows on the milking platform. It is assumed economies of scale are involved given the scope of the project.

#### **10.4.1.2 Increased feeding costs**

Additional feed input is required to utilise the feeding infrastructure of the shed similar to an open feed pad. Best practice use of the shed would involve feeding a portion of the cows diet in the facility from January through September where proximity to the milking shed, shade and reduced walking requirements bring synergies for milk production and ease of farm management.

Further there is a large increase in feed required to winter cows at home on the platform to eliminate the cost of winter grazing. Table 10.1 details the percentage of diet fed in the housing facility and the total amount of supplement feed required.

Table 10.1 Amount of feed used in housing scenario (% of diet & total feed)

	Total Diet (kgDM/Cow/Day)	Fed in housing facility	Amount of Feed per cow per day kgDM	Number of Cows in Facility	Total Feed Eaten in Facility/ Day	Feed per Month kgDM
January	18	12%	2	2,400	5,184	155,520
February	18	12%	2	2,400	5,184	155,520
March	16	12%	2	2,400	4,608	138,240
April	16	18%	3	2,400	6,912	207,360
May	15	20%	3	2,500	7,500	225,000
June	11	100%	11	2,500	27,500	825,000
July	11	100%	11	2,500	27,500	825,000
August	16	25%	4	2,500	10,000	300,000
September	17	12%	2	1,500	3,060	91,800
October	18					
November	18					
December	18					
					Total Feed in Shed	2,923,440

Table 10.2 Current feed usage

Current Feed Usage	kgDM
Fruit	200,000
PKE	270,000
Silage	1,400,000
Total Suppl. Feed Current Scenario (On farm)	1,870,000
Plus winter grazing (External)	1,320,000
Total purchased feed	3,190,000

Table 10.3 Feed usage housing scenario

Feed Usage Housing Scenario	kgDM
Fruit	403,360
PKE	676,720
Silage	1,603,360
Gains from utilisation of feed	240,000
Supplement feed housing scenario	2,683,440
Total feed in shed	2,923,440
Increase from base scenario (on farm)	813,440

Supplementary feed used in the housing facility was assumed to be pasture silage harvested on the farm, fruit pomace from the Hawkes Bay and Palm Kernel Expeller. The total amount of feed used in the shed is 2,923,440 kgDM annually (Table 10.1). Table 10.3 shows an additional 813,440 kgDM requirement for the housing scenario compared to the current on farm feeding levels (Table 10.2). Notably this includes an increase in utilisation of current feed equal to 240,000kgDM annually.

Table 10.4 Allocation and cost of additional supplementary feed

Palm Kernel increased volume (kgDM)	406,720
PKE cost per kgDM	\$ 0.32
Total PKE cost	\$ 130,150
Increase Silage Required (kgDM)	203,360
Cost per kgDM Silage	\$ 0.20
Total Silage Cost	\$ 40,672
Increased Fruit Required (kgDM)	203,360
Cost per kgDM Silage	\$ 0.20
Total Silage Cost	\$ 40,672
<b>Total Cost</b>	<b>\$ 211,494</b>

Allocation of additional feed is summarised in table 10.4. An additional 406,720 kgDM of PKE is required at a cost of 32 cents per kgDM. Equal increases are assumed for feeding of fruit and of silage with an additional 203,360 kgDM of each required. The cost of fruit is assumed to be 20 cents per kgDM and silage also

valued at 20 cents per kgDM. The total cost of additional feed is modelled as \$211,494

#### **10.4.1.3 Increased tractor and feeding out cost**

With housed feeding infrastructure in place there is an increased cost associated with operating and maintaining feeding out machinery. It is assumed that on average over the year, the tractor would run for one additional hour per day and is assigned an economic value of \$100 per hour to include: labor, fuel, R&M and depreciation.

#### **10.4.1.4 Increased animal health expense**

For a successful cow housing scenario to work, all cows would need to be teat sealed prior to being wintered in the barn. It is assumed the cost of this is offset by reductions in animal health such as lameness. As such no increased animal health cost is modelled.

#### **10.4.1.5 Repairs and maintenance to housing facility**

It is assumed that repairs and maintenance associated with the housing facility begin in year three of operation and are related to the initial capital cost of the shed as a percentage. Repairs and maintenance from year three were assumed to be 0.2 percent of capital cost; increasing to 0.4 percent in year 10 for the remaining lifespan of the housing facility.

#### **10.4.1.6 Borrowing and repayment**

Implementation of cow housing is assumed to be debt funded with the total cost of the project financed by debt. An equal debt repayment schedule is formulated over the life of the housing facility based on a 30 year repayment period.

Interest costs are calculated as a percentage of the structures remaining debt. It is assumed the average interest rate of the 30 year period is 6.5 percent.

## **10.4.2 Benefits**

(See Appendix 4)

The benefits of cow housing were assumed to be:

1. Eliminate the cost associated with winter grazing 2000 cows per year
2. Increase pasture production
3. Increase milk production
4. Reduced death rate
5. Reduced empty rate
6. Reduced fertilizer cost/ valuation of effluent captured
7. Improved feed utilisation
8. Improved feed conversion efficiency

### **10.4.2.1 Estimated cost saving associated with winter grazing**

The current winter grazing arrangement includes 2000 cows grazing at neighboring property for the months of June and July. This incurs a cost of \$25 per cow per week a total of \$450,000 annually. A benefit of the housing facility would be eliminating this cost to the business or reducing the cost by wintering more of the 2000 cows on the platform. Notably this cost is offset by the increased feed cost to keep cows on the platform.

### **10.4.2.2 Increased milk solid production**

Milk solid production increases as a factor of higher feed input of the cows through both greater levels of brought in feed as well as through better utilisation of the current feeding levels. Increase in production was calculated as the difference between the housing scenario and the current scenario.

It is assumed current feed utilisation for pasture silage is 70 percent and 75 percent for PKE and fruit pomice respectively. Increasing the utilisation of feed to 90 percent for all feed using appropriate feed infrastructure the total volume of additional feed is 16,000kgDM per year. A feed to milk solid conversion of 15 kgDM feed to 1 kgMS is used to give an increase in production of 6 kgMS per cow.

Further, it is calculated that reducing walking distances on the farm by housing cows and optimising land closer to the cow shed, milk production per cow is increased. The increased production is considered to be a factor of partitioning less of feed energy to walking, reduced time out of lactation for lame cows as well as increased time harvesting or consuming feed. An increase on 0.05kgMS per day is assumed to be gained from reducing the long walks for 100 days in milk. This results in an increase of 5 kgMS per cow per year.

In summer months the value of a cow housing barn is in providing shade for the cows. It is assumed based upon the work of Dikmen and Hansen (2009) that 0.06 kgMS per cow per day is lost in the hottest 30 days of the year. This is equal to 2 kgMS per cow per year.

Similarly, warmth in the winter months is said to increase production through partitioning of feed by 0.06 kgMS per cow per day. It is assumed a cow housing facility would enable this gain to be achieved for a 30 day period. This equates to an increase of 2kgMS per cow per day.

It is assumed that 'days in milk' are extended by ten days with increased feeding and higher cow condition score. An increase of 10 days in milk is modelled at 1.3 kgMS per day. This results in an increase of 13 kgMS per cow per year.

An increase in conversion efficiency of feed of 0.01 kgMS per kg of feed is assumed for all supplement fed in the barn. This results in an increase of 5 kgMS per cow per year.

Total increase in milk solid production per cow is the sum of the above assumptions equating to 31 kgMS per cow per year.

The increased volume of the milk production is valued at the average payout less the average operating expenditure per milk solid. A gross margin per additional kgMS of \$3.00 is assumed. This results in a \$246,444 increase in revenue for the farm on an annual basis

#### **10.4.2.3 Increased pasture production**

A 1 percent lift in total pasture production over the whole farm has been assumed on the basis of reduced damage to pasture from pugging and over grazing. Further, there is an increase in pasture production from the even distribution of effluent from the wintering facility over the effluent block. An increase in pasture production is calculated over 1000 hectares at 1 percent. With current pasture growth equal to 8500kgDM per hectare, the increased growth provides a further 85 kgDM of pasture per hectare per year. Using a DairyNZ forage valuation index price of \$0.30 per kgDM of pasture grown, the value of increased feed is \$26 per hectare. Over the 1000 hectares assumed to increase by 1 percent this results in an increase of \$26,000 of feed.

#### **10.4.2.4 Reduced death rate**

Taharua currently has a high cow death rate. The contributing factors include Johnes disease, aging cows, stress from long walks and the extreme weather conditions. Of the contributing factors, managing the stress of the weather and the

physical walking distances are the only controllable factors. It is assumed building a wintering barn for use year round would prevent cow deaths by reducing walking distances on farm, maintaining the herd in higher body condition score and protecting cows from the elements during colder months. Cow housing would assist in management of animals with poor health keeping them sheltered well fed and easily accessible to staff. In total it is assumed a reduction of 1.5 percent in the death rate equivalent to 37 cows per year eliminating a write down in livestock valued at \$1000 per cow.

#### 10.4.2.5 Reduced empty rate

It is assumed that empty rate could be reduced by 1.5 percent from 12 percent to 10.5 percent. It is assumed the reduction in empty rate results in a reduced requirement for replacement heifers. The value of an in calf heifer is assumed to be \$900.

#### 10.4.3 Other Assumptions

Average DM production(KgDM/Ha)	8500
Efficiency of utilisation of pasture DM via Grazing	85%
Utilisation of feed within the wintering Barn	90%
kgDM per kgMS	15

## **10.5 Optimisation of Taharua**

An optimisation scenario using cow housing is modelled for Taharua and compared to the current farm scenario to compare and contrast the environmental and economic performance of the farm.

### **10.5.1 Base Scenario**

In the 2013/14 season Taharua milked 2300 cows twice a day. Total milk solid production was mid 600,000's kgMS. 2000 cows (74 percent) of the herd were winter off the farm at neighboring properties at a cost of \$25 per head per week for a total cost of \$450,000 per year. Significant pasture growth in late spring is harvested as pit silage with 1400t DM of pit silage made per year. Planned start of calving is the 15<sup>th</sup> of August, aiming to fit with the pasture growth curve.

The expansive farming systems is favorable for measuring environmental performance on a per hectare basis. N leaching for the 2013/14 season is modelled in Overseer as 20kg N leached per hectare. High levels of N leachate on the winter crop area of 138kg N/ha bring up the farm average. Leaching on pastured areas of the milking platform range from 16 to 18 kg N per hectare. An enabler of such low N leaching is the exclusion of cows over the winter months at winter grazing and the strategic use of expansive hill country to graze stock.

Table 10.5 Nutrient budget base scenario

	N leaching/ha	kg N/year
Non-Effluent West	18	12933
Non-Effluent East	18	5629
Effluent West	16	1992
Effluent East	16	3749
Winter Crop	137	8252
Tree and Scrub	3	450
Extensive	11	3793
Other sources		1143
Whole Farm	20	34281

Table 10.6 Summary of current scenario

	<b>Current Scenario</b>
Effective Hectares	1250
Peak cows milked	2300
kgMS per Cow	250- 275
kgMS per Ha	450- 500
Feeding infrastructure	In Shed
Supplement feed eaten	
Supplement feed imported	
Average cost of imported feed	\$0.25
Silage grown on Farm	
Crop grown on farm	
Death Rate	5-10%
Empty Rate	8-12%
Planned start of calving	
Winter grazing	Yes (75%)
Cost of Winter Grazing	\$450,000

### **10.5.2 Housing Scenario**

A cow housing scenario for Taharua involves building a wintering barn facility to house peak cow numbers of 2500 cows at 7m<sup>2</sup> per cow for a total cost of \$3,375,000.

The facility is 17,500m<sup>2</sup> or 1.75 hectares under cover.

In this scenario, all 2500 milking cows are wintered on the milking platform being fed indoors for June and July. This results in an initial reduction of \$450,000 dollars to the business in external winter grazing.

Winter feeding policy includes cows fed 11 kgDM per day on a combination of pasture, grass silage, PKE and fruit pumice.

Milk production is increased 32 kgMS per cow to above 300kgMS per cow. Per hectare production is lifted from near 500 kgMS per hectare to near 600 kgMS per hectare. For the farm as a whole production is increased to above 750,000 kgMS.

### **10.5.3 Financial Implications**

A 30 year discounted cash flow model is used to derive the net present value and internal rate of return for the cow housing project. A long term average milk price of \$6.50 is used to value the increase in milk solids less the marginal cost of production assumed to be \$3.50. Therefore a gross margin on additional milk solids is equal to \$3.00.

Both the NPV and IRR are calculated excluding interest cost on a discounted net cash flow. An initial discount rate of 6 percent is used on all future cashflows. A sensitivity to this rate is considered.

For the housing scenario modelled using the physical and financial assumptions detailed above, building a cow housing facility returns a positive NPV of \$2,572,348 and an IRR of 13.87 percent.

Return on asset inclusive of borrowing and repayment is shown to be 6 percent in years 1 through 5 increasing linearly to 12 percent with a diminishing cost of interest. Average return on asset is 9.1 percent for the 30 year analysis period.

## Sensitivity analysis

In modelling the cow housing scenario for Taharua several assumptions are made such as to long term averages on input prices and interest rates as well as to the capital cost of the project. The following explores the financial sensitivity to movement in the assumed cost.

Initial build cost is shown to have the largest cost influence on the housing scenario. It is assumed the housing facility could be built at a cost of \$1350 per cow. As the cost of the facility is increased there is a relative decrease in both the IRR and NPV of the scenario. Table 10.7 show an increase of \$350 per cow in initial build cost will result in NPV diminished to only 51 percent of the NPV at \$1350 build cost.

Table 10.7 Sensitivity to initial capital cost

	\$ 1,350	\$ 1,400	\$ 1,450	\$ 1,500	\$ 1,550	\$ 1,600	\$ 1,650	\$ 1,700
IRR	13.87 %	13.08 %	12.34%	11.64 %	11.00 %	10.39%	9.81 %	9.27 %
NPV	\$ 2,572,348	\$ 2,392,486	\$ 2,212,624	\$ 2,032,761	\$ 1,852,899	\$ 1,673,037	\$ 1,493,175	\$ 1,313,313
ROA	9.1 %	8.52 %	7.98 %	7.49 %	7.02 %	6.59 %	6.18 %	5.79 %

Long term average milk sold payout has an influence on the feasibility of the housing facility. Sensitivity analysis ranging from \$5.00 per kgMS to \$7.50 per kgMS shows a respective range of IRR from 8.76 percent to 17.32 percent (Table 10.8).

Table 10.8 Sensitivity to milk price payout

	\$ 5.00	\$ 5.50	\$ 6.00	\$ 6.50	\$ 7.00	\$ 7.50
IRR	8.76 %	10.48 %	12.18 %	13.87 %	15.58 %	17.32 %
NPV	\$ 876,214	\$ 1,441,592	\$ 2,006,970	\$ 2,572,348	\$ 3,137,725	\$ 3,703,103

A significant assumption of the financial analysis performed on the housing scenario was setting a discount rate of 6 percent. The discount rate is the required rate of return on all future cash flows. A range of discount rates from 5 percent to 8 percent were modelled for their effect on the scenarios NPV. Table 10.9 shows the change in NPV as a function of an increasing discount rate

Table 10.9 Sensitivity to discount rate

	5%	5.50%	6%	6.50%	7%	7.50%	8%
	\$	\$	\$	\$	\$	\$	\$
NPV	3,210,695	2,877,111	2,572,348	2,293,491	2,037,955	1,803,446	1,587,921

Lastly, with increased reliance on purchased supplementary feed to winter cows on the milking platform, there is an increased risk exposure to the price of imported feed. PKE has been modelled to fill the majority of the increased feed requirement. Table 10.10 shows the relative loss of profitability through the diminishing NPV and IRR as a function of an increase in the cost of purchased Palm Kernel from 25 cents to 40 cents.

Table 10.10 Sensitivity to cost of purchased Palm Kernel Expeller

	\$ 0.25	\$ 0.30	\$ 0.35	\$ 0.40
IRR	15.06 %	14.21 %	13.37 %	12.53 %
NPV	\$ 2,964,238	\$ 2,684,316	\$ 2,404,395	\$ 2,124,473

#### 10.5.4 Nutrient Implications

Table 10.6 details the results of a nutrient budgets for the cow housing scenario and is contrast to the base scenario. Notably, there is a decrease of one kg in the kgN leached per hectare. N leaching is decreased to 19 kg N per hectare despite wintering all cows on the milking platform. In net terms total N lost is reduced by 1.1 tonnes to 33.1 tonnes annually. Changes to the nutrient budget from the base scenario include an 8.2 tonne reduction in N loss through crop however an increase in N loss through the effluent area through disposing of effluent from the housing facility on the same scale effluent area.

Table 10.11 Nutrient budget housing scenario versus base scenario

	Base Scenario		Housing Scenario		Change	
	KG N leaching/ha	kg N/year	KG N leaching/ha	kg N/year	KG N leaching/ha	kg N/year
Non-Effluent West	18	12933	15	7853	-3	-5080
Non-Effluent East	18	5629	15	5017	-3	-612
Effluent West	16	1992	26	4230	+10	2238
Effluent East	16	3749	43	10048	+27	6299
Winter Crop	137	8252	-	-	-137	-8252
Tree and Scrub	3	450	3	450	-	-
Extensive	11	3793	11	3835	-	-
Other sources	-	1143	-	1749	-	606
Whole Farm	20	34281	19	33181	-	-1100

Table 10.12 Summary of housing scenario

	<b>Current Scenario (2014)</b>	<b>Proposed Housing Scenario</b>
Effective Hectares	1250	1250
Peak cows milked	2300	2500
kgMS per cow	250 - 270	300- 350
kgMS per Ha	450 - 550	600- 658
Total kgMS	600 - 650,000	700- 750,000
Feeding infrastructure	In Shed	Cow barn w/ feedpad
Supplement feed eaten		
Supplement feed imported		
Average cost of imported feed		
Silage grown on Farm	1400T	1400T
Winter Crop grown on farm	60ha	0ha

## **10.6 Housing Scenario Discussion**

In support of the evidence presented in chapter eight and nine, modelling of a cow housing scenario for a large scale Taharua dairy unit shows there are economic and environmental efficiencies to be made from investment in a cow housing facility.

Financial modelling over a 30 year useful life shows the end of year cash flows including borrowing and repayment cost to be positive when modelled using a range of discount rates and long term milk price payouts.

For Taharua farm with a relatively low base line nutrient loss, the gains in environmental performance are not as large as on other farming systems measured on a per hectare basis. However a decrease of 1.1 tonnes of N loss is a significant reduction for the catchment. A winter housing facility eliminates the need for winter cropping which is the largest contributor to the N loss for the farm system on a per hectare basis. Further the use of housing builds future capacity for the farm to increase in terms of cow numbers with the expected gains in pasture growth whilst maintaining a stable or decreasing environmental footprint.

It is shown that implementing cow housing as in the above modelled scenario that the breakeven payout across the whole dairy unit can be lowered, therefore removing risk and adding resilience to the farm system. An additional \$200,000 of modelled economic benefit in the first ten years can be spread across the milk solid production giving a further 26 cents per kgMS produced. This increases to \$400,000 by year 30 giving another 52 cents per kgMS produced of increased margin. At the same time, an intensified farm system has a greater risk exposure to the cost of feed as modelled in the sensitivity to palm kernel cost with a decrease of 2.5 percent in

the IRR as palm kernel price increased from 25 cent per kgDM to 40 cents per kgDM.

The initial capital cost of housing at this scale is a hurdle for many farm systems. The extent to which some large dairy farms are geared financially makes investment in housing facilities non-viable. In this analysis the initial capital cost is near 30 percent of the farms capital value. As such the availability of debt finance is a variable factor and must be considered on a case by case basis. However, compared to other mitigation strategies for environment compliance, the investment in certain cow housing facilities is proven to generate a cash return on invested capital. Other such compliance infrastructure investments fail to generate sufficient increased revenue to cover the cost of installation and debt servicing.

## **11.0 Survey of Compliance Cost**

The primary objective of this research was to determine the comparative on farm cost of compliance for Waikato farm systems. Modelling of average Waikato farm systems in chapter nine detailed the relative environmental and economic impact of changing farm management and farm infrastructure for each farming system. An understanding of the specific costs incurred to achieve compliance under each farm system is needed to analyse the efficiencies and comparative costs between systems. Specific costs and characteristics of compliance spending have been collected through an interview and survey process of selected questions to Waikato dairy farmers of differing scales, farming systems and physical/geographical constraints. The following section discusses the data collected and provides analysis of the comparative costs of compliance.

### **11.1 Characteristics of the Survey**

A short three page survey (Appendix 5) was presented to Waikato dairy farmers in hard copy and electronic (email) form as the basis for discussion and information gathering regarding the initial capital cost of environmental compliance for their own farm system. Importantly, the survey was completed on a voluntary basis with no incentive to farmers outside the benefit of contributing to the knowledge pool of compliance information and farm system optimisation.

The survey can be summarised as three sections. Section one gathers a physical systems profile with regard to scale, farm system and production. The second section is used to determine what, when and why investment was made in compliance, as well as the economic cost of compliance incurred. Finally, the third section questioned the benefits of the compliance spending with regard to receiving

certification of a compliant farm system from the Waikato Regional Council as well farm nitrogen efficiencies and losses. This section also provided scope for farmers to discuss support mechanisms for environmental compliance and their general attitude and understanding of the compliance process.

As discussed in chapter four, the survey was strictly limited length with a majority of the questions asked requiring only a yes or no tick box answers. This approach to survey design ensured maximum response of the vital information whilst still giving those with further time to expand answers through an optional general comment question. It is important to note, the survey was not widely distributed to all Waikato farmers. Rather, farmers were approached to complete the survey. Farmers were selected being known to the researcher and research supervisors or through DairyNZ discussion groups, as such a range of farmer responses were gathered.

## **11.2 Survey Results**

Survey results gathered from a range of Waikato owner operator farmers has provided compliance cost data from across the region. The average scale of all farms surveyed was 353 cows and 107 hectares. An equal spread of farming systems were surveyed ranging from low stocking rate and low input to highly stocked intensive system five dairy farms. Of the respondents, 29 percent were low input systems, 38 percent medium input and 33 percent high input systems.

Aggregated survey results show the cost of environmental compliance is a real cost to every farm business through either a one off infrastructure establishment cost or through an ongoing financial cost or opportunity cost to run an environmentally compliant farm system change. Of the Waikato farmers surveyed every farm

indicated they had incurred some degree of economic cost of environmental compliance as a result of regulation imposed from the Waikato Regional Council or from their dairy company. For the majority of farmers surveyed, the costs incurred to date have been regarding effluent compliance and the need for upgraded storage and treatment of effluent. An underlying theme evident in each survey response is the general lack of existing effluent infrastructure. This highlights that central government objectives - under the National Policy Statement for Freshwater of moving to compliant farm systems- requires significant technological advancement in effluent infrastructure. Secondly, the lack of existing infrastructure provides insight as to the mentality shift required by dairy farmers, who have for generations seen limited effluent infrastructure as adequate.

### **11.3 Quantitative Results**

The economic cost of compliance was determined in asking dairy farmers the initial capital cost of farm infrastructure for compliance as well as for a quantified loss of revenue due to changes in farming system. The responses given were used in conjunction with the physical parameters stated in section one of the survey to report a cost of compliance expressed as a per cow, a per hectare and a per milk solid capital cost.

Within the survey questions the cost of compliance infrastructure was asked for in grouped valuations to the nearest \$50,000. For the purposes of this analysis, where the actual cost was not specified, the midpoint of each valuation group was used as the actual cost.

Aggregated results show the average initial capital cost of compliance surveyed is \$1.03 per kgMS. For the average farm system surveyed this places the capital spend required in the bracket of \$130,000 to \$170,000 dollars as establishment cost. For the average Waikato dairy farm (DairyNZ, 2014), with lower total milk solids, the capital cost is \$110,000. Further analysis shows that average capital costs were \$1487 per hectare and \$404 per cow.

A clear indication of the comparative capital cost of compliance is gained by analysing survey responses in their respective farm system groupings. Table 11.1 details the results of the analysis per farm system.

Table 11.1 Survey results by farm system

	<b>Aggregated</b>	<b>Low</b>	<b>Medium</b>	<b>High</b>
<b>Cost per kgMS (\$)</b>	1.02	0.65	1.24	0.93
<b>Cost per hectare (\$)</b>	1,490	718	1,507	2,112
<b>Cost per cow (\$)</b>	403	234	472	464
<b>Average total (\$)</b>	138,556	75,000	167,000	158,333

For the low input farms surveyed the capital cost of compliance is found to be lowest across each measure. This is due to the lower impact of these farm systems on the environment through lower stocking rates and less effluent generation. Costs per kgMS are recorded as \$0.65, half that of the medium input system. Per hectare costs are \$718 and per cow costs were \$234. Of the farmers surveyed the average investment in compliance systems to date was \$75,000.

Medium input systems incur increased need for compliance infrastructure as a function of stocking rate and nutrient input. This is reflected in the survey data which shows cost of compliance per milk solid is \$1.24, the highest of all systems. Further, the reported cost per cow is inflated being \$472 per cow. For the medium

input farms (38 percent of total survey), the average investment in compliance was the highest of all systems being \$167,000.

For the high input farms surveyed, results show that despite the higher infrastructure requirements needed to operate a compliant high input system, the capital cost of establishing compliance infrastructure and farm management systems is a more effective investment when considered from a per milk solid and a per cow perspective. However, as a function of higher stocking rates the cost per hectare is greater. Results from high input farmers (33 percent of respondents) show the cost per kgMS is \$0.93, being \$0.31 lower than that for the medium input system. Similarly per cow cost is lower, however by a smaller margin than the per milk solid cost. Capital cost per cow is \$464 compared to \$472 for the medium system. A steep increase in the compliance cost of \$605 per hectare was calculated for the high input systems surveyed when compared to the medium input systems. Total capital cost per hectare is shown as \$2112.

Further, analysis of the aggregate survey data shows there is a significant cost differential on the basis of farm size. For the large farms surveyed (Above 150 hectares), the average farm size was 220 hectares. Despite the higher total cost as a function of scale, there are efficiencies of the cost incurred when analysed per milk solid, per cow and per hectare. The capital cost of compliance per kgMS, per hectare and per cow are all shown to be less than for the aggregated survey results. Average capital cost per kgMS was \$0.56 near half the cost in the aggregated results. Similar reductions are recorded in both the per hectare and the per cow measures being \$681 and \$221 respectively.

An explanation for the lower compliance cost structure is given through qualitative survey results. Of the large farms surveyed, there is a higher level of existing compliance infrastructure in place therefore lowering the required capital spend to achieve minimum compliance standard. Further, there are evident economies of scale with regard to implementing capital infrastructure projects with fixed cost spread over greater production and scale.

A validation of the quantitative survey results is provided through the survey of environmental spending conducted for the Horizons Manawatu region. The survey published by Federated Farmers reports average compliance spending of \$110,000 per farm (i.e. 85 cents per kgMS) (Stewart, 2014).

Currently there is no regulatory obligation for dairy farmers in the Waikato to perform nutrient budgeting or to understand their environmental impact measured through N leaching. Despite this, self-imposed nutrient reporting facilitated by dairy companies and fertilizer company representatives has given some farmers the ability to understand their nutrient impact. Within the survey, farmers were asked for their most recent N leaching figure if known. It was found 44 percent of surveyed farmers knew their N leached per hectare. The average N leaching for all farms surveyed was 40 kg N per hectare. Notably, the N leaching data reported was from nutrient budgets completed 'post' installing compliance infrastructure. It is therefore possible to extrapolate this result to conclude that compliance investment to date has not been concentrated on diffuse environmental impacts, rather mitigating point source effluent contamination.

#### **11.4 Qualitative Results**

Section three of the survey provided farmers with the opportunity to expand on their experience with the compliance process, dealings with the Waikato Regional Council and their thoughts as to the ideal support structures for compliance as well as providing recommendations for administration of future of future regulatory frameworks.

A thematic assessment of survey responses revealed four major discussion points for farmers. Individual farmer comments were grouped accordingly to their nature. The first and most significant theme which emerged in comments related to uncertainty with regard to regulation. This encompassed an uncertainty for the future of regulatory frameworks as well as a lack of understanding of the current regulation. A second and equally discussed theme is the negative public perception of dairy farmers present in society. This includes the lack of understanding by general public as to the financial cost of compliance as well as the economic contribution of the dairy sector to the economy. The popular media campaign of “dirty dairying” was a reoccurring theme in responses with comments discussing the damage caused to the industry. A third theme established in survey comments is the high financial cost of compliance with little tangible financial reward on the business. A general consensus was formed in the majority of the surveys to suggest the significant capital cost imposed on the business was high with regard to existing capital commitments and annual cash flow. Lastly, the survey asked respondents as to their opinion of current support mechanisms and structures for the compliance process as well as seeking to prompt discussion as to the optimum support structures.

#### 11.4.1 Farmer Uncertainty

A general uncertainty in farmer attitude toward compliance is noted in the survey. There is both uncertainty as to current regulation as well as the impact that future regulation will impose on the farm business. One identified uncertainty was the number of authorities and advisors in the regulatory process. For Waikato farmers, regulation is ultimately set and administered by the Waikato Regional Council. However, further to this individual dairy companies such as Fonterra have taken an active role in auditing and enforcing the environmental compliance of farms. From survey responses, there is uncertainty as to what is required and by whom. Currently farmers are reporting data on compliance to multiple organisations with several visits down the tanker track. For the purposes of accuracy, a standardised cross organisation data collection process would eliminate wastage and go some way to resolving farmer uncertainty.

A significant majority of the farmers surveyed (84 percent) had been visited by a representative of the Waikato Regional Council to discuss their individual farm with regards to the existing regulation. Contrary to popular perception, selected results indicate that farm visits from a council representative were helpful in understanding the obligations for compliance under existing regulation. However, it was noted that although able to comment on existing regulation, council representatives were unable to advise on suitable compliance measures to ensure the farm meet regulatory requirements into the foreseeable future.

Further, comment in 22 percent of the surveys indicated that despite the farmers having invested significantly to become environmentally compliant, Regional Council staff were not able to advise if the farm met or would continue to meet

compliance regulation to become compliance approved. For administrators of the regulatory framework, amending the perception of uncertainty post compliance investment is necessary in shifting both attitude and a culture of compliance, especially given further regulatory restriction and subsequent changes to farm systems will be required in future.

Despite the uncertainty expressed in the survey responses, there is an appreciation by dairy farmers that the science informing regulatory frameworks is a continuous process and as such, regulation will change. In response, it was suggested that fixed term compliance certificates could be granted as a guarantee for farm businesses to assist with annual planning for capital works as well as allowing for flexibility from both regulator and farmer as to the terms of environmental compliance for future periods.

An appreciation of current flexibility by council with regard to deadlines for compliance is in some instances promoting a culture of postponing compliance investment in case of rule changes. There is general consensus that fixed and specific guide lines at a local catchment level would provide a stable platform for farmers to invest in compliance by removing the termed ‘grey’ area from investment decisions.

#### **11.4.2 Poor Public Perception**

Survey responses used as a proxy for a regional snapshot suggest the majority of Waikato dairy farmers have incurred a cost of compliance in lifting their environmental performance. Despite the significant investments being made, mainstream media headlines continue to highlight a minority group of farms who

are environmentally unlawful. As a consequence, there is building negativity toward the dairy industry in the Waikato.

The extent to which Waikato farmers are concerned about their environmental image is best summarised through a survey response stating

*“I am sick of the continuous media bashing in mainstream media and traction made by the dirty dairy campaign”*

The concern of dairy farmers regarding the perception of dairy is such that two survey responses indicated a desire for a publicised platform whereby the industry could showcase the investment and progress made toward compliance and sustaining the environment.

#### **11.4.3 High Capital Cost Requirements**

The capital cost of compliance was identified as having a poor rate of return on the farm business. The majority of respondents struggle to see the benefits from the infrastructure investment and see it rather as a new operational and infrastructure expense. With the average cost of compliance determined in the survey as being above \$130,000, the implementation of adequate compliance infrastructure is not realistically financed out of farm cash flow. DairyNZ (2013a) reported national average farm surplus for drawings and investment in capital projects to be \$1.01 per kgMS meaning for most farm businesses the cost of compliance is equal to the pre drawings surplus. This means to complete effluent compliance there is a necessity for debt funding. The compliance loan facilities of money offered at the cost of capital by some banks was welcomed by farmers surveyed. Despite the uncertainty regarding the cost versus benefit of compliance investment, the high

capital costs were adequately placed into perspective by a survey respondent with the remark “ *..the costs to our business will be greater if we do not do anything*”.

#### **11.4.4 Support structures**

In surveying farmers regarding support organisations and systems for compliance, there is evidence to suggest the current system is not sufficiently meeting the needs of farmers in the compliance process. The main causes for inadequacy relate to the multi organisation and mixed message approach. At the same time, several recommendations are put forward for a optimised future support structure.

Asked who should be providing support for dairy farmers with understanding and implementing compliant farm systems there was unity in opinion. Within the survey farmers showed that support from DairyNZ, the respective dairy company and the Waikato Regional Council is required on an ongoing basis. However the continued support must be provided in a unified approach.

There is a general consensus in the survey responses that dairy farmers are financially supporting DairyNZ through a milk solid levy, Fonterra sustainability teams through the cooperative ownership model as well as the Waikato Regional Council through paying rates. It is agreed in the current ownership and payment structures there is sufficient financial contribution from farmers to develop adequate support for the compliance process without the need for further financial input from the farmer.

## 12.0 The Costs of Compliance

The increase in environmental regulation and the subsequent need for compliant dairy farming systems has several implications for New Zealand's dairy industry economically, socially and environmentally. The following discussion summarises the key findings of this research with regard to the objective of determining the comparative costs of environmental compliance between Waikato farming systems and the implications of an increasing regulatory framework for the Waikato dairy industry.

As a result of the increasing regulatory environment there is a need to optimise the way in which farm systems are employed and managed so as to maximise the profitability and environmental sustainability of all farms. Improving the environmental performance of New Zealand dairy farms will require farm management change, additional farm infrastructure and changes in land use policy with the requisite for maintaining a stable or increased economic return. At the same time, farming within the limits of environmental regulation has the potential to generate a tragedy of the commons whereby each individual farm system moves to optimise their individual performance at the detriment of the common good. It is possible that without appropriate checks, that at both a catchment and national level the common resource (New Zealand's water quality) could deteriorate under limits based environmental regulation. When considering the interaction of dairy and the environment, there is an underlying requirement for improvement of the common resource through an overall lowered impact.

For the Waikato pastoral farm systems analysed, there is a clear increase in the modelled environmental impact as the farm system is intensified through increased feed and stocking rate. Given this increase, it can be said the abatement cost increases with farm system intensification. Despite a higher modelled environmental impact through N loss, comparative analysis of N leaching efficiency for the same farm systems show that N leaching efficiency is increased for high input farm systems by nature of milk solid production increasing at a greater rate than N loss. However, for the modelled system three farms, the extent to which N losses are increased are not met by increases in production. As a result the N leaching efficiency of system three farms is lower than that of the low and the high input farm systems.

Further analysis of Waikato farm systems for their economic and environmental efficiency through Overseer and Dairy Feed Planner modelling showed that for the average low input farm system there is a 25 percent lower environmental impact compared to the medium input system by nature of lower stocking rates and low intensity feeding. Using long term pricing models for farm gate milk price and feed cost, the relative economic performance of the same low input farming system was shown to be higher measured through farm surplus per hectare.

In economic modelling of mitigation options, the performance of the low input farm system provided economic stability. A linear response to payout is recorded in which farm surplus per hectare remains positive to the lowest modelled payout of \$4.50 per kgMS for all mitigation options modelled. This is in contrast to both the medium and high input farm systems modelled. Adopting the same mitigation scenarios for the medium and high input system, a greater sensitivity to farm gate milk price payout is observed. However the larger returns on a high payout are

offset by negative farm surplus at a \$4.50 and \$5.00 payout for the medium and high input farm respectively. This modelling therefore suggests lowering the farm system intensity lowers exposure to both economic risk and environmental performance risk while increasing the resilience of the farm business.

Supporting evidence from low input farm systems was collected in farmer surveys which suggests there are material economic advantages regarding the capital cost of compliance with all measures reporting lowered cost as a function of high base line performance and less change required on a comparative basis to achieve compliance.

However, for all of the Waikato dairy farm systems to move toward lower input farm systems so as to achieve a lower comparable cost of compliance, there is a significant opportunity cost with regard to volume of production and productivity. This has significant flow on effects for key economic measures such as employment, regional development, export targets, government growth agendas and manufacturing efficiency.

There is further need to consider that for a farm system investing in compliance through infrastructure or management changes, the decision making process is driven by multiple variables, influenced by the biophysical nature of a dairy farm system. Farm management practices, stocking rate, existing infrastructure, business objectives and the level of intensity within the chosen farm system each have a significant impact on the amount of N leaching reduction able to be achieved. For example, supplementary feeding practices are strongly influenced by farm context particularly the capacity to grow feed on farm, the cost of purchased feed and ability to feed out. All this suggests farmers are unlikely to make major changes to their

supplementary feeding practices to reduce nutrient emissions. As such the notion of a rational decision maker where by all compliance decisions result in the highest level of N reduction is not valid in the compliance process. Drivers of farm systems which have influence on the compliance decision making process include the high debt level carried by industry (current average \$1.39 per kgMS (DairyNZ, 2013a). Notably, the variables which influence the desired outcomes of investment in compliance vary on a regional and seasonal basis and are significantly influenced by the individual management actions of the farmer.

When considering the marginal cost of compliance between farm systems surveyed, there are notable increases between the farm systems. The marginal cost of compliance between a low and a medium input system is shown as \$0.59 per kgMS, \$789 per hectare and \$238 per cow. Compared to the marginal cost reported between the medium and high input system which is \$0.31 less per kgMS, \$8.00 less per cow but \$605 more per hectare. This reflects that for the system three farms surveyed the increased production achieved was not increased to the extent that compliance infrastructure costs increased.

There is growing concern at central government level that there is a limit to the growth that the dairy industry can sustain to meet value creation targets whilst simultaneously meeting water quality targets. The way in which dairy will “add value” is changing from purely manufacturing increased export volumes to considering the industry environmental footprint. However, given the requirement for value growth and the need to maintain economic performance metrics, there is a need to determine where dairy can best achieve this value creation. One measure of value add for the industry under increase regulation is increasing the volume of export produce whilst maintaining an equal N footprint. Current dairy statistics

indicate growth in the supply of milk is occurring at 2.2 percent per annum (DairyNZ, 2013a). Extrapolated from this figure, the ten year increase in milk solid supply is equal to 27 percent growth from current levels. For the dairy industry nationally, the opportunity to add value is in minimizing or maintain the same nitrogen footprint. Research by DairyNZ indicates that to maintain a steady N loss footprint over the next ten years requires a reduction in total N lost by 21 percent (Pridmore, 2014).

The ability of New Zealand dairy farmers to adapt to the regulatory changes imposed by regional and central government will be a key determinant of the industry's success. It is found through farmer survey that dairy farmers with an interest and willingness to develop their own understanding of the environmental issues and as a result who incorporate environmental best practice into their farming systems will be the most successful in the long run. In the Waikato it is evident that there has been a shift in farmer mindset toward environmental compliance. This shift has been driven largely by the lack of existing effluent infrastructure and the need for most farms to upgrade the way effluent is managed. For dairy farms this change has been a tangible investment in farm infrastructure which has provided the farm benefit above compliance approval. The investment in compliant farm effluent systems has been reflected in rural media, industry strategy documents, and has been confirmed through the farmer surveys in this research. Despite the traction gained in moving toward compliant and profitable farming systems, there is still a general lack of understanding as to how investment in compliant infrastructure and compliant farm systems can be maximised.

Even with the cultural shift to have Waikato farms effluent compliant, the next step being suggested to improve waterways in the Waikato region, as set out within the

National Policy Statements for Freshwater, is a limits based regulation. For many dairy farmers the shift to full nutrient budgeting and mitigation of N loss – an intangible- will require a significant shift in mindset.

Substantial impediments to progress in the compliance process for Waikato farms include lack of resource in independent compliance advisory, on farm mind set, and limited scenario research detailing the economic and environmental impacts. With barriers to achieving compliance identified there is a threat that the shift to fully compliant farm systems is not completed in a timely fashion and also that the investment and subsequent infrastructure and management changes are inappropriate solutions to the identified problem. Further there is risk for the industry that slow response to regulation will add to the negative industry perception by the public and consumers. Additionally, there is a risk that the regulatory framework will move to impose further limiting regulation resulting in an unmanageable framework.

An important driver of building a mind-set of environmental compliance for dairy farmers is the relationship between regulator and farmer. Results within the survey to Waikato farmers demonstrated those who took a proactive approach to farming within the regulation enjoyed a positive working relationship with the regulators. For the dairy industry moving forward under an increasingly regulated environment, the relationship between individual farmers and their regulatory body will be a significant driver of the extent to which regulation is implemented, monitored and enforced. The initial efforts made on behalf of farmers through industry good organisations such as DairyNZ, Federated Farmers as well as through dairy processors can only go so far in the efforts to develop a supportive regulatory environment. There is a strong need for regulators and farmers to approach both the

environmental and economic on-farm implication of compliance with open minds to creating a sustainable industry.

The public perception of dairy remains a critical point for the industry while trying to achieve full environmental compliance. The current lack of unity between industry and non-industry is having a negative influence on political and social credit being built by the industry as a large majority of farms become environmentally compliant. Progress with regard to effluent compliance has minimised the frequency and severity of events able to be published under a 'dirty dairy' brand, however there continues to be negative portrayal in mainstream media discrediting compliance investment. A complicating variable within dairy systems is the time delay between management actions and the resulting nutrient effect. Thus, despite action taken to mitigate nitrogen loss there continues to be water quality reporting indicating no significant decreases. This also contributes to the poor public perception of the industry.

The opportunity cost for not investing in adequate storage and application of effluent in the short term is likely to increase as the use of fines and the threat of dairy companies refusing to collect milk becomes common practice. Fundamentally, compliance with environmental regulation is a minimum standard which the dairy industry must adopt. The target is for industry best practice, which involves a daily challenge for dairy farmers and their staff to manage all elements of the farming system with the highest regard for the natural environment.

This research has looked at the economic and environmental implications for Waikato farmers changing farm systems under increasing regulation. A large number of assumptions have been used to generate scenario comparisons between

farming systems to show comparisons. Specifically modelling of milk price, feed cost and rainfall data have been kept to long term averages. In performing modelling of farm systems there has been emphasis on running 'most likely scenarios' with regard to the extent of mitigation options modelled. While the modelling is not farm or seasonally specific, there is scope to apply the modelled framework to an individual Waikato farm with actual data inputs to measure the change in nutrient loss and financial position. There is further research needed to run similar mitigation scenarios to model the economic and environmental implications for other dairy regions using soil types and farm systems appropriate to those areas. It is necessary for further research to be in advance of the likely regulatory and policy changes such as caps to nitrogen leaching for all New Zealand land uses.

In surveying Waikato farms this research was limited by the constraints of post graduate studies. As such results were used as a snapshot of compliance spending to reinforce modelled data. A further wide spread survey of compliance data would provide industry with solid evidence of investment to date and go some way to removing the poor public perception.

## 13.0 Conclusion

Achieving environmental sustainability of dairy farm systems has become a leading driver for the New Zealand dairy industry. Inherently there is a financial cost to adapting traditional dairy farm systems to achieve improved environmental performance. The total cost of mitigating environmental impact is shown to be closely linked to the intensity of the farm system. However there are certain measures which show efficiencies of investment for higher input farms by nature of increased production and cow numbers.

The increasing stringency of environmental regulation in the Waikato has changed farmer and industry culture with regard to the necessity for adopting sustainable farm systems. To date, regulation has been focused on mitigation of point source pollution, increasing effluent compliance and water consenting. This reflects that in the Waikato catchment, the large number of individual farms and the small scale of operations is a limiting factor in implementing regulation which targeted both point source and diffuse source pollution.

The average initial capital cost of effluent upgrades to date is found to be \$1 per kgMS for Waikato dairy farm systems. With the Waikato region producing 378,529,678 kgMS (DairyNZ, 2014), it is estimated the capital cost of compliance infrastructure to date is above \$300,000,000.

Dairy farming with environmental sustainability as a key farm business driver represents a significant shift in culture for the dairy industry as a whole. Existing regulation in the Waikato has been used to shift farmer attitude toward accounting for their impact on the environment and providing guidance for investing in environmental sustainability. Continued shifts in the regulatory framework will aid

the shift of an industry culture toward greater environmental awareness and compliance. Farming with N loss limits is likely to be reality for Waikato farmers in the future. This analysis has shown that for Waikato dairy farm systems there are opportunities in which additional farm infrastructure and changes in farm management policies can provide increased economic and environmental sustainability.

One possible farm infrastructure investment is the use of cow housing technology which is shown to decrease N loss by up to 15 percent whilst increasing farm surplus per hectare by 17 percent on average. Despite the clear advantages, high capital cost remains a barrier to implementation, more so in a volatile short term economic climate of increasing interest rates and suppressed farm gate milk price.

Fundamentally, environmental regulation is not yet the determining driver of current Waikato farm systems in the majority of catchments across the region. Existing regulation has been used to deal with lifting the standards of effluent storage and application. It is likely that as N loss limits are used to generate future regulation that farm nutrient budgets will be used to inform the implementation of changes to farm systems. At this point there are efficiencies to be gained through lower input and lower footprint farm systems as well as through high input farms with sufficient mitigation strategies in place.

## 14.0 References

- AgResearch. (2014). *Farm Software*. Retrieved from <http://www.agresearch.co.nz/business/products/farm-software/Pages/default.aspx>
- Anastasiadis, S., & Kerr, S. (2013a). *Land Use and Farming Intensity For 1996,2008 and 2020*. Motu Economic and Public Policy Research
- Anastasiadis, S., & Kerr, S. (2013b). Mitigation and Heterogeneity in Management Practices on New Zealand Dairy Farms *Motu Economic and Public Policy Research, 13-11*
- Anderson, W., & Ridler, B. (2010). Application of resource allocation optimisation to provide profitable options for dairy production systems *Proceedings of the New Zealand Society of animal production* (pp. 291-295):
- ANZ. (2012). *Greener Pastures, The Global Soft Commodity Opportunity for Australia and New Zealand*. Retrieved from [www.anzbusiness.co.nz](http://www.anzbusiness.co.nz)
- Azzone, G., Noci, G., Manzini, R., Welford, R., & Young, C. W. (1996). Defining environmental performance indicators: an integrated framework. *Business Strategy and the Environment, 5*(2), 69-80.
- Ballenger, N., & Krissoff, B. (1996). Environmental Side Agreements: Will They Take Center Stage? *Agriculture, Trade and the Environment: Discovering and Measuring the Critical Linkages*
- Baskaran, R., Cullen, R., & Colombo, S. (2009). Estimating values of environmental impacts of dairy farming in New Zealand. *New Zealand Journal of Agricultural Research, 52*(4), 377-389.
- Basset-Mens, C., Ledgard, S., & Boyes, M. (2009). Eco-efficiency of intensification scenarios for milk production in New Zealand. *Ecological economics, 68*(6), 1615-1625.
- Bell, B. A. (2012). Agricultural productivity and Environmental Sustainability Are we going to throw the baby out with the bathwater? *2012 Conference, Nelson* (New Zealand Agricultural and Resource Economics Society).
- Bensemam, J. (2012). *Marketing Strategies of New Zealand Lamb Producers* Massey University Retrieved from [http://mro.massey.ac.nz/bitstream/handle/10179/4245/02\\_whole.pdf?sequence=1](http://mro.massey.ac.nz/bitstream/handle/10179/4245/02_whole.pdf?sequence=1)
- Beukes, P., Palliser, C., Macdonald, K., Lancaster, J., Levy, G., Thorrold, B., et al. (2008). Evaluation of a whole-farm model for pasture-based dairy systems. *Journal of dairy science, 91*(6), 2353-2360.
- Beukes, P., Romera, A. J., & Clark, D. (2014). Farming within limits - can system fundamentals be the key? *Proceedings of the New Zealand Society of Animal Production, Volume 74*, 241-244.
- Beukes, P., Scarsbrook, M., Gregorini, P., Romera, A., Clark, D., & Catto, W. (2012). The relationship between milk production and farm-gate nitrogen surplus for the Waikato region, New Zealand. *Journal of environmental management, 93*(1), 44-51.
- Bewsell, D., & Drake, C. (2008). Socio-economic issues in pasture-based farming. *Environmental Impacts of Pasture-based Farming*. (Ed. RW McDowell.) pp, 98-121.
- Blaikie, N. (2007). *Approaches to social enquiry: Advancing knowledge*: Polity.
- Bryant, J., Ogle, G., Marshall, P., Glassey, C., Lancaster, J., Garcia, S., et al. (2010). Description and evaluation of the Farmax Dairy Pro decision support model. *New Zealand Journal of Agricultural Research, 53*(1), 13-28.

- Burrell, G., & Morgan, G. (1994). *Sociological paradigms and organisational analysis: Heinemann*.
- Cassells, S. M., & Meister, A. D. (2001). Cost and trade impacts of environmental regulations: effluent control and the New Zealand dairy sector. *Australian Journal of Agricultural and Resource Economics*, 45(2), 257-274.
- Cherryholmes, C. H. (1992). Notes on pragmatism and scientific realism. *Educational researcher*, 21(6), 13-17.
- Christensen, Hedley, Hanly, & Horne. (2012). Three years of duration controlled grazing - What have we learned. *FLRC Workshop 2014*
- Christensen, C., Hanly, J., Hedley, M., & Horne, D. (2011). Nitrate leaching and pasture production from two years of duration-controlled grazing. *Adding to the knowledge base for the nutrient manager'.*(Eds LD Currie, CL Christensen).(Fertilizer & Lime Research Centre: Palmerston North)
- Christensen, C., Hedley, M., Hanly, M., & Horne, D. (2012). Nitrogen loss mitigation using duration-controlled grazing: field observations compared to modelled outputs *Proc NZ Grassl Assoc* (pp. 115-119):
- Clark, D., Caradus, J., Monaghan, R., Sharp, P., & Thorrold, B. (2007). Issues and options for future dairy farming in New Zealand. *New Zealand Journal of Agricultural Research*, 50(2), 203-221.
- Conforte, D., Garnevska, E., Kilgour, M., Locke, S., & Scrimgeour, F. (2008). *Key elements of success and failure in the NZ dairy industry*: Lincoln University. Agribusiness and Economics Research Unit.
- Coriolus. (2010). Fonterra and the New Zealand Dairy Industry - Industry Report to Fonterra and the Dairy Industry.
- Cornforth, I. C. (1999). Selecting indicators for assessing sustainable land management. *Journal of environmental management*, 56(3), 173-179.
- Creswell, J. W. (1994). *Research design: Qualitative & quantitative approaches*: Sage Publications (Thousand Oaks, Calif.).
- Creswell, J. W. (2009). *Research Design, Qualitative, Quantative and Mixed Methods Approaches*. California USA: Sage.
- Creswell, J. W. (2012). *Qualitative inquiry and research design: Choosing among five approaches*: Sage.
- Crotty, M. (1998). *The foundations of social research: Meaning and perspective in the research process*: Sage.
- Currie, L. D., & Christensen, C. L. (2010). *Farming's future: Minimising footprints and maximising margins*. Massey University, Palmerston North
- DairyBase. (2014). *About DairyBase*. Retrieved from [www.dairybase.co.nz](http://www.dairybase.co.nz)
- DairyNZ. (2012). *Dairy Statistics 2011-2012*.
- DairyNZ. (2013a). *2012/13 Dairy economic survey*. Retrieved from [www.dairynz.co.nz](http://www.dairynz.co.nz)
- DairyNZ. (2013b). *DairyBase*. Retrieved from [www.dairybase.co.nz](http://www.dairybase.co.nz)
- DairyNZ. (2013c). *Making Dairying Work for Everyone* DairyNZ Retrieved from [www.dairynz.co.nz](http://www.dairynz.co.nz)
- DairyNZ. (2014). *Dairy Statistics 2013-2014*.
- Dalley, D., Hunter, M., & Pinxterhuis, I. (2013). Nutrient Limits - Making money when the rules change. *SIDE Conference, 2013*
- Davies, A., Kaine, G., & Lourey, R. (2007). Understanding Factors Leading to Non-compliance With Effluent Regulations by Dairy Farmers. *Environment Waikato Technical Report 2007/37*
- DCANZ. (2013). *Sustainable Dairying Water Accord*. Retrieved from <http://www.dcanz.com/>
- De Klein, C., Monaghan, R., Ledgard, S., & Shephard, M. (2010). A System's Perspective on the Effectiveness of Measures to Mitigate the Environmental Impacts of

- Nitrogen Losses From Pastoral Dairy Farming. *Proceedings of the Australasian Dairy Science Symposium, August 2010*, 14-28.
- Dewes, A., & Bolt, J. (2012). MINIMAL FOOTPRINT – OPTIMAL PROFIT FARMING SYSTEMS TOMORROWS FARMS TODAY – UPPER WAIKATO. *Advanced Nutrient Management: Gains from the Past-Goals for the Future.*(Eds LD Currie and C L. Christensen). <http://flrc.massey.ac.nz/publications.html>. Occasional Report
- Di, H. J., & Cameron, K. C. (2000). Calculating nitrogen leaching losses and critical nitrogen application rates in dairy pasture systems using a semi - empirical model. *New Zealand Journal of Agricultural Research*, 43(1), 139-147.  
doi:10.1080/00288233.2000.9513415
- Dikmen, S., & Hansen, P. (2009). Is the temperature-humidity index the best indicator of heat stress in lactating dairy cows in a subtropical environment? *Journal of dairy science*, 92(1), 109-116.
- Doole, G. J., Marsh, D., & Ramilan, T. (2013). Evaluation of agri-environmental policies for reducing nitrate pollution from New Zealand dairy farms accounting for firm heterogeneity. *LAND USE POLICY*, 30(1), 57-66.  
doi:10.1016/j.landusepol.2012.02.007
- Doole, G. J., & Pannell, D. J. (2012). Empirical evaluation of nonpoint pollution policies under agent heterogeneity: regulating intensive dairy production in the Waikato region of New Zealand\*. *Australian Journal of Agricultural and Resource Economics*, 56(1), 82-101.
- Doole, G. J., & Romera, A. J. (2014a). Implications of a leaching efficiency metric in a pasture-based dairy system. *In press*
- Doole, G. J., & Romera, A. J. (2014b). Trade-offs between profit, production, and environmental footprint on pasture-based New Zealand dairy farms. *In press*
- Drever, E. (1995). *Using Semi-Structured Interviews in Small-Scale Research. A Teacher's Guide*: ERIC.
- Edmeades, D. (2014). Overseer. *The Fertiliser Review*(31), 4-9.
- Edmeades, R. H., Metherell, A., Rahn, C., & Thorburn, P. (2013). A peer review of OVERSEER® in relation to modelling nutrient flows in arable crops.
- Environment Court. (2011). *Decision No. [2011] NZEnvC 380 Variation 6*
- Environmental Defence Society. (2014). *Resource Management Act For the Community*  
Retrieved from <http://www.rmaguide.org.nz/rma/plandocs/natpolicystmts.cfm>
- Fish and Game New Zealand. (2014). *Farming and the Environment*. Retrieved from <http://www.fishandgame.org.nz/sites/default/files/Horizon%20Research%20Farming%20and%20the%20Environment%20Survey%20Report%20070314%20FINAL.pdf>
- Fonterra. (2013). *Annual Review 2013* Retrieved from [www.fonterra.com](http://www.fonterra.com)
- Fonterra Co-operative Group. (2014). *Milk Supply Curves*. Retrieved from [www.fonterra.co.nz](http://www.fonterra.co.nz)
- Gauntlett, W. (2009). The Costs and Benefits of Effluent Management Compliance in the Waikato Region of New Zealand *2009 Conference (53rd), February 11-13, 2009, Cairns, Australia* (Australian Agricultural and Resource Economics Society).
- Glassey, C., Mashtan, K., & McCarthy, S. (2014). A farm systems perspective on sensible options for reducing nitrogen loss from dairy farms using indicators related to N surplus and N conversion efficiency. In L. D. Curry & L. J. Yates (Eds.), *Nutrient Management for the farm, catchment and community* (p. 84). Massey University, Palmerston North New Zealand
- Glassey, C., McCarthy, S., & Serra, V. (2013). STOCKING RATE: MORE IS NOT ALWAYS BETTER. *SIDE Conference, 2013*
- Goodstein, E. S. (2011). *Economics and the Environment*: Wiley. com.

- Gray, D., Dooley, E., & Shadbolt, N. (2008). *Risk and Dairy Farm Management in New Zealand: A Review of Literature*: AgResearch.
- Greig, B. (2012). Changing NZ dairy farm systems. *SIDE Conference, June 25-27 2012*(Dunedin, New Zealand), pp. 217-228.
- Hamilton, D., & Wilkins, S. (2004). Review of the Science underpinning the 20 percent nitroducton target for Lake Taupo. *Center for Biodiversity and Ecology Research, University of Waikato*
- Hayati, D., Ranjbar, Z., & Karami, E. (2011). Measuring agricultural sustainability *biodiversity, biofuels, agroforestry and conservation agriculture* (pp. 73-100): Springer.
- Hedley, P., Glassey, C., Fisher, D., Newman, M., & Taylor, P. (2014). Principles of System Intensification. *In press*
- Hedley, P., Kolver, E., Glassey, C., Thorrold, T., Van Bysterveldt, A., Roche, J., et al. (2006). Achieving high performance from a range of farm systems - (pp. Pages 147-166, 143-145 April):
- Heubeck, S., Nagels, J., & Craggs, R. (2014). Variability of effluent quality and quantity on dairy farms in New Zealand. In L. D. Currie & C. L. Christensen (Eds.), *Nutrient management for the farm, catchment and community* (Massey University, Palmerston North:
- Horizons Regional Council. (2010). *One Plan* Retrieved from <http://www.horizons.govt.nz/about-us/one-plan/>
- Howard, S. (2013). Nitrogen Leaching - Dairy Farm Mitigation Options *SIDE Conference, 2013*
- Jarvis, P., & Wilkinson, R. (1998). *Survey of compliance costs of New Zealand farmers: a study of costs and an exploration of issues*
- Javis, S., Hutchings, N., Brentrup, F., Olesen, J., & van de Hoek, K. (2010). Nitrogen flows in farming systems across Europe. *The European Nitrogen Assessment: sources, effects and policy perspectives.* , Cambridge University Press, 211-227.
- Jay, M., & Morad, M. (2007). Crying over spilt milk: A critical assessment of the ecological modernization of New Zealand's dairy industry. *Society and Natural Resources*, 20(5), 469-478.
- Journeaux, P. (2013). Economic Analysis on the Value of Winter Housing for Dairy Farming in Tararua District.
- Kahn, J. (1998). The economic approach to environmental and natural resources.
- Kaine, G., Murdoch, H., Lourey, R., & Bewsell, D. (2010). A framework for understanding individual response to regulation. *Food Policy*, 35(6), 531-537.
- Kaye-Blake, B., Schilling, C., Monaghan, R., Vibrat, R., Dennis, S., & Post, E. (2013). Potential impacts of water related policies in Southland On the agricultural economy and nutrient discharges. *NZIER report to Ministry for the Environment*
- Kedgley, S. (2014). Keep our Cows out of factory farms. *The New Zealand Herald*. Retrieved from [http://www.nzherald.co.nz/nz/news/article.cfm?c\\_id=1&objectid=11193262](http://www.nzherald.co.nz/nz/news/article.cfm?c_id=1&objectid=11193262)
- Keeney, D., Gregg, P., & Lynch, B. (1982). Nitrogen fertilisers and the nitrogen cycle. *Nitrogen fertilisers in New Zealand agriculture*. Auckland, Ray Richards Publisher. Wellington, New Zealand, The New Zealand Institute of Agricultural Science
- Kennedy, M. M. (1979). Generalizing from single case studies. *Evaluation Review*, 3(4), 661-678.
- KPMG. (2013a). *Balancing the needs of the environment, communities and business*. KPMG New Zealand
- KPMG. (2013b). Balancing the needs of the environment, communities and businesses. *Agribusiness Agenda*, 4

- Langemeier, M. (2010). Persistence in financial performance. *Journal of International Farm Management*, 5(2), 1-15.
- Ledgard, S., Crush, J., & Penno, J. (1998). Environmental impacts of different nitrogen inputs on dairy farms and implications for the Resource Management Act of New Zealand. *Environmental pollution*, 102(1), 515-519.
- Ledgard, S., Finlayson, J., Gavin, J., Blackwell, M., Carran, R., Wedderburn, M., et al. (2003). Resource use efficiency and environmental emissions from an average Waikato dairy farm, and impacts of intensification using nitrogen fertiliser or maize silage *Proceedings of the New Zealand Grassland Association* (pp. 185-189): New Zealand Grassland Association.
- Ledgard, S., Penno, J., & Sprosen, M. (1997). Nitrogen balances and losses on intensive dairy farms. *Proceeding of the New Zealand Grasland Assoiation*, 59, 49-53.
- Ledgard, S., Penno, J., & Sprosen, M. (1999). Nitrogen inputs and losses from clover/grass pastures grazed by dairy cows, as affected by nitrogen fertilizer application. *The Journal of Agricultural Science*, 132(2), 215-225.
- Ledgard, S., Sprosen, M., Judge, A., Lindsey, S., Jensen, R., Clark, D., et al. (2006). Nitrogen leaching as affected by dairy intensification and mitigation practices in the resource efficient dairying (RED) trial. *Implementing sustainable nutrient management strategies in agriculture. Occasional Report(19)*, 263-268.
- LIC. (2013). *2012/13 Dairy Industry Statistics*. Retrieved from [www.LIC.co.nz](http://www.LIC.co.nz)
- Lynn, I., Manderson, A., Page, M., Harnsworth, G., Eyles, G., Douglas, G., et al. (2009). *Land Use Capability Handbook. 3rd Edition*
- Macdonald, T. O., Scrimgeour, F., & Rowarth, J. (2013). COW HOUSING SYSTEMS—AN ECONOMIC ANALYSIS.
- MacLeod, C. J., & Moller, H. (2006). Intensification and diversification of New Zealand agriculture since 1960: An evaluation of current indicators of land use change. *Agriculture, ecosystems & environment*, 115(1), 201-218.
- Marshall, K., Avery, G., Ballard, R., & Johns, D. (2012 ). *A Call to Arms - a contribution to the New Zealand agri-food strategy*. Riddet Institute Retrieved from <http://riddet.massey.ac.nz/sites/default/files/content/A%20Call%20to%20Arms.pdf>
- McCarthy, S., Hutchinson, K., & Bowler, L. (2007). IDENTIFYING OPPORTUNITIES TO REDUCE N LEACHED WHILE MAINTAINING FARM PROFITABILITY AND MILKSOLIDS PRODUCTION—A CASE STUDY ANALYSIS.
- McDowell, R., Monaghan, R., & Carey, P. (2003). Potential phosphorus losses in overland flow from pastoral soils receiving long - term applications of either superphosphate or reactive phosphate rock. *New Zealand Journal of Agricultural Research*, 46(4), 329-337.
- McDowell, R. W. (2008). *Environmental impacts of pasture-based farming*: CABI.
- McHaffie, N. (2012). Will the introduction of nutrient benchmarks help to achieve sustainable milk production systems?
- Meyer, S. M. (1995). The economic impact of environmental regulation. *Journal of Environmental Law & Practice*, 3(2), 4-15.
- Ministry for Primary Industries. (2013). *The Dairy Industry Restructuring Act* Retrieved from <http://www.mpi.govt.nz/agriculture/pastoral/dairy/dairy-industry-restructuring-act>
- Ministry for Primary Industries. (2014a). *Agriculture and the New Zealand Economy*. Retrieved from <http://www.mpi.govt.nz/agriculture>
- Ministry for Primary Industries. (2014b). *Primary Growth Partnership*. Retrieved from <http://www.mpi.govt.nz/>
- Ministry for the Environment. (2001). *Managing waterways on farms: A guide to sustainable water and riparian management in rural New Zealand*.

- Monaghan, R. (2008). The environmental impacts of non-irrigated, pasture based dairy farming. *Environmental Impacts of Pasture-based Farming*. RW McDowell, ed. CAB Int'l., Oxfordshire, UK, 209-231.
- Monaghan, R., Hedley, M., Di, H., McDowell, R., Cameron, K., & Ledgard, S. (2007). Nutrient management in New Zealand pastures—recent developments and future issues. *New Zealand Journal of Agricultural Research*, 50(2), 181-201.
- Monaghan, R., Paton, R., Smith, L., Drewry, J., & Littlejohn, R. (2005). The impacts of nitrogen fertilisation and increased stocking rate on pasture yield, soil physical condition and nutrient losses in drainage from a cattle - grazed pasture. *New Zealand Journal of Agricultural Research*, 48(2), 227-240.
- Monaghan, R., Smeaton, D., Hyslop, M., Stevens, D., De Klein, C., Smith, L., et al. (2004). A desktop evaluation of the environmental and economic performance of model dairy farming systems within four New Zealand catchments *Proceedings of the New Zealand Grassland Association* (pp. 57-67):
- Morgan, G., & Smircich, L. (1980). The case for qualitative research. *Academy of Management Review*, 5(4), 491-500.
- Moynihan, H., Holgate, B., & Crowder, V. (2014). Competitive Challenges- Environmental regulations are changing the rules of the game. *Rabobank food and Agribusiness Research and Advisory*, June 2014
- Neal, M., Fulkerson, W., Levy, G., Wastney, M., Thorrold, B. S., Palliser, C., et al. (2006). *The Potential Cost to New Zealand Dairy Farmers from the Introduction of Nitrate-Based Stocking Rate Restrictions*. International Association of Agricultural Economists
- National Policy Statement for Freshwater (2011).
- New Zealand Government. (2012). *The Business Growth Agenda Progress Reports: Building Export Markets*. . New Zealand Government. Retrieved from [www.mbie.govt.nz](http://www.mbie.govt.nz)
- Newman, M., & Howard, S. (2013). Economic assessment of reducing on-farm nutrient leaching. *Primary industry Management*, 17(4), 3-5.
- Newman, M., & Savage, J. (2009). Benchmarking—Key drivers for successful dairy businesses. *Proceedings of the SIDE conference*
- NZIER. (2007). *Off-Farm Agribusiness Compliance Costs Report to the Ministry of Agriculture and Forestry* Retrieved from <http://nzier.org.nz/>
- NZIER. (2010). Dairy's role in sustaining New Zealand - the sector's contribution to the economy.
- NZIER. (2013). Potential impacts of water-related policies in Southland on the agricultural economy and nutrient discharges. *NZIER report to the Ministry for the Environment*
- OECD. (1993). *Agricultural and environmental policy integration: Recent progress and new directions* Paris, France Organisation for Economic Co-operation and Development Publication Services.
- Park, S., Kingi, T., Morrell, S., Matheson, L., & Ledgard, S. (2014). NITROGEN LOSSES FROM LAKE ROTORUA DAIRY FARMS-MODELLING, MEASURING AND ENGAGEMENT.
- Parris, K. (1998). Agricultural nutrient balances as agri-environmental indicators: an OECD perspective. *Environmental pollution*, 102(1), 219-225.
- Patton, M. Q. (1980). *Qualitative evaluation methods*. Beverly Hills: cA: Sage.
- Pellows, R., Lee, S., Metherell, A., McCallum, R., Moir, J., Roberts, A., et al. (2013). *Assessing the impact of input choices within overseer(V6) on the modelled N losses to water for Lincoln University Dairy Farm*. Paper presented at the Accurate and efficient use of nutrients on farms, Massey University, Palmerston North, New Zealand

- Pow, T., Longhurst, B., & Pow, Z. (2014). THE FUTURE OF NZ DAIRY FARMING SYSTEMS: SELF MANAGING COWS WITH ACCESS TO PARTIAL HOUSING. *FLRC Workshop 2014*
- Powell, B. (2011). Taharua Cow Pads and Housing. *Hawkes Bay Regional Council*
- Pridmore, R. (2014). *Dairying versus New Zealand pure- Can we have both?* In Press.
- Ridler, B., & McCallum, R. (2014). Farm Averages Dont Tell True Resource Story. *NZ Farmer*.
- Robson, M., Brown, I., Ford, R., Lilburne, L., Norton, N., & Wedderburn, M. (2012). SETTING CATCHMENT WATER QUALITY LIMITS AND IMPLICATIONS FOR NUTRIENT MANAGEMENT IN CANTERBURY.
- Rossmann, G. B., & Wilson, B. L. (1985). Numbers and Words Combining Quantitative and Qualitative Methods in a Single Large-Scale Evaluation Study. *Evaluation Review*, 9(5), 627-643.
- Rowarth, J., & Edmeades, D. (2013). The Value of Models in agriculture. *New Zealand Institute of Primary Industry Management Vol 16 No 1*
- Schilling, C., Zuccollo, J., & Nixon, C. (2010). *Dairy's role in sustaining New Zealand - the sector's contribution to the economy*. Retrieved from <https://www.fonterra.com/wps/wcm/connect/fcf7000044f43b8bb2b2fbac5c5d2692/NZIER+economic+report+to+Fonterra+and+DNZ+2010.pdf?MOD=AJPERES>
- Schultz, M., & Hatch, M. J. (1996). Living With Multiple Paradigms the Case of Paradigm Interplay in Organizational Culture Studies. *Academy of Management Review*, 21(2), 529-557.
- Selbie, D., Watkins, N., Wheeler, D., & Shepherd, M. (2013). Understanding the distribution and fate of nitrogen and phosphorus in OVERSEER®. *Proceeding of the New Zealand Grassland Association 75*
- Shadbolt, N. (2013). Resilience of New Zealand Dairy Farm Businesses. *One Farm Center of Excellence in Farm Business Management*
- Shadbolt, N., & Olubode-Awosola, F. (2013). New Zealand Dairy Farmers and Risk: Perceptions of, Attitude to, Management of and Performance under Risk and Uncertainty. *One Farm Center of Excellence in Farm Business Management*
- Shadbolt, N., & Valentine, B. (2013). On-Farm Impacts of environmental policy - a journey. *New Zealand Agricultural and Resource Economics Society, Proceedings of 2013 Nelson conference*
- Shadbolt, N. M. (2012). Competitive strategy analysis of NZ pastoral dairy farming systems. *International Journal of Agricultural Management*, 1(3), 19-27.
- Shepherd, M., & Wheeler, D. (2012). OVERSEER® Nutrient Budgets—the next generation. *Advanced Nutrient Management: Gains from the Past-Goals for the Future*. (Eds LD Currie and C L. Christensen). <http://flrc.massey.ac.nz/publications.html>. Occasional Report(25)
- Sinclair, E. (2011). System 5 Profitability and Key drivers, Case studies of Canterbury system 5 dairy farms. *Unpublished Honours dissertation. Lincoln University*
- Smyth, A., & Dumanski, J. (1995). A framework for evaluating sustainable land management. *Canadian Journal of Soil Science*, 75(4), 401-406.
- Statistics New Zealand. (2013). *Dairy product exports grow for 20 years*. Retrieved from <http://www.stats.govt.nz>
- Sterns, J. A., Schweikhardt, D. B., & Peterson, H. C. (1998). Using case studies as an approach for conducting agribusiness research. *The International Food and Agribusiness Management Review*, 1(3), 311-327.
- Stewart, J. (2014). Survey of Environmental Management Costs- Horizons Region *Federated Farmers New Zealand*
- Tashakkori, A., & Teddlie, C. (2003). *Handbook of mixed methods in social & behavioral research*: Sage.

- Valentine, I., Hurley, E., Reid, J., & Allen, W. (2007). Principles and processes for effecting change in environmental management in New Zealand. *Journal of environmental management*, 82(3), 311-318.
- Van Bysterveldt, A. (2014). Lincoln University Dairy Farm - A commercial farm incorporating proven science. *SIDE Conference*
- Waikato Regional Council. (2010). *Waikato Regional Plan - Variation 5* Retrieved from <http://www.waikatoregion.govt.nz/>
- Waikato Regional Council. (2014a). *Applying effluent to land*. Retrieved from <http://www.waikatoregion.govt.nz/Environment/Natural-resources/Land-and-soil/Applying-effluent-to-land/>
- Waikato Regional Council. (2014b). *Our Natural Environment* Retrieved from <http://www.waikatoregion.govt.nz/Community/About-the-Waikato-region/Our-natural-environment/>
- Watkins, N., & Shepherd, M. (2013). A COMPENDIUM OF NEW ZEALAND PASTURE FARMLET EXPERIMENTS MEASURING NITROGEN LEACHING.
- Weber, R. P. (1990). *Basic content analysis*: Sage.
- Wheeler, Power, & Shepherd. (2008). NUTRIENT CONVERSION EFFICIENCY ON FARM – LESSONS FROM OVERSEER® EXAMPLES *Overseer Development Project*
- Wheeler, D., Ledgard, S., De Klein, C., Monaghan, R., Carey, P., McDowell, R., et al. (2003). OVERSEER® nutrient budgets–moving towards on-farm resource accounting *Proceedings of the New Zealand Grassland Association* (pp. 191-194):
- Wheeler, D., Ledgard, S., & Monaghan, R. (2007). Role of the Overseer® nutrient budget model in nutrient management plans. *Designing sustainable farms: critical aspects of soil and water management*, 58-62.
- Wright, J. (2013). *Water quality in New Zealand: Land use and nutrient pollution*. Retrieved from <http://www.pce.parliament.nz/assets/Uploads/PCE-Water-quality-land-use-website.pdf>
- Yin, R. K. (2009). *Case study research: Design and methods* (Vol. 5): Sage.
- Zahra, A. L. (2006). *Regional tourism organisations in New Zealand from 1980 to 2005: Process of transition and change*. The University of Waikato.

## **Appendix 1 Dairy Feed Planner Results of Mitigation Scenarios**

## Appendix 2 Nutrient Budgets for Mitigation Scenarios

N specific component of nutrient budgets performed in Overseer v6 for the low, medium and high input farm systems under four mitigation scenarios.

<b>Base scenario</b>			
	<b>Low</b>	<b>Medium</b>	<b>High</b>
<b>N Leached</b>	32	43	47
<b>NCE</b>	34	32	34
<b>NLE</b>	34	33	39
<b>N Surplus</b>	170	231	273

<b>Destocking</b>			
	<b>Low</b>	<b>Medium</b>	<b>High</b>
<b>N Leached</b>	27	34	36
<b>NCE</b>	32	34	35
<b>NLE</b>	37.93	37.15	46.53
<b>N Surplus</b>	156	194	237

<b>Increasing effluent area</b>			
	<b>Low</b>	<b>Medium</b>	<b>High</b>
<b>N Leached</b>	30	39	42
<b>NCE</b>	36	34	36
<b>NLE</b>	36.47	34.33	41.88
<b>N Surplus</b>	154	210	255

<b>Winter grazing</b>			
	<b>Low</b>	<b>Medium</b>	<b>High</b>
<b>N Leached</b>	29	39	43
<b>NCE</b>	35	33	35
<b>NLE</b>	37.72	34.33	41.74
<b>N Surplus</b>	163	233	263

<b>Cow housing</b>			
	<b>Low</b>	<b>Medium</b>	<b>High</b>
<b>N Leached</b>	27	33	40
<b>NCE</b>	28	29	31
<b>NLE</b>	40.52	40.58	44.88
<b>N Surplus</b>	199	247	291



## Appendix 4 Cow Housing Model – Valuation of Assumptions

Table A.2 Cost Assumptions

Cost Modelling	
<b>1 Initial Build Cost</b>	
Cows	2500
Cost per Cow	\$ 1,350
Total cost	\$ 3,375,000
<b>Consent &amp; Consult cost</b>	
Total Cost	\$10,000
<b>2 Increased Tractor costs</b>	
Hours per day	1
Cost per Hour	100
Days	365
total cost	\$ 36,500.00
<b>3 R&amp; M cost</b>	
year 3-10 %	0.2%
Year 11-30 %	0.4%
Capital cost	\$ 3,375,000
Total R&M Year 3-10	\$ 6,750.0
Total R&M Year 10-20	\$ 13,500.0
<b>4 Feed Cost</b>	
Palm Kernel increased volume	406720
PKE cost per kgDM	\$ 0.32
Total PKE cost	130150
Increase Silage Required	203360
Cost per kgDM Silage	\$ 0.20
Total Silage Cost	\$ 40672
Increased Fruit Required	176798
Cost per kgDM Silage	\$ 0.20
Total Silage Cost	\$ 40672
Total Cost	\$ 211494
<b>5. Interest</b>	
Interest Rate	6.50%
Capital cost	\$ 3,385,000
Total Interest	\$ 220,025.00
<b>6. Borrowing Repayment</b>	
Repayment terms	30
Capital Cost	\$ 3,385,000
Equal Repayment annual	\$ 112,833

Table A.3 Benefit Modelling

<b>Benefit Modelling</b>	
<b>1 Reduce Cost of winter Grazing</b>	
Number of Cows at gazing	2000
Weeks Grazing	9
Cost per cow per week	\$ 25.00
Total Cost to be eliminated	\$ 450,000.00
<b>2 Increased Pasture production</b>	
Hectares	1000
Current pasture grown	8500
increase %	1%
Increased Pasture Grown	8585
Increase kgDM	85
Value of Pasture	\$ 0.30
Total Benefit per HA	\$ 26
Total Benefit	\$ 25,500
<b>3 Increased Milk solid Production</b>	
Cows	2500
Increase per cow	32.86
Increased kgMS	82148.14815
Marginal cost of production	\$ 3.50
Payout	\$ 6.50
gross margin per additional kgMS	\$ 3.00
Value	\$ 246,444
Base per cow	272
New per cow production	305
Base per HA	507
New per HA	610
Base Total	637024
New Total	762148
<b>4 Reduced Death Rate (incl. cow wastage)</b>	
# of Cows	2500
Death Rate reduction	1.50%
Number of cows not lost	38
Value	\$ 1,000
Total Benefit	\$ 37,500
<b>5 Reduced Empty Rate</b>	
# of Cows	2500
Empty Rate Reduction	1.50%
Number of increased cows not culled	38
Reduced Hfrs required to buy in	33
Value of Hrf	\$ 900
Benefit	\$ 29,250

Table A.3 Assumptions of Production Increases

Assumptions of production increases	
<b>Feed Utilisation</b>	
Volume of Feed now in Facility	240000
Increase factor	15%
Increased feed	16000
Feed per kgMS	15
kgMS per cow	5.93
<b>Heat Stress</b>	
Production increases per day	0.06
Days	30
Per cow increase	1.8
<b>Days in milk</b>	
increased Days	10
kgMS /day	1.3
Increased kgMS/Cow	13
<b>Reduced Walking Energy</b>	
kgMS from energy partition to production	0.05
Days in Milk walk is reduced	100
kgMS	5
<b>Warmth in Winter</b>	
Production increases per day	0.06
Number of Days	30
per cow increase	1.8
<b>Conversion Efficiency</b>	
Cows	2700
Precious Conversion	0.08
New Conversion	0.07
Feed in Shed	1440000
Change in efficiency	0.01
Increase in kgMS/co/day	5
<b>Total Increases</b>	<b>32</b>

### Compliance Survey Information Sheet



*Waikato Management School*

Te Raupapa

- Thank you for considering involvement with this survey regarding compliance costs for Waikato dairy farmers
- This research is being conducted by Thomas Macdonald an agribusiness master's student and supervised by both the Agribusiness and Economics departments of the Waikato Management School.
- The purpose of the research is to evaluate environmental regulation pertaining to the New Zealand dairy industry and to determine the comparative financial cost of compliance between different dairy farming systems
- ALL data collected will remain anonymous. Data which appears within the research publications will be in aggregate form providing a snapshot for the region as opposed to at an individual farm level
- Information collected will be seen in individual form by Thomas Macdonald and Jacqueline Rowarth in the capacity of researcher and research supervisor.
- If you are uncomfortable answering any of the survey questions, please leave the field blank and continue with the remaining questions.
- Participants may opt out of the study by emailing [thomasmacdonald@xtra.co.nz](mailto:thomasmacdonald@xtra.co.nz) prior to the 1<sup>st</sup> June 2014
- Further information or specific questions can be directed to Thomas Macdonald on 0274470166 or [thomasmacdonald@xtra.co.nz](mailto:thomasmacdonald@xtra.co.nz) or Prof. Jacqueline Rowarth at [jrowarth@waikato.ac.nz](mailto:jrowarth@waikato.ac.nz)
- A copy of the published research will be available to you upon completion in October 2014. If you wish to receive a summarised copy of the survey data please leave your email address below
- I look forward to reviewing the data you provide. This research is highly important for the dairy industry as it navigates increased environmental compliance and the need to remain profitable.

# On Farm cost of environmental compliance



THE UNIVERSITY OF  
**WAIKATO**  
Te Whare Wānanga o Waikato

*Waikato Management School*

Te Raupapa

## Thomas Macdonald- Masters of Agribusiness- The cost of dairy compliance

If you are uncomfortable answering any of the below questions, please leave blank and progress to next question

### 1. Farm physical details:

- a) Effective Hectares: \_\_\_\_\_
- b) Peak cows milked: \_\_\_\_\_
- c) DairyNZ farm system(1-5): \_\_\_\_\_
- d) Soil type: \_\_\_\_\_
- e) Milk solids produced: \_\_\_\_\_ kgMS – Average year

### 2. Did your farm have existing environmental compliance infrastructure prior to 2010? E.g. Pond storage,

Yes

No

If yes – Detail: eg: unsealed pond, sump

\_\_\_\_\_

\_\_\_\_\_

### 3. In the last 4 years, has your farm upgraded the effluent system, stand-off/ feed pads, water metering, restricted water use technology or any other measures to increase compliance with environmental regulation.

Yes

No

### 4. If No, is upgrading required within the next 3 years for the effluent system, stand-off/ feed pads, water metering, restricted water use technology or any other measures to increase compliance with environmental regulation.

Yes

No

### 5. What compliance infrastructure have you now installed/plan to install?

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_ Date of installation/proposed installation date: \_\_\_\_\_

6. What has been/will be the cost to your farm business in implementing the above environmental compliance infrastructure?

\$0 to \$50,000

\$50,000 to \$100,000

\$100,000 to \$200,000

\$200,000 to \$300,000

\$ 300,000 to \$500,000

\$ 500,000+

7. To your understanding, will the above changes classify the farm as compliant with current regulation for the Waikato region?

Yes

No

Don't Know

**Comment:** \_\_\_\_\_

8. Has your on farm management or farming system changed in light of investment into compliance infrastructure? e.g. Stocking rate, imported feed, reduced fertiliser use? \_\_\_\_\_

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

9. Has your farm been visited by a representative of the Regional Council in the past two years?

Yes

No

10. If Yes, was the visit helpful in understanding your obligations to meet environmental regulation and the expectations of the Regional Council?

No

Yes  **Comment:** \_\_\_\_\_

\_\_\_\_\_

11. Do you know a recent value for Nitrogen loss (leaching) per hectare for your farm?

Yes  - \_\_\_\_\_ kg N per Hectare lost per year

No

**12. Do you know the Nitrogen Leaching Efficiency of your farm system?**

Formula = kgMS Ha / Kg N leached per hectare

Yes  - \_\_\_\_\_ kgMS per kg N leached

No

**13. Who do you think should be providing on-farm support for environmental compliance given the current framework of rates, retentions and levys? Tick all that apply**

- DairyNZ
- Dairy company
- Waikato Regional Council
- Independent farm consultants
- Other \_\_\_\_\_
- \_\_\_\_\_

**14. What form of support will best suit the needs of your farm business in terms of the compliance process and the requirements of environmental compliance?**

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

**15. General comments regarding the cost of environmental compliance for your farm?**

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

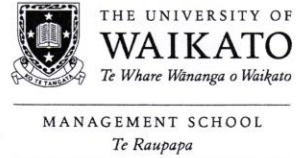
\_\_\_\_\_

\_\_\_\_\_

## Appendix 6 Research Ethics Approval

Research Office  
Waikato Management School  
The University of Waikato  
Private Bag 3105  
Hamilton 3240  
New Zealand

Amanda Sircombe  
Research Manager  
Phone +64 7 838 4376  
Fax +64 7 838 4063  
Email [amandas@waikato.ac.nz](mailto:amandas@waikato.ac.nz)  
[www.management.ac.nz](http://www.management.ac.nz)



3<sup>rd</sup> February 2014

Thomas Macdonald  
83 Puke Road  
RD 1  
Hamilton

Dear Thomas

*Ethical Application WMS 14/6  
An evaluation of environmental regulation pertaining to New Zealand dairy farms and the  
comparative financial cost of compliance for different farm systems*

As per my earlier email the above research project, as outlined in your application, has been granted Ethical Approval for Research by the Waikato Management School Ethics Committee.

Please note: should you make changes to the project outlined in the approved ethics application, you may need to reapply for ethics approval.

Best wishes for your research

Regards,



Amanda Sircombe  
Research Manager

