Ministry for Primary Industries
Manatū Ahu Matua

Economic analysis of the impact on farming of limiting the loss of nitrogen and phosphorus

A Catchment Case Study: Aparima (Southland)

Final Report

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By Philip Journeaux (AgFirst Waikato Limited) and Kevin Wilson (Rural and Agri Business Research)

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Publications Logistics Officer
Ministry for Primary Industries
PO Box 2526
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Telephone: 0800 00 83 33
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Contents

Page

List of Tables

1 Executive Summary

1.1 KEY POINTS

- This study investigates the potential economic impacts at an aggregate farm level of imposing property based limits on N and P losses from farms under a range of scenarios.
- The Aparima catchment was selected as a case study because of land use change potential from sheep and beef to dairying (circa 50,000hectares), and the likely resultant increase in nutrient losses from farms. Assuming no restrictions, at the current 5 year average rate of conversion, this land will take 13 years to fully convert. At the 10 year average conversion rate it will take 18 years to convert.
- A number of good management practices (GMPs), based on model farms, were assessed by estimating potential reduction in N and P loss, using OVERSEER® (Version 6.1.1)[1], as to their costs and efficacy in reducing nutrient losses, and in the timing of their introduction. The economic impacts were assessed as net present value over a 45 year period using an 8 percent discount rate.
- Land use change in the Aparima catchment from sheep and beef to dairying will bring significant net economic benefits. If all sheep and beef land in the catchment considered suitable for dairying was converted to dairying and dairy support (an increase from 25,000 to 75,000 hectares), a net economic gain of around NPV $370 million has been assessed – an increase in farm income of $700 million versus the capital costs of conversion of around $330 million.
- The assumed land use intensification increases the modelled nutrient losses from farm land in the catchment. In the absence of any further mitigation measures, intensification results in increased nitrogen (N) losses of 43 percent (from 1,878 to 2,692 tonnes) and increased phosphorus (P) losses of 20 percent (from 71 to 85 tonnes).
- The potential effectiveness of farm based practices to reduce N and or P losses, was modelled using OVERSEER® (Version 6.1.1)[2]. When a full range of mitigation practices are implemented, and allowing for land use change, modelling indicates that farm nutrient losses at a catchment level can be kept at close to current levels (estimated 1 percent increase in N losses and 20 percent drop in P losses). This includes allowance for mitigation practices already being implemented by existing farms (e.g. 90 percent of existing dairy farms have fenced streams and 59 percent have adequate effluent management systems).
- If nutrient loss levels post-conversion were to be kept at the same level as pre-conversion, then:
  - For nitrogen, if the burden fell solely on dairy farms, they would need to collectively reduce N losses by 39 percent. For dairy farms and dairy support farms combined, the collective reduction would need to be 34 percent.
  - For phosphorus, if the burden fell solely on dairy farms, the collective reduction in losses would need to be 22 percent. For dairy and dairy support farms combined, the reduction in losses would need to be 19 percent.
- Mitigation practices cost money. Using the Farm Surplus for Reinvestment (FSR – the residual money after all farm expenses have been met which is available for further

[1] The OVERSEER® nutrient budget model (Overseer) calculates nutrient losses to the edge of farms and the bottom of the root zone. Overseer does not model losses or attenuation beyond these points including whether nutrients reach ground or surface water bodies.
[2] The OVERSEER® nutrient budget model (Overseer) calculates nutrient losses to the edge of farms and the bottom of the root zone. Overseer does not model losses or attenuation beyond these points including whether nutrients reach ground or surface water bodies.

investment/development) as the base, the indication is that most sheep and beef farms in the catchment should be able to afford the main P mitigation options (e.g. fencing, riparian management). Similarly, most dairy farms in the catchment should be able to afford to implement some GMP's (Scenario 2), but not necessarily all GMPs (Scenario 3).

- The introduction and enforcement of strict nutrient loss limits, particularly over a short time-frame, could have a significant adverse impact on the profitability of existing farms, and would very likely slow the rate of, or even stop, dairy conversions.
- Given the above two points, thought needs to be given to the identification of priority areas, and the possibility of staged implementation of GMPs in order to strike a balance between desired environmental outcomes versus economic impacts.
- Technology transfer and innovation programmes that help lift the profitability of the average farm, would in turn make mitigation practices more affordable, and hence assist uptake.

1.2 BACKGROUND AND PURPOSE

Regional Councils are in the process of setting and implementing policies for managing freshwater quality driven by requirements under the RMA and the National Policy Statement for Freshwater Management (NPSFM). In some catchments, this will require a reduction in the loss of various contaminants from farm land and other sources.

The **purpose** of this analysis is to investigate the economic impacts at a **farm level** of implementing mitigation practices to limit/reduce modelled N and P losses from farms. The Aparima catchment in Southland was selected as a case study because of land use change potential from sheep and beef to dairying.

The analysis is an aggregate farm level analysis. It does not assess flow-on effects to the wider catchment or region. Consideration of the environmental benefits, or an assessment of the impacts of nutrient losses or resultant reduction in losses on water quality was outside the scope of the study.

1.3 SCENARIOS AND METHODOLOGY

Within the Aparima catchment there is significant opportunity for dairy conversion out of sheep and beef farming. This study was modelled based on approximately 50,500 hectares available for conversion (as shown in the Table 1 below), and on two possible rates of annual land use change (3.7 percent and 5.6 percent), with resultant modelled increases in N and P losses from farms. In the absence of any mitigation, the modelled increase in nitrogen and phosphorus losses from farm land in the Aparima catchment above current loss levels is 43 percent (from 1878 to 2692 tonnes) and 20 percent (from 71 to 85 tonnes), respectively, if all the potentially available land in the catchment is converted to dairying.

Farm-level mitigation practices were introduced based on scenarios around possible farm-level nutrient loss limits aimed at maintaining water quality in the catchment.

Table 1 Pre- and Post-Conversion Land Use (Hectares)

Land Use	Pre Conversion	Post Conversion
Dairy	24,868	63,717
Dairy Support		11,521
Sheep & Beef	70,483	20,113

Three scenarios were analysed.

Scenario #	Scenario Description
1	No limits baseline The base scenario; expected land use change and intensification trends in the absence of any freshwater limits or limits on the loss of nutrients from farm land, and without the adoption of any further mitigation practices. Assumptions include allowance for some existing mitigation at baseline.
2	Some limits on N and P losses from farms implemented from 2014, with further stricter limits implemented in 2025 Farm level N and P nutrient losses capped at 2012 levels. Some nutrient loss limits implemented from 2014, and further stricter limits implemented from 2025. Assumes all the potentially available land in the catchment is converted to dairying with adoption of mitigation.
3	Limits on N and P losses from farms implemented from 2015 Farm level N and P nutrient losses capped at 2012 levels. Farm based nutrient loss limits implemented from 2015 onwards. Assumes all the potentially available land in the catchment is converted to dairying, with adoption of a range of stricter mitigation practices.

Note The mitigation practices and start of implementation are detailed in Table 11.

A number of good management mitigation practices (GMPs) were assessed as to their costs and efficacy in reducing nutrient losses, and in the timing of their introduction. The economic impacts were assessed as net present value over a 45 year period.

The efficacy of possible on farm good management practices (GMPs) can be quite variable as previous research indicates, due to the range of variables involved, e.g. soil type, slope, stock type, rainfall, etc. For the purposes of this study, the analysis used the nutrient budget software model Overseer as the best available means of estimating potential nutrient losses at the farm level. Overseer also estimates the potential reduction in nutrient losses at a farm level that may result from the adoption of each of those GMP's. This Overseer analysis has been run in conjunction with a number of assumptions around the parameters of an average farm in the Aparima catchment. The Overseer analysis has not been undertaken on any individual properties within the catchment for the purposes of producing this report.

1.4 RESULTS

1.4.1 Aggregate on-farm costs and benefits of land use change and implementing mitigation practices (GMPs)

The net economic benefit from conversion of sheep and beef land into dairy is substantial if it is assumed that there are no environment constraints. The faster land use change happens, the greater the economic gain.

In Scenario 2, the economic cost of GMPs is significant at an aggregate farm level but could be considered “affordable” at 17 to 24 percent of the net benefit from land conversion to dairying. Note these figures are at an aggregate level across the catchment, and could vary at an individual farm level.

In Scenario 3, where nutrient loss limits are imposed more quickly than in Scenario 2, the economic costs at an aggregate farm level are substantial. They absorb 63 to 70 percent of the benefits of conversion at 8 percent discount rate and 24 to 25 percent at the 2.5 percent discount rate. Imposition of this scenario would be expected to impact on the rate of conversion from sheep and beef to dairying by slowing it significantly.

Table 2: Net economic gains from land use change to dairying and costs of imposing limits for nitrogen and phosphorus losses from farms (NPV at an aggregate farm level)

– *Rate of dairy conversion*	– 3.7%		– 5.6%	–
– *Discount rates*	– 8%	– 2.5%	– 8%	– 2.5%
– Farm Income (Benefit)	– $701m	– $2.8b	– $843m	– $3.0b
–	–	–	–	–
– Capital Expenditure on Farm (Cost)	– -$328m	– -$0.540b	– -$389m	– -$0.564b
– Net benefit at farm gate of land use change to dairy	– $373m	– $2.26b	– $454m	– $2.44b
– *Cost of GMPs to meet loss limits and % of net benefit*				–
– Scenario 1	– 0	– 0	– 0	– 0
– Scenario 2	–	–	–	–
– NPV of GMPs	– -$88m	– -$0.4b	– -$97m	– -$0.418b
– Cost of GMPs as % of net benefit	– 24%	– 18%	– 21%	– 17%
– Scenario 3:	–	–	–	–
– NPV of GMPs	– -$262m	– -$0.564b	– -$284m	– -$0.576b
– Cost of GMPs as % of net benefit	– 70%	– 25%	– 63%	– 24%

1.4.2 Efficacy and affordability of mitigation practices (GMPs)

The analysis indicated that implementation of the full range of available mitigation practices on an average dairy farm in the Aparima catchment can reduce annual farm boundary nitrogen loss by up to 40 percent and phosphorus loss by 33 percent (Table 5). A similar Overseer simulation using the MPI Southland-South Otago Hill Country Sheep and Beef Model resulted in no demonstrable reduction of nitrogen loss but a possible reduction in phosphorus loss by 50 percent (Table 3).

The outcome of nutrient loss was modelled assuming the full Aparima catchment underwent the projected land use change and all available GMPs are implemented on existing and newly converted dairy farms. The result showed that the aggregated increase in modelled N losses would be close to pre conversion, or 2012 levels, while P losses would be lower than 2012 levels, allowing that some GMPs are already in place on some farms. This is illustrated below.

Table 3: Summary of the Impact of Mitigation Practices on Total N Losses

	Pre Conversion N Losses (tonnes)	Post conversion losses (tonnes)	Modelled mitigation levels assuming no existing mitigation (tonnes)	Existing mitigation Loss reductions (tonnes)	Net mitigation reductions (tonnes)	Total post conversion losses as a % of pre-conversion losses
Scenario 2	1,878	2,692	750	56	694	+6
Scenario 3	1,878	2,692	855	64	791	+1

Table 4: Summary of the Impact of Mitigation Practices on Total P Losses

	Pre Conversion P Losses (tonnes)	Post conversion losses (tonnes)	Modelled mitigation levels assuming no existing mitigation (tonnes)	Existing mitigation Loss reductions (tonnes)	Net mitigation reductions (tonnes)	Total post conversion losses as a % of pre-conversion losses
Scenario 2	71	85	29	7	22	-11
Scenario 3	71	85	34	6	28	-20

The analysis also showed that the ability of farmers to pay for GMPs is constrained due to limitations in the amount of “surplus” cash availability. While dairy farmers could afford a number of the lower-cost mitigation strategies, many could not afford all of them, based on an annual farm surplus for reinvestment for an average Southland dairy farm of $247 per cow ($709 per hectare).

Table 5: Reduction in Nutrient Losses due to Progressive introduction of GMP strategies on an average dairy farm in the Aparima catchment[3] and related costs

Mitigation Practice	N reduction (%)	P reduction (%)	*Dairy Farm* Net Annual cost per cow ($/cow)	*Dairy Farm* Capital cost per cow ($/cow)
Scenario 2				
Stock exclusion i.e. fencing off streams (FW)	5	17	$7.00	$61.60
FW + Farm dairy effluent storage (ES)	8	25	$31.60	$361.60
FW + ES + No winter N (NWN)	23	25	$35.10	$361.60
Total of above GMPs	23%	25%	$35.10	$361.60
FW + ES + NWN + Nitrogen inhibitor (NI)	35	25	$113.60	$361.60
FW + ES + NWN + NI + Riparian Strips (RS)	35	25	$137.60	$599.90
Total for Scenario 2	35%	25%	$137.60	$599.90
Scenario 3				
FW + ES + NWN + NI + RS + Wintering facilities (WF)	38	33	$192.70	$2,599.90
FW + ES + NWN + NI + RS + WF + Constructed wetlands	40	33	$269.20	$3,504.20
Total for Scenario 3	40%	33%	$269.20	$3,504.20

Note

1. The sale and application of nitrification inhibitor products containing DCD (dicyandiamide) was suspended in New Zealand by manufacturers at the beginning of 2013.

2. Overseer 6 does not allow for riparian strips to be installed on tile drained areas, which most of the dairy farms in the Aparima catchment have.

The situation on sheep and beef farms is different, mainly because the main mitigation strategies applicable relate to reducing phosphorus loss, which tend to be lower cost than N mitigation measures (see Table 4). The annual farm surplus for reinvestment for an average Southland-South Otago hill country sheep and beef farm is $142 per hectare (MPI sheep and beef farm monitoring programme).

[3] Based on the average dairy farm in the Aparima catchment; 157 hectares and 409 cows. Financial information sourced from the MPI Southland Dairy Model.

Table 6: Reduction in Nutrient Losses due to progressive introduction of GMP strategies on an average Southland sheep and beef hill country farm[4] and related costs

Mitigation Practice	N reduction (%)	P reduction (%)	*Sheep & Beef Farm* Net Annual cost per ha ($/ha)	*Sheep & Beef Farm* Capital cost per ha ($/ha)
Scenario 2				
Stock exclusion i.e. fencing off streams (FW)	0	0	$4.00	$36.10
FW + Facilitated wetlands (Wet)	0	0	$12.40	$103.80
FW + Wet + Riparian Strips (RS)	0	50	$15.90	$145.20
Total for Scenario 2	0	50	$15.90	$145.20
Scenario3				
FW + Wet + Riparian Strips (RS) [*as above]*	0	50	$15.90	$145.20
Total for Scenario 3	0%	50%	$15.90	$145.20

The sooner, and stricter, water quality limits are imposed the greater the economic cost to farmers in present day money value terms. Scenario 2 shows a net aggregate cost of $88 million at the 8 percent discount rate and would achieve a modelled 28 percent reduction in N losses, and a 34 percent reduction in P losses from farms across the catchment (dairy, dairy run-off and sheep & beef farms), relative to the potential losses if no mitigation was used. Scenario 3 would cost $262 million, and achieve a modelled 32 percent reduction in N losses and a 40 percent reduction in P losses from farms across the catchment relative to the potential losses if no mitigation was used.

The introduction and enforcement of strict nutrient loss limits and over a short time-frame (Scenario 3) would have a significant adverse impact on the profitability of existing farms, and would very likely slow the rate of, or even stop, dairy conversions. A longer time frame will lessen the impacts; this time frame may need to be intergenerational.

Within this case study analysis, no allowance was made for the financial support of a technology transfer programme, although it is assumed that technology transfer or extension activities are operational, most likely supported by industry good bodies and/or by the Council. In the absence of such programmes, adoption times are likely to be much longer.

[4] Based on MPI Southland-South Otago Hill Country Sheep and Beef Model; 723 hectares.

1.5 CONCLUSIONS

The main conclusions from the Aparima catchment case study are:

- Land use in the Aparima catchment is likely to shift towards more intensive uses such as dairying, as there is potentially significant economic gain from this land use change.
- Land use change into dairying from sheep and beef farming without the adoption of Good Management Practices (GMPs) results in increased modelled nutrient losses from farms.
- The adoption of GMP mitigation strategies reduces modelled nutrient losses from individual farms, but does not eliminate them. Implementation of a full range of mitigation practices on existing and new farms, while allowing for land use change, can keep aggregated modelled nutrient losses from farms at a catchment level at close to pre-intensification levels.
- The adoption of GMP mitigation strategies cost money. However, there is significant variation in both the cost and effectiveness of different GMPs. Some strategies are highly cost-effective, while others are very expensive and could render some individual farms unviable (in terms of their present cost structure; they could still be viable under a lower cost structure or different land use).
- While there is an obligation on farmers to mitigate contaminant flows, for average performing farms (in terms of profitability) there is a limit to the number of GMPs that farmers can implement and remain viable. Farmer performance is highly variable, however, and the best performing farmers will find it easier (in a monetary sense) to adopt GMPs and remain viable.
- A relatively intensive technology transfer programme is required (i.e. significantly more than is occurring at the present) in order to achieve adoption of the GMPs in a reasonable time span. Such a programme, if well-resourced and targeted, would also have positive spin-offs in lifting farm profitability.
- Implementation timeframes are highly influential. Faster implementation of farm based nutrient limits will result in higher overall costs and likely more social disruption.
- If economic development from land use intensification remains an important value for communities, then there are some cost effective mitigation strategies that could be implemented/required now that significantly reduce the modelled losses of N and P from farms and thus allow for further land use intensification over time.

2 Background and Purpose

2.1 BACKGROUND

Intensification of land and changing land use can result in an increasing level of contaminant discharges into water systems. The Resource Management Act (RMA) and the National Policy Statement for Freshwater Management (NPSFM) requires quantity and quality limits to be set. Regional Councils are responsible for setting and implementing policies around limits for freshwater. Across New Zealand, Councils are at different stages of the policy and limit setting process. Further changes to the policy framework for managing water can be expected as a result of the government's proposed fresh start for freshwater reforms.

2.2 PURPOSE

The **purpose** of this project, "Economic analysis of the impact on farming of limiting the loss of nitrogen and phosphorus" is to investigate the economic impacts at an **aggregate farm level** of setting water quality limits.

The Aparima catchment was selected as a case study because of land use change potential from sheep and beef to dairying.

3 Method of Study

This project is a case study assessment of the Aparima catchment in Southland, aimed at getting a preliminary understanding of potential economic impacts on land users of setting and implementing water quality limits.

This case study investigates the economic costs and benefits, at a farm level, of implementing the more readily available on-farm mitigation options or good management practices (GMPs) to minimise loss of nitrogen and phosphorus. This study is not intended to be a comprehensive cost benefit analysis of the effect of setting water quality limits.

This report covers the case study assessment of the Aparima catchment.

The study method follows that used by Journeaux *et al.* (2011) in an economic analysis of reducing nitrogen input into the Upper Waikato River catchment.

The **method of analysis** involves:

- categorising the catchment under study by land use and number of commercial farms;
- assessing likely land use change;
- using MPI Farm Monitoring models to represent typical farms in the catchment;
- using MPI Farm Monitoring models and the nutrient budgeting and management tool, Overseer®, and other information, to assess nutrient losses from farms;
- applying a range of mitigation practices or GMPs to an average farm and assessing the costs/benefits of these;
- using Overseer® version 6.1.1, assessing how much nutrient losses could be mitigated over a number of time frames and the net cost at a farm level;
- scaling up from an average farm and aggregating these to represent reduced nutrient losses from farms at a catchment level; and
- using Net Present Value (NPV) analysis at 2 discount rates over a 45 year period.

Two discount rates are used in this analysis:

- Treasury Guideline Rate, based on the "government opportunity cost of capital" (Treasury, 2008), is used as the "risk based rate". This gives a default discount rate of 8.0 percent real (deflated for inflation and tax).

  This is calculated as follows:
  WACC (real) = [(1+WACCn)/(1+i)]-1
  Where: WACCn = [RFR x (1-Tc) + (Ep x βa)] / (1-Te)
  Tc (corporate tax rate) = 30%
  Te (effective tax rate) = 20%
  Ep (equity risk premium) = 7%
  RFR (risk free rate) = 6.4%
  i (inflation rate) = 3%
  βa (asset beta) = 0.67

The second discount rate would be considered as the "risk-free alternative", or social time preference rate, which is taken as the ten-year average of the ten-year government bonds. This equals 5.6 percent (nominal) (Treasury, 2012). If this is deflated as per the equation above, the real discount rate becomes 2.5 percent. This is the figure used as the real risk-free rate in this analysis.

The study considers a number of limit setting scenarios for the Aparima catchment.

Not considered in this study

- Water quantity issues.
- Land use change as a mitigation option (e.g. pastoral farming to forestry).
- Attenuation of “beyond farm boundary” nutrient losses – so farm boundary nutrient losses cannot be equated with catchment load as a result of land use change.
- Consideration of the environmental effect of reducing farm level nutrient losses was outside the scope of this study.
- This project is a technical study as opposed to a policy analysis and does not attempt to investigate or propose options for land use within the catchment.
- The economic, social and environmental flow-on effects across the region as a whole are important (beyond the farm gate), but were not covered in this study.
- On-farm intensification, beyond conversion of land from sheep and beef farming to dairying.
- The option of reducing stocking rates to limit nutrient losses.

4 Background to Aparima Catchment, Southland

4.1 LAND USE

The Aparima catchment is in south western Southland, covering an area of 153,740 hectares. Current land use is outlined in Table 7 and Figure 1. Predominant land use is agriculture, with an increasing level of land use conversion from sheep and beef to dairy.

Other primary sector land uses within the catchment, e.g. deer, forestry, and arable, are minimal and not showing a significant expanding or contracting trend.

The estimated number of **commercial farms** (farms > 25 ha) within the catchment is 150 dairy farms and 251 sheep & beef farms.

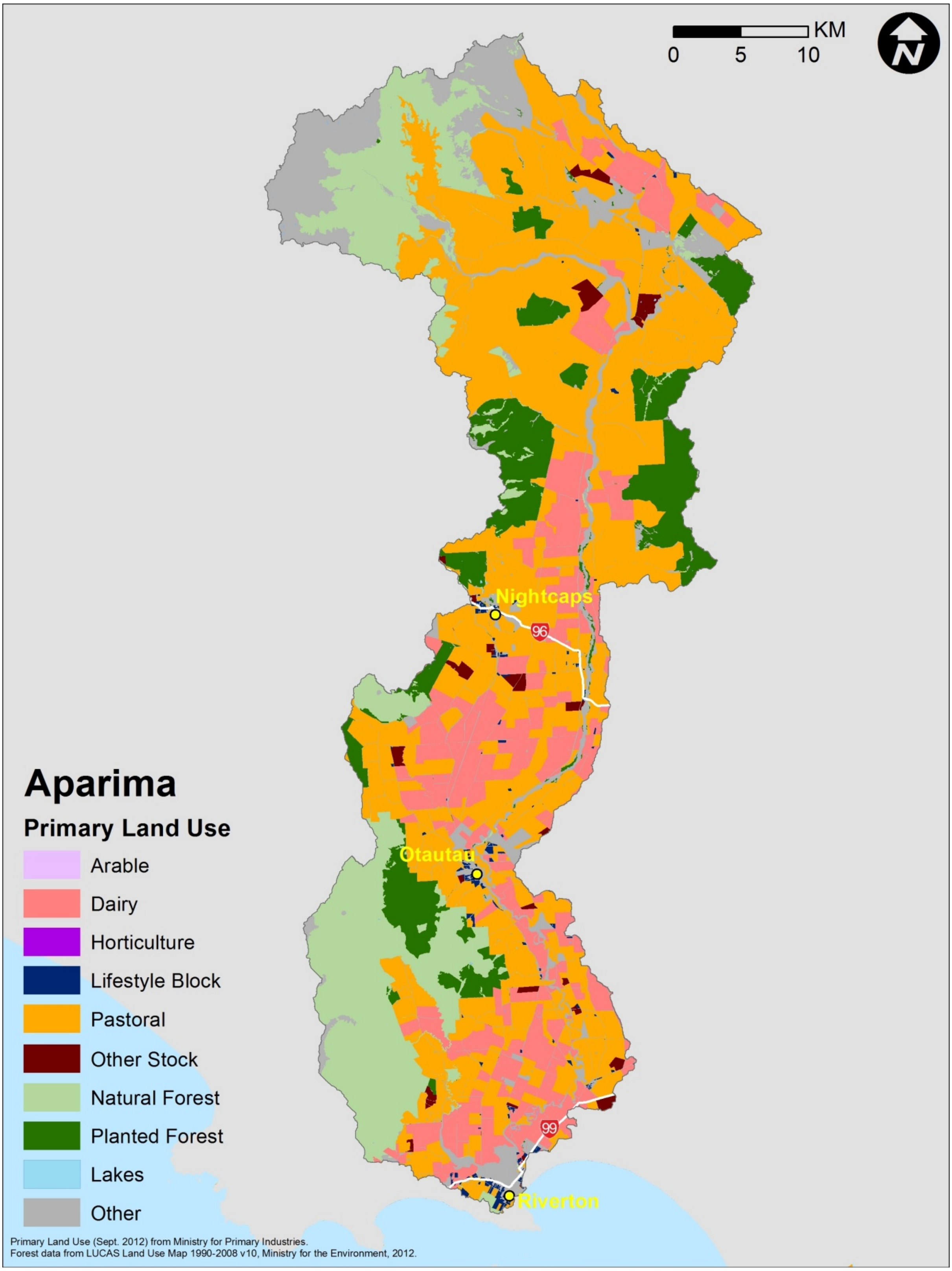
Table 7: Land Use in the Aparima Catchment

Primary usage	Number of properties*	Area (ha)
Pastoral	400	70,490
Dairy	201	24,870
Pigs	2	190
Deer	23	1,630
Horses	3	10
Total Agriculture	629	97,190
Forestry Exotic	42	17,490
Forestry-Indigenous	5	3,540
Forestry-Protected	5	4,720
Reserve	12	16,130
Total Other	64	41,880
All Other	347	14,670
Catchment Total	1,040	153,740

Source: MPI

Note
*Includes small farms (farms < 25ha)

Figure 1 Land Use in the Aparima Catchment



Source: MPI

4.2 STREAMS

There are 2,524 kilometres of streams within the catchment, as shown in Table 8 below.

Streams of Order 1 are occasional flowing/ephemeral streams; Streams of Order 6 are major rivers.

Table 8: Length of Streams in the Aparima Catchment

Stream Order	Length (km)
1	1,226
2	672
3	334
4	117
5	82
6	93
Total	2,524

Source: MPI

4.3 WATER QUALITY IN THE APARIMA CATCHMENT

The main contaminants entering waterways and the Aparima estuary from farms are nutrients (N and P) and sediments. The impact of these is particularly evident at the mouth of the Aparima River (Environment Southland, 2010; Parts 1, 2 and 3). These contaminants also impact the Macroinvertebrate community and levels of algae in the Aparima River. Microbial contamination is an issue with respect to swimming, and taking of whitebait and shellfish.

There are recognised nitrate “hotspots” in the Southland region and the Aparima catchment appears to have areas of elevated risk (Environment Southland, 2012). Most monitored groundwater sites in the Southland region have potable water, but 36 percent of sites show deteriorating trends, and where those levels are elevated, Southland concentrations are higher than in some other regions. Nitrogen (N) losses are likely to increase with land use intensification, including dairy conversions.

The water quality objectives in the Southland Regional Water Plan (2010) recognise that water quality is poor in some parts of the region and should not be allowed to deteriorate further. A key goal or policy objective of the Regional Water Plan is a 10 percent improvement in water quality by 2020 in degraded areas. This is specified as achieving a minimum of 10 percent improvement in levels of the following water quality parameters by 2020 in degraded surface waterways:

- Microbial contaminants;
- Nitrate;
- Phosphorus; and
- Clarity.

Environment Southland has developed the “Water and Land 2020 and Beyond” project, in part in response to the National Policy Statement for Freshwater Management. This is a partnership project to achieve community goals for maintaining and improving water quality within the Southland region.

The Water and Land 2020 and Beyond project has identified the following priority focus activities to work on over 2013 to 2015:

1. Nutrient Management;
2. Wintering;
3. Riparian Management/Overland Flow;
4. On-site Wastewater Systems;
5. Hill Country Development;
6. Manures and Slurries;
7. Community Sewage Schemes; and
8. Five existing notified Plan Changes

With respect to land management, the emphasis is on implementing GMPs and halting the decline in water quality. The focus activities are still under development, but the main GMPs likely to be promoted through a mix of methods are:

- improve nutrient management through widespread adoption of nutrient budgeting;
- improved winter forage crop paddock selection and management;
- improving the management and reducing loss from critical source areas;
- targeted stock exclusion from waterways;
- dairy effluent storage coupled with low rate application;
- riparian management plans; and
- controls on hill country development.

4.4 CHANGE IN LAND USE AND NUTRIENT LOSSES

The baseline analysis for this report assumes continued conversion of sheep and beef farms into dairying. Within the Aparima catchment there are c. 50,500 hectares of sheep and beef land on land use classes (LUCs) 2, 3, and 4 which are considered suitable for conversion. At the current rate of conversion, (5 year average of 5.6 percent compound increase in numbers per year, plus 3.6 percent compound per year increase in average size) all this land will be dairy or dairy support by 2024. A slower 3.7 percent (10 year average) increase in conversions per year will see 50,500 ha converted by 2031.

For every 3 dairy conversions, 1 sheep and beef farm on LUC 4 land will be assumed to be converted to dairy support. Dairy support blocks are where young stock and dry cows are grazed, and supplementary feed is often made on these blocks for feeding out on the milking platform.

Over the last 10 years stocking rates on sheep & beef farms in Southland have decreased by an average of 2 percent, while stocking rates on dairy farms have increased by an average of 0.4 percent. The correlation between stocking rate and estimated nutrient loss on dairy farms is low (MPI, 2011) due to the various winter management strategies used by farmers. For these reasons, the effects of any increase in nutrient loss as a result of on-farm intensification, beyond conversion of land from sheep and beef farming to dairying has not been taken into account in this study.

4.4.1 Current Levels of Nutrient loss from farms

Estimates of the current levels of nutrient loss from farms within the Aparima catchment/Southland were obtained from nutrient budgets done by Ballance Agri-Nutrients Ltd, using Overseer 6. (J Risk, pers com).

In as much as Overseer 6 has only been released for approximately 18 months, there is somewhat limited data to draw from, and this is in the form of ranges rather than averages (see Table 9 below).

Table 9: Typical nutrient losses from Southland farms

Farm Type	N Loss (Kg N/Ha/year)	P Loss (Kg P/Ha/year)
Dairy	25-40	0.8-1.2
Dairy Support	15-35	0.4-1.0
Sheep and Beef	10-20	0.5-0.8

It is difficult to give a reliable average, given the range of farming systems, soil types, fertiliser applications, etc. Phosphorus losses for example are influenced by soil type (with many Southland soils being Pallic, with low P retention), Olsen P levels, slope, and rate and timing of fertiliser applications.

For the purposes of this study, a mid-point between the ranges was used for the analysis outlined in Table 10 below.

Assuming all the suitable land is converted, in the absence of any mitigation, the total annual N losses from pastoral agriculture is estimated to increase from 1,878 tonnes to 2,692 tonnes (43 percent increase), as shown in Table 10. The total P loading is estimated to increase from 71 to 85 tonnes (20 percent increase).

Table 10: Modelled increase in annual average N and P losses from farms in the Aparima catchment due to dairy conversions

Pre-conversions					
	Hectares	N leaching rates (kgN/ha/annum)	Tonnes N	P leaching rates (kgP/ha/annum)	Tonnes P
Dairy	24,868	33	821	1.0	25
Sheep & Beef	70,483	15	1,057	0.65	46
	95 351		1,878		71

Post-conversions					
	Hectares	N leaching rates (kgN/ha/annum)	Tonnes N	P leaching rates (kgP/ha/annum)	Tonnes P
Dairy	63,717	33	2,103	1.0	64
Dairy run-off	11,521	25	288	0.7	8
Sheep & Beef	20,113	15	302	0.65	13
	95,351		2,692		85

5 Good Management Practices for Managing and Reducing Nutrient Losses from Farms

5.1 INTRODUCTION

The contaminants considered in this analysis are nitrogen (N) and phosphorus (P). Microbes and sediment are recognized as other agricultural contaminants of importance but data limitations hindered a robust analysis.

As a generalization, the main pathway for N loss from farms is by leaching into groundwater, while for P, microbes and sediment loss, the main pathway is surface run-off into waterways. One variation to this is loss via mole or tile drains, whereby all the contaminants can readily bypass the soil profile and be discharged into receiving waterways (Monaghan *et al.* 2010). This is particularly important in Southland where such drainage is common.

There is a range of known technologies or approaches that can be used by farmers to reduce contaminant loss from farms that may enter water bodies. These are variously described as good management practices (GMPs), good agricultural practices (GAPs), and good environmental management practices (GEPs). For the purposes of this report they will be referred to as GMPs. Many of these GMPs have mitigation impacts across a range of contaminants, while others are more specific, especially for N. For a more detailed discussion on GMPs, refer to Waugh (2013).

AgResearch (Monaghan, pers. com.; McDowell, 2011) has organised GMPs into two tiers relative to their efficacy and cost in mitigating nitrogen and phosphorus in research trials and modelling work (see Table 11). Tier One strategies or practices are cheaper and/or more cost effective, whereas Tier Two strategies are more expensive and/or less cost effective.

Table 11: Good Management Practices (GMPs) and their efficacy in nitrogen and phosphorus mitigation *(based on a range of research and modelling work)*

Tier One

GMP	Target contaminants	N reduction (%)	P reduction (%)
Optimum soil P test	Phosphorus	Not applicable	5-20
Low solubility P fertiliser	Phosphorus	Not applicable	0-20
Stock exclusion from waterways	Phosphorus, Microbes, Ammonium-N, Sediment	2-5	3-30
Optimal dairy effluent management	Phosphorus, Microbes, Ammonium-N	2-6	10-30
Facilitated wetlands	Microbes, Nitrogen, Sediment	Data not available	<10

Tier Two

GMP	Target contaminants	N reduction (%)	P reduction (%)
No winter N fertiliser	Nitrate-N	0-15	Not applicable
Nitrification inhibitors	Nitrate-N	0-35	Not applicable
Wintering cows in herd shelters	Nitrate-N, Ammonium-N, Microbes, Phosphorus	18-40	3-15
Substituting N-fertilised pasture with low N feeds	Ammonium-N	Data not available	Data not available
Tracks and lanes sited away from streams & lane runoff diverted to land	Phosphorus, Microbes, Ammonium-N, Sediment	Data not available	Data not available
Constructed wetlands	Nitrate-N, Ammonium-N, Microbes, Sediment	24-50	-426-77
Grass buffer strips	Nitrate-N, Ammonium-N, Microbes, Phosphorus, Sediment	4-14	0-62

5.2 DETAILS OF GMP MITIGATION OPTIONS

Mitigation options modelled in this study include a selection of the Tier 1 and 2 GMPs outlined in Table 11.

5.2.1 Nutrient Management Plans

It is assumed that nutrient management plans (NMPs) are to be developed for all farms. NMPs describe nutrient inputs and outputs from the farm, along with grazing management strategies and mitigation strategies to minimise nutrient loss. The plan itself does not reduce nutrient discharges – it is more a "call to action" for the farmer. The cost of this would be an initial cost of developing the plan and an ongoing annual cost to monitor the plan.

5.2.2 Stock Exclusion

Streams are fenced off so as to exclude stock. Within the study catchment the majority of existing dairy farms have already fenced off relevant streams. The requirement to do so on dairy farms is covered under the Dairying and Clean Streams Accord, and its successor, the "Sustainable Dairying: Water Accord", and more recently as a supply requirement to Fonterra under the "Supply Fonterra" programme. Given that it is a supplier requirement, and that 90 percent of the streams are already fenced-off, the cost of fencing the remaining streams on existing dairy farms was considered a sunk cost and ignored.

Costs involved on new dairy farms and existing sheep and beef farms include the capital cost of the fencing and an ongoing maintenance cost. While it could be argued that new dairy farms have to fence off streams as part of the "Sustainable Dairying: Water Accord" this is still (a) a cost to the farm to reduce nutrient losses, and (b) part of the dairy industry's response to increasing environmental restrictions.

Within the study, it was assumed that only streams of Order 2 and above were fenced. Order 1 streams are in effect mostly ephemeral streams; these are streams that flow only during and immediately after heavy or sustained periods of precipitation.

It was assumed that 25 percent of streams on hill country sheep and beef farms in the Aparima catchment could not be fenced for topographical reasons.

The MPI survey (MPI, 2011) indicated that 90 percent of permanent streams through existing dairy farms are already fenced. The analysis assumes that the 67 percent of the remaining length to be fenced on existing dairy farms occurred in 2012 and the last 33 percent finished in 2013. All exclusion fencing on dairy conversion farms will be assumed to happen in the year of conversion, and sheep and beef farms will follow the 20 year adoption curve.

5.2.3 Dairy Effluent Storage

The intent of this practice is to prevent run-off/leaching of effluent from dairy sheds and over-wintering facilities onto soils that are saturated by deferring irrigation of effluent until soils are able to absorb the effluent, reducing the risk of runoff, leaching and loss in preferential drainage pathways. For the purpose of this study, this GMP involves the installation of a storage pond with the capacity to store 90 days of effluent. The costs include the capital cost of the pond, ongoing maintenance cost, and an initial cost for consent to build the pond and irrigate the effluent. The economic benefit from this strategy would be the value of the nutrients saved and able to be applied at times of active pasture growth, to reduce fertilizer requirements.

As at 2012, it was estimated that 59 percent of existing dairy farms in the Aparima catchment already have effluent storage facilities. The analysis makes the assumption that as existing discharge consents come up for renewal over the next 11 years, starting in 2013, Environment Southland will enforce rules for the construction and use of effluent storage ponds on dairy farms.

5.2.4 Facilitated Wetlands

These are boggy areas that are fenced off and planted with shrubs and trees, i.e. natural wetland areas that intercept run-off, especially from ephemeral streams. The outcome is an enhanced performance of the wetland as protected plants soak up discharges. Costs involved include fencing and the planting of the sites, and ongoing maintenance.

5.2.5 No Winter Nitrogen

This strategy involves no application of nitrogen fertiliser over the high risk winter months of May/June/July on dairy farms, giving a 20 percent reduction in overall N applied per hectare per annum. A reduction in nitrogen fertiliser application over these critical months has two effects:

(i) It will avoid direct leaching of the applied fertiliser nitrogen, which can be up to 30 percent of the N applied, depending on the nitrogen rate, rainfall, and any specific conditions within that year (Ledgard *et al.* 1988); and

(ii) An indirect effect of less nitrogen fertiliser applied overall, resulting in less N in pasture which reduces urine N excreted, but also less pasture growth (Ledgard *et al.* 1999).

The cost of this practice is the loss of pasture grown, with a benefit being the saved cost of applying the nitrogen fertiliser.

While in Southland the winter period is considered to be May to September, September is considered a low-risk month for leaching nitrogen. Given this, nitrogen fertiliser was still applied in September within the analysis.

5.2.6 Nitrification Inhibitors

Note

The sale and application of nitrification inhibitor products containing DCD (dicyandiamide) was suspended in New Zealand by manufacturers at the beginning of 2013.

Nitrification inhibitors can reduce nitrate leaching. The normal practice is to apply one dressing in late autumn (May) and a second dressing in late winter (August). The cost of this strategy is obviously the cost of applying the inhibitor, whereas the benefit is in any pasture response from the increase in available N within the soil profile and decreased risk of loss from urine patches. For Southland, research results would indicate a relatively minimal pasture response; less than one percent over a four year period (Monaghan, 2009; Gillingham *et al*. 2012). The one percent response is included in the analysis, but in practical terms this response would be virtually impossible to recognise and gain any advantage from.

The effect of a nitrification inhibitor applied in late winter could well be nullified by the use of a wintering facility. Even allowing for on-off grazing using the wintering facility, very little urine would be deposited on the pasture over the winter period and hence the efficacy of the second application of an inhibitor could be significantly less. The recommendation in this situation would still be to apply the two applications, but both in the autumn. Research has shown that an application in March and another in late April/early May were quite effective at reducing nitrate leaching over that period (Monaghan pers. com). Given this, no change was made in the analysis for costing nitrification inhibitors even if a wintering facility was also being used.

5.2.7 Riparian Margins

In conjunction with fencing off streams is the opportunity to develop riparian margins, which can be very effective in reducing overland flows of phosphate, sediment, and microbes. One of the major decisions around riparian margins is the width of the margin, and the vegetative cover. In many respects farmers could well just fence 1 to 3 metres back from the stream, which would reduce the amount of land lost for productive purposes.

The width of riparian strips, to be effective, depends very much on soil type and slope (Quinn pers. com.). In general the greater the slope, the greater the width needs to be to act as an effective filter to manage run off. For the purposes of this study, it was assumed that dairy farmers fenced 5 metres back from the stream; sheep and beef farmers planted 8 metres back (on the assumption that they are on steeper country and water run-off velocity is greater) and planted up the margin in a variety of (mostly) native plants.

The design of riparian buffers can be complex, depending on what they are required to do. If stream bank stability and biodiversity are prime goals, then planting the strips is required. To control nutrient run-off, grass strips are often more effective. With a 5 metre margin, the amount of light entering the strip would be high, and a reasonable level of grass growth could be expected. Within this study, the assumption was made that the riparian strips would be planted up.

Environment Southland has a “Living Streams” programme in the region which provides financial assistance to landowners to assist with riparian development – it contributes 50 percent of the cost of plantings, and 25 percent of the cost of fencing. However, the Aparima catchment does not currently have any eligible “living streams” sites and therefore the subsidies are not applicable. Environment Southland considers that it is logical to assume there would be more funding allocated to land sustainability / resource care type programmes in the future to support the implementation of Water and Land 2020 and Beyond; however it is hard to say geographically where additional funding may be targeted. Hence, *the analysis assumed no subsidy was available* for riparian fencing and planting. If a subsidy was provided, the mitigation cost would still be incurred but shared by the ratepayers and the farmers, although, the rate of adoption for riparian planting would likely be faster if a subsidy was provided.

5.2.8 Wintering Facility

A physical structure is built for use as an on-off grazing system over the winter months. Possibilities range from a sawdust-bark stand-off pad through to a free-stall facility or herd home. The costs include the capital cost of the structure, ongoing maintenance and operating cost for the facility, i.e. the cost of any bought in feed. Economic benefits would include the saved costs of not grazing cows off over winter on contract, reduction in pugging damage on run-offs, reduced travel costs to run-offs, increased milking period, reduced amount of bought in supplementary feed – more would be made on the run-off due to a lower winter stocking rate, better cow condition, and less dry/empty cows.

5.2.9 Constructed Wetlands

This strategy involves the physical construction of a wetland to intercept drainage off a catchment (McKergow *et al.* 2007). In Southland, this could well be an opportune strategy to intercept tile drain outflows which would normally bypass all other mitigation strategies.

To be effective, a constructed wetland needs to be a minimum of 2.5 percent of the size of the catchment it is servicing. For the analysis, it was assumed that on the existing dairy farms a 2.5 hectare wetland was constructed catching drainage from 100 hectares, while on the converted dairy farms, which were larger, two such 2.5 hectare wetlands were constructed on each farm. The costs include the capital cost of the wetland, an ongoing maintenance cost, and the opportunity cost of any productive land which was taken out of grazing and incorporated into the wetland.

5.2.10 Tussock Development

In the Southland hill country there is still an area of tussock which could be developed into improved pasture land. The assumption for the analysis was that further development was prohibited given the increased nutrient and sediment flows from developed land, and hence the cost of such a strategy is the opportunity cost of lost income less any development costs.

5.2.11 Mitigation Strategies not modelled

The effectiveness of mitigations practices that were not modelled in this study would vary, depending on the individual farm circumstances. As a generalisation, with the exception of forestry, they would likely have a lesser effect compared with the practices included in the study.

(i) Grazing off

This involves grazing the milking cows off the milking platform over the winter period. This is a common and cost effective means of both conserving winter feed through to the spring, and reducing nitrate leaching. While a relatively common practice, this strategy was not costed in the analysis, the main reason being that it does not represent a permanent reduction in nutrient output, but shifts the issue from one catchment to another. However, it is acknowledged that the receiving catchment might be able to manage the overwintering of dairy cows within its nutrient limits or that other soil types/climates may be more suited to wintering practices or that N loss potential could be managed differently.

(ii) Diet manipulation

Another approach to reducing nitrogen leaching is via diet manipulation, whereby dairy cows are fed a proportion of their diet which is low in protein, high in carbohydrates, e.g. maize silage. Generally New Zealand pastures are high in protein, but relatively low in energy (i.e. carbohydrates). By feeding a mix of pasture and maize silage it is possible to lower the ammonia content in urine, and hence reduce nitrogen leaching.

However, such a management system has its challenges. There is the issue of the proportion of pasture "not eaten" (i.e. the amount of the diet fed via the supplement instead of grass). That means the uneaten pasture must be either conserved as supplementary feed and/or the stocking rate lifted to accommodate it, with an accompanying lift in nitrogen leaching due to the greater number of cows.

But growing the maize often results in the same amount of nitrogen leaching as the original system. While the maize could be grown outside of the catchment, and there are management techniques to reduce nitrogen leaching from maize, this system of diet manipulation, in respect to managing the potential N loss, is very complex, and was not analysed within this study.

(iii) Run-off from farm tracks and raceways

Nutrient run-off in surface water into water-courses from rain on farm tracks and raceways can be significant (Monaghan and Smith, 2012). Within this study it was assumed that shifting of existing tracks would not be an alternative although it may be possible for farmers to divert run-off from raceways, albeit that much of the run-off would be directed onto pastures.

For dairy conversions, it was assumed that the development of raceways would be part of the conversion exercise, and due consideration of their placement would be made as part of this exercise. The cost of races and tracks is an integral part of the conversion cost, and was not treated as a separate cost within the analysis.

(iv) Optimum soil phosphate levels

On a number of farms, especially well-developed dairy farms, the soil phosphate level is often above the optimum level. Reducing soil phosphate levels assists in reducing phosphate loss, and one strategy therefore is to reduce or eliminate phosphate fertiliser applications until soil levels have dropped to the optimum level. The main gain is when Olsen P levels are quite high (e.g. 40-60) and are reduced down to the optimum level of around Olsen 30. Reductions below this level have a limited impact in reducing P loss, and can reduce pasture growth. While recognising its potential, the applicability of this GMP is very much on a case-by-case basis, and was not modelled within this analysis.

(v) Phosphate fertilizer type

Slow release phosphate fertilisers (e.g. rock phosphates) can result in a lesser run-off of P, particularly in the first 2-3 months after application as it takes time for the fertiliser to dissolve and the P to become plant-available. Once a soil has reached its optimum P level, the use of slow release fertilisers used to maintain this have no advantage for reducing P loss. The applicability of using this type of fertiliser is farm dependent, so again while recognising it is a possibility; it was not modelled within this analysis.

(vi) Forestry options

Commercial forestry as a land use option generally has minimal nutrient loss given (a) the absence of animals to create the loss, and (b) they are effective at intercepting overland flows, given sufficient depth of forested land.

The exception could be loss of sediment from clear-cut areas of forestry, which requires its own mitigation strategies.

Within the study catchment the probability of forestry areas either expanding or contracting was considered very low due to the incompatibility of high land value and relatively lower profitability of forestry. As a result any change in forestry as a land use was ignored within the study, as was the possibility of planting areas up within farms as a mitigation strategy.

5.3 ADOPTION RATES

Three different adoption rates or curves were used in the case study depending on the mitigation strategy or practice in question. These adoption curves were a 20 year curve, a 10 year curve, and a 5 year curve, as outlined in the figures below. The figures behind these curves are shown in Appendix 1.

Figure 2 20 Year Adoption Curve

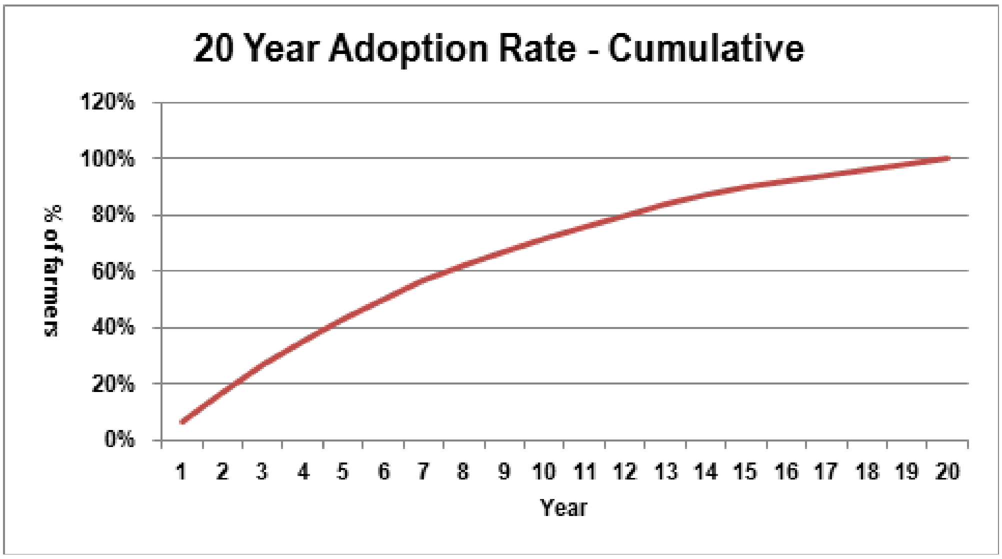


Figure 2 10 Year Adoption Curve

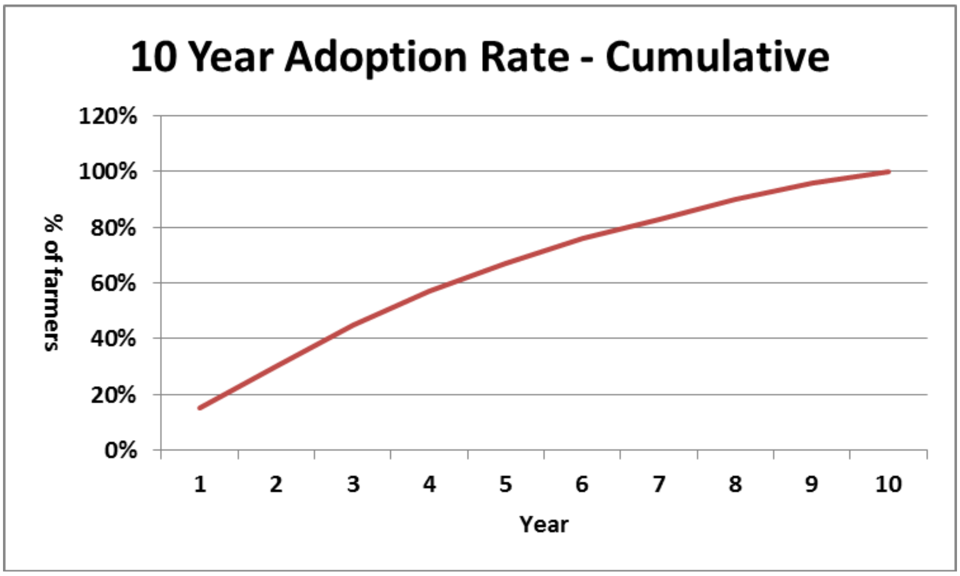
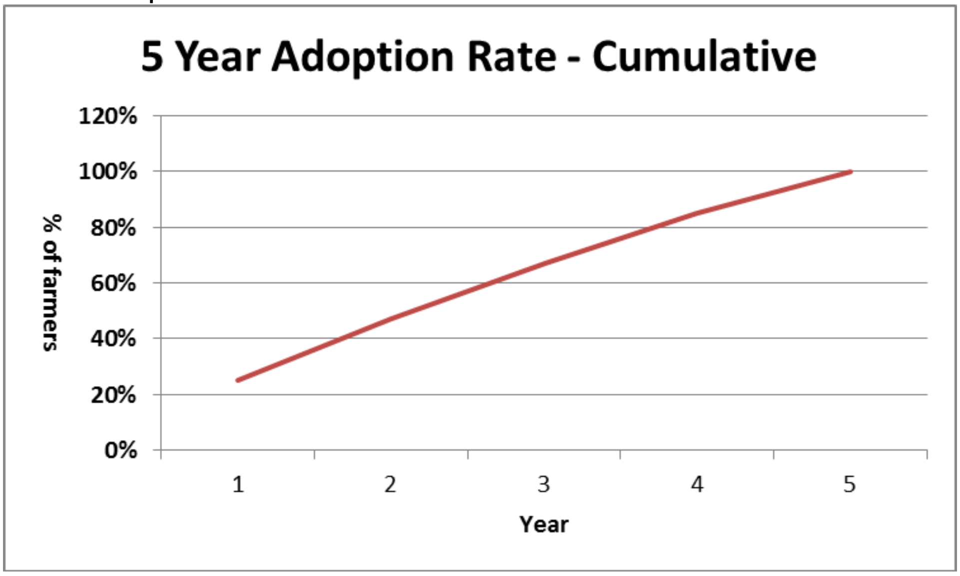


Figure 4 5 Year Adoption Curve



The significance of these curves is that the rate of adoption of the GMP drives the timing of the subsequent economic costs and benefits calculated as illustrated in the table below.

Table 12: Difference in Economic Cost Due to Variable Adoption Periods

GMP	Difference in $ million Adoption Period			Difference in cost over adoption periods (%)		
	5 years	10 years	20 years	5 vs. 10	10 vs. 20	5 vs. 20
Winter N	4.6	4.3	3.9	7	10	17
Effluent storage	13.1	11.4	10.2	14	12	28
Winter facilities	202.0	126.8	103.5	59	23	95
Nitrification Inhibitors	127.8	119.4	93.9	7	27	36
Riparian Management	5.9	5.2	4.1	14	26	44
Facilitated Wetlands	7.8	4.4	3.9	76	12	97
Constructed Wetlands	98.1	94.9	89.4	3	6	10

Note
The adoption period relates to the existing properties; new conversions were assumed to adopt the practice at the time of conversion.

The exception to using the adoption curves above was the implementation of effluent storage ponds in the Aparima catchment. The intent by Environment Southland is to have farmers install ponds as their current discharge consent expires – this starts in 2013, and finishes in 2023, so the exact timing and numbers involved were reflected in the analysis.

5.4 TECHNOLOGY TRANSFER

Technology transfer programmes, or extension, are a critical means of enabling farmers to adopt new innovations. There has been significant research to show the value of farm extension in assisting farmers adopt innovations or new farming systems (see Journeaux 2009 and references therein).

Many environmental GMPs are complex, provide little relative advantage to the farmer (especially economic), and outcomes are usually difficult to monitor and observe in the short term.

Technology transfer or extension programmes, including social marketing, are needed to help speed up the adoption of GMPs for environmental outcomes. These programmes, provided they take the recommended farm systems approach, will also improve farm profitability, making the adoption of GMPs more affordable over time.

Technology transfer on its own would not be sufficient to ensure adoption of the more expensive GMPs (e.g. wintering facilities, constructed wetlands) – in this instance other methods including consideration of regulation would be necessary to incentivise such changes over a defined timeframe.

Further discussion of technology transfer for the adoption of environmental GMPs is included in Appendix 2.

Within this case study analysis, no allowance was made for the financial support of a technology transfer programme, although it is assumed that technology transfer or extension activities are operational, most likely supported by industry good bodies and/or by the Council.

6 Scenarios and Assumptions

6.1 SCENARIOS ANALYSED

6.1.1 Scenario 1 – No limits baseline

The base scenario; assumed expected land use change to dairying, without any restrictions, or limits on nutrient losses from farms. The effective start date of this scenario is 2012.

6.1.2 Scenario 2 – Limits on N and P losses from farm land implemented from 2025 with assumed land use change

This scenario assumes:

(i) land use change of all available suitable land to dairying, starting from 2012;
(ii) the adoption of stock exclusion from 2013 and GMP mitigation practices identified as potential mitigation options as part of the "Water and Land 2020 and Beyond project" from 2014 (see Table 9); and
(iii) the requirement for catchment N and P losses from farm land to be held at 2012 levels, starting from 2025. A five year transition period after 2025 is assumed and another ten years to fully implement. So the implementation period is 2025 – 2040 to achieve 2012 N and P losses from farms.

6.1.3 Scenario 3 – Limits on N and P losses from farm land implemented from 2015 with assumed land use change

This scenario assumes:

(i) land use change of all available suitable land to dairying, starting from 2012;
(ii) the adoption of stock exclusion from 2013 and GMP mitigation practices identified as potential mitigation options as part of the "Water and Land 2020 and Beyond project" from 2014 (see Table 11); and
(iii) the requirement for catchment N and P losses from farm land to be held at 2012 levels, starting from 2015.

Hence this scenario assumes the implementation of a wide range of GMPs from 2015 to help meet the nutrient loss limits.

Table 13: Proposed Time Line for the Introduction of GMP's to meet limits as per the scenarios, for the Aparima Catchment

Scenario & GMPs	Start Year			
	Existing farms	*Rate of adoption from start year*	*Dairy farm conversions*	*Rate of adoption from start year*
Scenario 1	2012	Not applicable	2012	Not applicable
Scenario 2 • Adoption of some GMPs from 2013 and 2014. • Set catchment loss limits from 2025. Assume limit means holding N and P losses from farm land in the catchment at 2012 levels so further GMPs are implemented from 2025.				
Nutrient management plans	2014	5 years for existing dairy farms; 10 years for sheep & beef farms	-	At conversion
Stock exclusion i.e. fencing off streams	2013	2 yrs for existing dairy farms; 20 yrs for sheep & beef farms	-	At conversion
Farm dairy effluent storage	2013	At time of renewal of resource consent for existing dairy farms;	-	At conversion
Facilitated wetlands	2014	20 years for all farms		20 years from conversion
No winter nitrogen	2014	10 years for existing dairy farms	-	At conversion
No tussock development	2014	20 years	-	Not applicable
Nitrification inhibitors	2025	20 years for existing dairy farms	-	20 years from conversion
Riparian strips	2025	20 years for existing dairy farms 20 years for sheep and beef farms	-	At conversion
	Existing farms	*Rate of adoption from start year*	*Dairy farm conversions*	*Rate of adoption from start year*
Scenario 3 • Adoption of some GMPs from 2013 and 2014. • Set catchment loss limits from 2015. Assume limit means holding N and P losses from farm land in the catchment at 2012 levels so further GMPs implemented from 2015.				
Nutrient management plans	2014	5 years for existing dairy farms; 10 years for sheep & beef farms	-	At conversion
Stock exclusion i.e. fencing off streams	2013	2 yrs for existing dairy farms; 20 yrs for sheep & beef farms	-	At conversion
Farm dairy effluent storage	2013	At time of renewal of resource consent for existing dairy farms;	-	At conversion

Facilitated wetlands	2014	20 years for all farms		20 years from conversion
No winter nitrogen	2014	10 years for existing dairy farms	-	At conversion
No tussock development	2014	20 years	-	Not applicable
Nitrification Inhibitors	2015	20 years for existing dairy farms	-	20 years from conversion
Riparian Strips	2015	20 years for existing dairy farms 20 years for sheep and beef farms	-	At conversion
Wintering facilities	2015	20 years for existing dairy farms	-	At conversion
Constructed wetlands	2015	20 years for existing dairy farms	-	20 years from conversion

6.2 ASSUMPTIONS

6.2.1 Farm Profitability

Farm profitability was based on an inflation adjusted 10 year average economic farm surplus (EFS), which is a recognised economic measure of farm profitability. It is calculated as: Net cash income plus change in livestock stock values less farm working expenditure less depreciation, less wages of management.

The data used in the analysis was based on the Ministry for Primary Industries (MPI) farm monitoring models; Southland Dairy, Southland-South Otago Hill Country Sheep and Beef, and Southland-South Otago Intensive Sheep and Beef. The EFS/ha for the ten years 2003 – 2012 were inflated through to 2012 values using the relevant Primary Producers Index (PPI) (Stats NZ 2012) and then averaged.

Similarly the dairy pay-out figure used was the ten year nominal pay-outs inflated through to 2012 using the dairy PPI and then averaged. Figures are shown in Appendix 3.

6.2.2 Farm Statistics

The Aparima catchment includes the following number of **commercial farms**:

- 150 dairy farms, averaging 157 hectares and 409 cows; and
- 251 sheep and beef farms averaging 266 hectares

Livestock Improvement Corporation dairy statistics over the past ten years were used to calculate the compound rate of increase in the number of dairy farms in the Southland region and districts.

Table 14: Rate of Increases in Dairy Farm Numbers in Southland (compound percent)

	Ten Year Average	Five Year Average
Southland Region	3.8	5.8
Southland Districts	3.7	5.6

The average size of the farms in the Southland district over the last five years increased by 3.6 percent compound per year.

For the purposes of this analysis, two scenario analyses were carried out, based on the Southland District figures: a 3.7 percent and 5.6 percent rate of conversion, with the average farm increasing in size by 3.6 percent per year.

6.2.3 Dairy Conversions

The total area of “pastoral” land (read Sheep and Beef land) in the catchment is 70,470 hectares, of which 50,540 hectares is in land use classification (LUC) 2 – 4. The assumption was that this area would be targeted for dairy conversion, at the rates described above. The current average size of dairy farm in Southland is 214 hectares, which was the starting size of a dairy conversion in the analysis. In addition, for every three dairy conversions, one sheep and beef farm was taken out – assumed split up as a run-off for the conversion farms (MWH 2011, Burborough pers. com). It was assumed that the dairy conversions occurred mostly in the LUC 2 – 3, and the run-off conversions mostly on the LUC 4.

At a conversion rate of 3.7 percent, all available LUC 2 – 4 land was taken up in 18 years, while the available land was taken up in 13 years at the 5.6 percent conversion rate.

6.2.4 Sunk Costs

All costs outside the immediate marginal cost for each mitigation strategy were assumed as sunk costs. For example, in the effluent storage strategy the assumption is that the existing farms already have the required irrigation system in place, and hence the only additional cost is the bigger storage pond itself. Similarly with the dairy conversions, the establishment of an effluent irrigation system is a requirement of the conversion and again the only extra cost is the cost of the bigger storage pond.

6.2.5 Tax and depreciation

Inasmuch as a real discount rate was used, tax is ignored in this analysis. For significant capital items such as wintering facilities, the cost was depreciated over a 50 year life span. This no longer has implications for tax, as they are no longer depreciable for tax purposes.

6.2.6 Scenario Assumptions

Within each mitigation scenario there are a range of assumptions pertaining to that strategy. These are outlined in the relevant GMP cash flows in Appendices 4 to 10.

7 Results

7.1 ECONOMIC EFFECTS OF LAND USE CHANGE AND THE IMPACTS OF LIMITING THE LOSS OF NITROGEN AND PHOSPHORUS FROM FARMS

The economic impacts of land use change, and the cost of imposing limits on nutrient loss is shown in Table 15.

Table 15: Net economic gains from land use change to dairying and costs of imposing limits for N and P losses from farms (NPV at an aggregate farm level)

Rate of dairy conversion	3.7%		5.6%	
Discount rates	8%	2.5%	8%	2.5%
Farm Income (Benefit)	$701m	$2.8b	$843m	$3.0b
Capital Expenditure on Farm (Cost)	-$328m	-$0.540b	-$389m	-$0.564b
Net benefit at farm gate of land use change to dairy	$373m	$2.26b	$454m	$2.44b
Cost of GMPs to meet loss limits and % of net benefit				
Scenario 1	0	0	0	0
Scenario 2				
NPV of GMPs	-$88m	-$0.4b	-$97m	-$0.418b
Cost of GMPs as % of net benefit	24%	18%	21%	17%
Scenario 3:				
NPV of GMPs	-$262m	-$0.564b	-$284m	-$0.576b
Cost of GMPs as % of net benefit	70%	25%	63%	24%

The main points to note are:

- The net economic benefit from conversion of sheep and beef land into dairy is substantial if it is assumed that there are no environment restrictions. The faster land use change happens, the greater the economic gain.
- In Scenario 2, the economic cost of GMPs is significant at an aggregate farm level but could be considered “affordable” at 17 to 24 percent of the net benefit from land conversion to dairying. Note these figures are at an aggregate level across the catchment, and could vary at an individual farm level. Affordability of GMPs at an individual farm level is discussed further in Section 7.3.
- In Scenario 3, where nutrient loss limits are imposed more quickly than in Scenario 2, the economic costs at an aggregate farm level are substantial. They absorb 63 to 70 percent of the benefits of conversion at 8 percent discount rate and 24 to 25 percent at the 2.5 percent discount rate. Imposition of this scenario would be expected to impact on the rate of conversion from sheep and beef to dairying by slowing it significantly.

7.2 NET ECONOMIC COSTS OF MITIGATION STRATEGIES OR PRACTICES

A more disaggregated breakdown of the net economic cost for each mitigation strategy is outlined in Table 16. This analysis assumes all GMPs start in year one.

Table 16: Net Economic Cost of each Mitigation Practice in the Aparima Catchment, irrespective of timing of introduction (NPV $m)

	Rate of Dairy Conversions (per annum)			
	3.7%		5.6%	
	Discount Rate		*Discount Rate*	
	8%	2.5%	8%	2.5%
Stock exclusion i.e. fencing streams	7.2	16.0	8.3	17.1
Farm dairy effluent storage	27.7	43.6	29.8	41.2
Nutrient management plans & miscellaneous#	4.7	9.6	5.0	10.7
Facilitated wetlands	3.9	8.8	4.2	9.3
No winter N fertiliser	4.3	15.0	4.7	15.6
Nitrification inhibitors	93.9	368.0	103.2	384.0
Riparian management	15.3	38.1	17.6	42.0
Winter facilities	103.5	164.0	132.0	110.0
Constructed wetlands	89.4	147.0	91.8	151.0
TOTAL	$350 million	$811 million	$397 million	$782 million

Note
Miscellaneous includes tussock development and Council monitoring costs.

7.3 IMPACT ON FARM PROFITABILITY

The analysis in this report used EFS as a basis for calculating the economic costs and benefits of GMPs, as this allows for easy comparison across differing farming systems.

For the analysis on the impact on farm profitability, the measure “Farm Surplus for Reinvestment” (FSR) was used. It is defined as the cash surplus from the farm business after all cash costs are accounted for, including interest, tax, and after deduction of personal drawings, that is available for expenditure on farm development, capital purchases, and debt reduction. In essence this is the surplus cash available to the farmer for investment into the farm business, which would include expenditure on environmental mitigation practices.

The analysis was based on the MPI Southland Dairy Model, and the Southland-South Otago sheep and beef models.

The farm surplus for reinvestment for the last ten years were inflated to 2012 values using the relevant PPI and then averaged. For the dairy model this gave a value of $709 per hectare or $247 per cow, while for the Southland-South Otago sheep and beef models the figure is $142 to $143 per hectare. This represents the annual amount of money available for the expenditure noted above, plus expenditure on environmental GMPs.

7.3.1 Impact on Profitability of Southland Dairy Farms

Table 16 shows the cost of implementing the GMPs on an average dairy farm in the Aparima catchment under Scenarios 2 and 3.

In Scenario 2, the five GMPs that are implemented from 2013 and 2014 could be afforded by almost all dairy farms at a net annual cost per cow of $38.60 ($110.80/ha), or 16 percent of the average annual Southland dairy farm FSR of $247/cow ($709/Ha). Implementation of two further GMPs from 2025, in response to limit setting, would bring the annual cost up to $141.10 per cow ($405/ha), or 57 percent of the average Southland dairy farm FSR. Without significant improvements in the average FSR by 2025, the cash buffer of many farms would be impacted.

Under Scenario 3, which includes the implementation of all available GMPs between 2013 and 2015, the cost of implementation (operating costs + cost of capital) at almost $273 per cow ($783/ha) on average, is in excess of the funds available of $247 (709/ha) per cow for the average Southland dairy farm. This means that for an average dairy farm, there would be no cash buffer to cover any debt reduction, other farm development, capital spending, or to buffer combinations of adverse seasons and/or fluctuations in dairy product prices.

Table 17: Annualised Cost ($) per Cow of GMP's for an average Dairy Farm in the Aparima catchment[5]

GMP	Capital	Interest	Operating Cost	Benefits	Net annual cost
Scenario 2					
Nutrient management plans	6.10	0.50	1.20	0.00	-$1.70
Stock exclusion i.e. fencing off steams	61.60	4.90	2.10	0.00	-$7.00
Farm dairy effluent storage	300.00	24.00	5.00	4.40	-$24.60
Facilitated wetlands	13.50	1.10	0.70	0.00	-$1.80
No winter N fertiliser	0.00	0.00	29.30	25.80	-$3.50
Total of above GMPs	$381.20	$30.50	$38.30	$30.20	-$38.60
Nitrification Inhibitors	0.00	0.00	92.30	13.80	-$78.50
Riparian management	238.30	19.10	4.90	0.00	-$24.00
TOTAL for Scenario 2	$619.50	$49.60	$135.50	$44.00	-$141.10
Scenario3					
Scenario 2 (as above)	*$619.50*	*$49.60*	*$135.50*	*$44.00*	*-$141.10*
Winter facilities	2,000.00	160.00	206.80	311.70	-$55.10
Constructed Wetlands	904.30	72.30	4.20	0.00	-$76.50
TOTAL for Scenario 3	**$3,523.80**	**$281.90**	**$346.50**	**$355.70**	**-$272.70**

Note
Figures have been rounded to the nearest 10 cents.

The capital cost of all the GMPs under Scenario 3 at $3,524 per cow takes the average total debt per cow from an already high $8,300 (MPI Farm Monitoring, 2012) to $11,824.

The combination of high indebtedness and no annual cash flow buffer leaves the average Southland dairy farmer who would have to adopt **all the GMPs**, in an untenable position.

The MPI dairy farm monitoring programme shows that the average FSR for dairy farms at a national level is higher, at $472 per cow, than it is for Southland ($247 per cow). It therefore allows greater room for adoption of the GMP's. But there is still a significant proportion of New Zealand dairy farmers (estimated at 30 percent) who cannot finance GMPs from cash flow and who cannot afford to take on more debt.

For the upper 25 percent quartile in the MPI dairy farm monitoring programme, with a FSR of $833 per cow, the burden of paying for GMPs is less albeit they end up with a smaller annual FSR to support the business.

[5] Based on the average dairy farm in the Aparima catchment; 157 hectares effective and 409 cows.

The better financial performance of the top quartile reinforces the concept of trying to increase the profitability of the average farm in order to pay for the environmental GMPs required to reduce the loss of Nitrogen and Phosphorus from farms.

7.3.2 Impact on Profitability of Southland Sheep and Beef Farms

For sheep and beef farms, the number of GMP strategies or practices available for implementation is more limited.

In this assessment, GMPs are applied at the farm level but reported on a per hectare basis for comparison purposes. For example, the total costs of fencing-off streams for stock exclusion are applied to the whole farm with 10 percent stock exclusion already assumed for the farm, 25 percent unable to be fenced, leaving 65 percent of the waterways needing to be fenced. The analysis takes account of the capital costs of fencing plus annual maintenance costs.

The FSR per hectare calculated from the MPI Southland-South Otago Intensive Sheep & Beef model and the Southland-South Otago Hill Country Sheep & Beef model are very similar at $143 and $142 per hectare, respectively.

The annualised cost of the GMPs is the same for Scenarios 2 and 3 at $18.60 per hectare, and is well within the ability of the average sheep and beef farm in the region, to pay (Table 18).

Table 18: Annualised Cost ($) per hectare of GMPs for a Southland Sheep & Beef Hill Country Farm[6]

GMP	Capital	Interest	Operating Cost	Net annual cost
Scenario 2				
Nutrient management plans	9.40	0.80	1.90	-$2.70
Stock exclusion i.e. fencing off steams	36.10	2.90	1.10	-$4.00
Facilitated wetlands	67.70	5.40	2.80	-$8.20
Riparian management	41.40	3.30	0.40	-$3.70
Total for Scenario 2	$154.60	$12.40	$6.20	-$18.60
Scenario 3				
As above	*154.60*	*12.40*	*6.20*	*-$18.60*
Total for Scenario 3	$154.60	$12.40	$6.20	-$18.60

Note:
Figures have been rounded to the nearest 10 cents.

[6] Based on MPI Southland-South Otago Hill Country Sheep & Beef Model; 723 hectares.

7.3.3 Tax Implications

The use of FSR as a measure of farm profitability also needs to consider taxation. FSR is a post-tax figure, and in as much as the mitigation practices discussed in the report would be tax deductible, they would in themselves alter the FSR.

Within this study, the costing assumption as shown in Tables 17 and 18 is that the capital cost of the mitigation practice is borrowed and the interest cost added to the operating cost. In this situation this total cost would be tax deductible, at the marginal tax rate for the Southland Dairy farm in 2011/12 which was 23.4 percent, and 21 percent for the Southland Sheep and Beef hill country farm.

This means that the figures shown as "Net Annual Cost" in Tables 17 and 18 should be reduced by 23.4 and 21 percent respectively. This in turn directly aids the affordability of the practices.

At a farm level, the situation is more nuanced. As noted earlier, the level of debt on the average farm means that many farmers could not afford to directly borrow for the capital costs involved. The treatment of farm expenses also comes into play; farm expenditure is (broadly) split between "operating expenditure" which covers most farm working expenditure and which is immediately deductible, and "development" which is expenditure on new items such as tracks and races, capital fertiliser, and structures, where the expenditure is capitalised and then depreciated at set rates – such depreciation being tax deductible. In addition, recent changes have meant that some farm structures are not deductible at all.

Within the mitigation practices modelled, the application of DCD, and the repairs and maintenance on mitigation structures, would be immediately deductible, whereas all the rest would be capitalised and depreciated.

Overall therefore, while tax would have an impact, this would generally be at the margin, and does not alter the thrust of the analysis within this study.

7.4 OVERSEER SIMULATION OF ON-FARM MANAGEMENT PRACTICES

A typical Aparima dairy farm[7] (using data from the MPI Southland dairy model where appropriate) was run through Overseer 6.1.1, to investigate the mitigating effects of various GMPs. The model assumes in the base case that cows are wintered off-farm during the months of June and July. Further details are provided in Appendix 12.

The simulation shows that no winter nitrogen, wetlands and nitrification inhibitors had the greatest impact on reducing nitrate leaching. Fencing off streams and effluent storage had the biggest impact on phosphate loss. Overall, using all mitigation options saw a potential 40 percent per annum reduction in nitrogen losses and a 33 percent per annum reduction in phosphorus losses from a typical dairy farm to beyond the farm boundary (Table 19).

[7] Based on 157 hectares effective and 409 cows.

Table 19: Potential Reduction in modelled Nutrient Losses from an Aparima Dairy Farm from implementing GMPs

Mitigation Practice	N reduction (%)	P reduction (%)
Stock exclusion – fencing off streams	5	17
Farm dairy effluent storage (90 day) & low volume	5	8
Constructed wetlands	8	8
No winter N fertiliser	15	0
Nitrification inhibitor	13	0
Riparian margins[1]	n/a	n/a
Winter facilities *[vs. Grazing off-farm over winter]*[2]	5	0
No grazing-off over winter	+5 (gain)	0
All mitigation options	40%	33%

Notes
n/a – not applicable.

1. Overseer 6 does not allow for riparian strips to be installed on tile drained areas, which most of the dairy farms in the Aparima catchment have.

2. The reduction in leaching of N from using a wintering facility is low due to the base farm model assuming cows are wintered off i.e. no leaching on the home farm during that time – albeit there may be N leaching from the winter grazed area outside the Aparima catchment (see Appendix 6). By wintering the cows on the home farm in a wintering facility, effluent is captured and spread in the late spring/summer when ground conditions are more suitable with no leaching occurring. The net N effect between the two practices is zero. So potentially the impact of the wintering facilities is equivalent to grazing-off over winter.

If the wintering facility is compared with no grazing off, then the reduction in N leaching is 10%. If a controlled grazing system is used throughout the late summer and autumn (e.g. 8 hours grazing, rest of the time in the wintering facility, plus cows are in the facility 100% of the time for June and July, then the reduction in N leaching is 32%.

For the dairy support farms in this study, the three mitigation GMPs assumed used on these farms were; fencing to exclude stock, riparian margins, and facilitated wetlands. The impact of these is shown in Table 20.

Table 20: Potential Reduction in modelled Nutrient Losses from an Aparima Dairy Support Farm from implementing GMPs

Mitigation Practice	N reduction (%)	P reduction (%)
Stock Exclusion – fencing off streams	-5%	-25%
+ Riparian margins	-5%	-83%
+ Facilitated wetlands	-5%	-83%

As can be seen from this Table, fencing off streams, and especially 5 metre riparian margins, have a significant impact on reducing phosphorus losses. It would appear that the facilitated wetlands have minimal impact – research shows that facilitated wetlands can have a localised impact, which Overseer is currently not sensitive enough to provide for without entering farm specific data.

A simulation was run for the average dairy farm in the catchment, with mitigation practices introduced progressively. The results are shown in Table 21.

The analysis of the modelling shows that the implementation of three GMPs (fencing-off streams, effluent storage, and no winter N) could achieve a 23 percent reduction in annual N loss and a 25 percent reduction in annual P loss from the farm boundary, at a relatively affordable annual cost for almost all dairy farms in the catchment at $35.10 per cow.

Investment in the more expensive mitigation practices of wintering facilities and constructed wetlands would be needed to achieve a 40 percent reduction in annual N losses and a 33 percent reduction in annual P losses from the modelled farm as illustrated in Table 21.

Table 21: Reduction in Nutrient Losses due to progressive introduction of GMP strategies on an average dairy farm in the Aparima catchment[8] and related costs

Mitigation Practice	N reduction (%)	P reduction (%)	*Dairy Farm* Net Annual cost per cow ($/cow)	*Dairy Farm* Capital cost per cow ($/cow)
Scenario 2				
Stock exclusion i.e. fencing off streams (FW)	5	17	$7.00	$61.60
FW + Farm dairy effluent storage (ES)	8	25	$31.60	$361.60
FW + ES + No winter N (NWN)	23	25	$35.10	$361.60
Total of above GMPs	23%	25%	$35.10	$361.60
FW + ES + NWN + Nitrogen inhibitor (NI)	35	25	$113.60	$361.60
FW + ES + NWN + NI + Riparian Strips (RS)	35	25	$137.60	$599.90
Total for Scenario 2	35%	25%	$137.60	$599.90
Scenario 3				
FW + ES + NWN + NI + RS + Wintering facilities (WF)	38	33	$192.70	$2,599.90
FW + ES + NWN + NI + RS + WF + Constructed wetlands	40	33	$269.20	$3,504.20
Total for Scenario 3	40%	33%	$269.20	$3,504.20

[8] Based on average dairy farm in the Aparima catchment; 157 hectares effective and 409 cows.

A similar simulation was run for an average hill country sheep and beef farm (based on the MPI Southland-South Otago Hill Country Sheep and Beef model), with mitigation practices introduced progressively. The results are shown in Table 22.

Table 22: Reduction in modelled nutrient losses due to progressive introduction of GMP strategies on an average Southland sheep and beef hill country farm[9] and related costs

Mitigation Practice	N reduction (%)	P reduction (%)	*Sheep & Beef Farm* Net Annual cost per ha ($/ha)	*Sheep & Beef Farm* Capital cost per ha ($/ha)
Scenario 2				
Stock exclusion i.e. fencing off streams (FW)	0	0	$4.00	$36.10
FW + Facilitated wetlands (Wet)	0	0	$12.20	$103.80
FW + Wet + Riparian Strips (RS)	0	50	$15.90	$145.20
Total for Scenario 2	0	50	$15.90	$145.20
Scenario 3				
FW + Wet + Riparian Strips (RS) [*as above]*	0	50	$15.90	$145.20
Total for Scenario 3	0%	50	$15.90	$145.20

The modelling shows no N reduction from the mitigation practices imposed on the hill country sheep and beef farm with only riparian strips offering any mitigation of P.

This hill country model is predominantly a sheep farm with a stock unit ratio of 86 percent sheep: 14 percent cattle. This explains the minimal mitigating impact of fencing-off streams as unlike cattle, sheep do not like to stand in water and cause less damage to, and hence less sediment loss from, the banks of waterways. In addition, N leaching for this farm model is relatively low at 8 kg N/ha/annum, overall (see Appendix 8).

It should also be noted that Overseer 6 rounds up results to the nearest 0.1kg, which leads to difficulties in assessing likely impacts of P mitigations on farms that have a naturally low level of P loss. There is likely to be a reduction in P losses from both fencing off streams and facilitated wetlands on hill country sheep and beef farms. However, because Overseer 6 has rounded the result, there is no apparent gain shown in the analysis.

It could be argued that the costings discussed in section 7.3.2 are overstated given an indication of no mitigation impact due to fencing off streams and facilitated wetlands on the modelled sheep and beef farm. As noted, this is related to the difficulty assessing this within Overseer; as Table 11 indicates, research has shown these strategies can reduce P losses.

7.5 NITROGEN LOSS

The current nitrogen loss from farms in the catchment was modelled at 1,878 tonnes N/annum. Overseer version 6.0 was used to estimate loss from ‘model’ dairy, dairy support and sheep and beef farms and aggregated in order to estimate potential loss from pastoral agriculture beyond the farm boundary (surface run off and loss beyond the root zone). No

[9] Based on MPI Southland-South Otago Hill Country Sheep and Beef Model; 723 hectares.

account has been taken of other contributors to total catchment load or attenuation of nutrients beyond the farm boundary.

If all suitable land is converted from sheep and beef into dairying, in the absence of any mitigation the total N losses from pastoral agriculture in the catchment is estimated to increase from 1,878 tonnes per year to 2,692 tonnes per year (814 tonnes or 43 percent increase) (Refer to Table 10).

To hold total nitrogen loading at the 2012 level (i.e. at 1,878 tonnes), at a base leaching of 33kg N/ha/annum (the mid-point of the ranges as illustrated in Table 9), all existing and new dairy farms in the catchment post conversion would have to reduce nitrogen leaching by 39 percent. Alternatively, if dairy support farms were included, then all dairy farms plus dairy support farms would need to reduce nitrogen leaching by 35 percent.

Modelling of the implementation of GMPs under Scenario 2 shows a potential 35 percent reduction in annual N losses, at a relatively affordable cost for some but not all dairy farms in the catchment (57 percent of average FSR). However these GMPs also include the use of nitrification inhibitors[10]. If nitrification inhibitors are removed from the suite of Scenario 2 mitigations, the reduction in N losses drops back to 23 percent (Table 21).

The Overseer version 6.1.1 analysis shows that mitigation of N losses by up to 40 percent are technically possible on an average Southland dairy farm using all modelled mitigation practices, as in Scenario 3. However, this is reliant on implementing the more expensive mitigation tools which many dairy farms in the catchment would be unable to afford.

Total nitrogen loss reduced across all farms in the catchment, and then adopt relevant modelled good management practices, would be:

- Scenario 2 = 750 tonnes [35 percent mitigation of nitrogen loss from dairy farms, 5 percent mitigation from dairy support farms and 0 percent mitigation from sheep and beef farms]
- Scenario 3 = 855 tonnes [40 percent mitigation of nitrogen loss from dairy farms, 5 percent mitigation from dairy support farms and 0 percent mitigation from sheep and beef farms]

This means that in Scenario 2, the mitigation strategies used across all farm types would reduce nitrogen losses to within 3 percent of pre-conversion levels, whereas Scenario 3 mitigation strategies across all farm types would reduce nitrogen losses to 2 percent below pre-conversion levels, assuming that none of the current farms are using mitigation strategies.

However, many of the existing farms, particularly dairy farms, have at least implemented a number of the lower-cost mitigation strategies such as fencing-off streams, riparian margins, effluent storage, and no winter nitrogen.

If this is taken into account, the above figures on the amount of nitrogen that could be mitigated are over-stated. What data is available indicates that 90 percent of existing dairy

[10] The sale and application of nitrification inhibitor products containing DCD (dicyandiamide) was suspended in New Zealand by manufacturers at the beginning of 2013.

farms have fenced streams, and 59 percent have effluent storage systems. Anecdotally, very few farmers apply nitrogen fertilizer over the high-risk winter months. These three factors mean that the amount of nitrogen that is possible to mitigate would be less than that modelled above, by about 64 tonnes[11] catchment wide (i.e. Scenario 3 N losses mitigated; 855-64 = 791 tonnes). This means that if all farms implement all mitigation strategies, modelled nitrogen losses from farms in the catchment would be around 1 percent above pre-conversion levels. Under scenario 2 a similar calculation means the modelled N losses would be 6 percent above pre-conversion levels.

This is summarised in Table 23 below.

Table 23: Summary of the Impact of Mitigation Practices on Total N Losses

	Pre Conversion N Losses (tonnes)	Post conversion losses (tonnes)	Modelled mitigation levels assuming no existing mitigation (tonnes)	Existing mitigation Loss reductions (tonnes)	Net mitigation reductions (tonnes)	Total post conversion losses as a % of pre-conversion losses
Scenario 2	1,878	2,692	750	56	694	+6
Scenario 3	1,878	2,692	855	64	791	+1

7.6 PHOSPHORUS LOSS

The current phosphorus loss from farms was modelled at 71 tonnes P/annum. Overseer version 6.0 to estimate loss from ‘model’ dairy, dairy support and sheep and beef farms and this data was aggregated to estimate potential loss from pastoral agriculture beyond the farm boundary (surface run off and loss beyond the root zone). No account has been taken of other contributors to total catchment load or attenuation of nutrients beyond the farm boundary.

If all suitable land is converted from sheep and beef into dairying, in the absence of any mitigation the total P losses from pastoral agriculture in the catchment is estimated to increase from 71 tonnes per year to 85 tonnes per year (14 tonnes or 20 percent increase) (Refer to Table 10).

To hold total phosphorus loading at the 2012 level (i.e. at 71 tonnes), at a base leaching of 1.0kg P/ha/annum (the mid-point of the ranges as illustrated in Table 9), all existing and new dairy farms in the catchment post conversion would have to reduce phosphorus leaching by 22 percent. Alternatively, if dairy support farms were included, then all dairy farms plus dairy support farms would need to reduce phosphorus loss by 19 percent.

The average loss of phosphorus from dairy and dairy support farms is assumed at 1.0 kg and 0.7 P/ha/annum (midpoint of the data sources) respectively, and from sheep & beef farms at 0.65 kg P/ha/annum.

[11] ((0.9*0.05)+(0.59*0.05))*855 tonnes = c.64 tonnes

The 20 percent increase in P loading is made up of a 189 percent increase from dairying land (from 25 tonnes to 72 tonnes), offset by a 71 percent decrease from sheep & beef land (from 46 tonnes to 13 tonnes).

The Overseer 6.1.1 simulation for a typical Southland dairy farm shows that the introduction of all GMPs reduces P losses by 33 percent. A reduction in losses of 25 percent could be achieved by implementing the more affordable mitigation practices.

The Overseer 6.0 simulation for a typical Southland-South Otago hill country sheep and beef farm shows that fencing off streams, and planting up riparian margins could reduce P losses by 50 percent, with much of this significant reduction coming from planting of 8 metre riparian margins.

Assuming that no mitigation currently applies, and that GMPs were applied across all dairy farmland and across all sheep and beef farmland, the aggregated farm based P losses mitigated across the whole catchment would be:

- Scenario 2 = 29.0 tonnes [25 percent mitigation of phosphorus loss from dairy farms, 83 percent mitigation from dairy support farms and 50 percent mitigation from sheep and beef farms]
- Scenario 3 = 34.0 tonnes [33 percent mitigation of phosphorus loss from dairy farms, 83 percent mitigation from dairy support farms, and 50 percent mitigation from sheep and beef farms]

Scenario 2 mitigation strategies therefore would reduce aggregated farm P losses to 56 tonnes overall, 21 percent below pre-conversion levels of 71 tonnes. Scenario 3 mitigation strategies would reduce aggregated farm P losses to 51 tonnes, 28 percent below pre-conversion levels, given the assumption that none of the current farms are utilising mitigation strategies. Again as discussed in section 7.5, many of the existing farms would have some mitigation strategies in place already. If fencing streams and effluent storage on existing dairy farms is taken into account, this would reduce the potential for P mitigation by around 7.0 tonnes[12] under Scenario 3, and 6 tonnes under Scenario 2. This is summarised in Table 24.

[12] ((0.9*0.17)+(0.59*0.08))*34 tonnes = c.7 tonnes

Table 24: Summary of the Impact of Mitigation Practices on Total P Losses

	Pre Conversion P Losses (tonnes)	Post conversion losses (tonnes)	Modelled mitigation levels assuming no existing mitigation (tonnes)	Existing mitigation Loss reductions (tonnes)	Net mitigation reductions (tonnes)	Total post conversion losses as a % of pre-conversion losses
Scenario 2	71	85	29	7	22	-11
Scenario 3	71	85	34	6	28	-20

Overall therefore the mitigation scenarios outlined would result in N loadings very close to original levels, and P loading much reduced relative to original levels.

7.7 MICROBES AND SEDIMENT

The modelling and estimate of costs and benefits of microbe and sediment loss and mitigation is outside the scope of this report.

8 Discussion

- The potential net economic gain at an aggregate **farm level** from changing land use from sheep and beef to dairying is substantial at around $370 million, at the 8 percent discount rate, assessed as the increase in farm income of $700 million versus the capital costs of conversion of around $330 million. The net economic gain at 2.5 percent discount rate is $2.26 billion.
- To hold total nitrogen (N) and phosphorus (P) losses from farm land at the 2012 level (i.e. prior to the additional dairy conversions), all existing and new dairy farms in the catchment post-conversion would collectively have to reduce N and P losses by 39 percent and 22 percent, respectively. Alternatively, all new and existing dairy farms plus all new dairy support farms would need to collectively reduce N and P losses by 34 and 19 percent respectively.
- Analysis using Overseer version 6.1.1 for an average Southland dairy farm shows that N mitigation up to 40 percent and P mitigation up to 33 percent is technically possible using a wide range of mitigation practices. However, it is reliant on implementing the more expensive mitigation tools, and also assumes no pre-existing mitigation practices.
- In reality, many of the existing farms in the Aparima catchment, especially dairy farms, already have a number of the lower-cost nutrient mitigation practices in place. This means that the modelled total amount of nutrients that could be mitigated using GMPs is over-stated. Taking into account that some mitigation measures are already in place, and using a wide range of GMPs, the analysis shows that the modelled increase in nutrient losses of N and P in the catchment from land use change can be mitigated to maintain modelled N losses at close to pre-conversion or 2012 levels, and P levels less than original levels.
- The analysis shows that the sooner, and harder, that nutrient loss limits are imposed, the greater the economic cost to farmers. Scenario 2 shows a net aggregate cost of $88 million at the 8 percent discount rate. Scenario 3 would cost an aggregate $262 million.
- At current farm profitability most dairy farmers in the catchment could afford to introduce some GMPs, over time, but not the full range of GMPs.
- The dairy industry is also currently carrying significant debt, with Southland above the national average. Funding the capital cost of the GMPs by debt would increase the level of financial risk on many farms.
- The introduction and enforcement of strict nutrient loss limits over a short time-frame, as in Scenario 3, would have a significant adverse impact on the profitability of existing dairy farms, and would very likely slow the rate of, or even stop, dairy conversions. A longer time frame will lessen the impacts.

- In theory, nutrient loss limits and enforcement could reduce the price of land, but this is (a) likely to take some time, and (b) subject to a number of variables, including the profitability of alternative land uses. Initially it would slow sales volumes until purchasers could factor in the costs of implementing the GMPs and vendors adjusted their expectations to the new profitability.
- The much less capital intensive GMPs on sheep and beef farms have a relatively small net cost relative to the farm surplus for reinvestment for the average Southland-South Otago hill country sheep and beef farm.
- A technology transfer/extension programme of some sort would assist with the adoption of GMPs by farmers. This could take a range of guises, but the most effective means of achieving adoption is via one-to-one interaction. Unless a relatively intensive technology transfer programme is introduced, adoption of GMPs would likely take longer than projected in this report. Adoption of the more expensive GMPs is unlikely in the absence of a regulatory framework.
- Technology transfer would also assist in improving the profitability of the average farm, which in turn would assist in the adoption of the GMPs.
- At the farm level, modelling demonstrates that significant mitigation of N and P losses can be achieved by adopting the less costly/more effective GMPs, for example; stock exclusion from streams, facilitated wetlands[13], and for dairy farmers, effluent storage, and reducing winter N applications.
- Other GMPs beyond those with immediate strong cost benefit could be implemented on some farms but a much longer time frame will be needed to make them affordable relative to their benefit.

[13] This was not represented well in the Overseer modelling; nevertheless facilitated wetlands do have a localised impact in reducing nutrient losses.

9 Conclusions

The main conclusions for the Aparima catchment case study are:

- Land use in the Aparima catchment is likely to shift towards more intensive uses such as dairying, as there is potentially significant economic gain from this land use change.
- Land use change into dairying from sheep and beef farming without implementation of GMPs results in increased modelled nutrient losses from farm land.
- The adoption of Good Management Practice (GMP) mitigation strategies reduces modelled nutrient losses from individual farms, but does not eliminate them. Implementation of a full range of mitigation practices on existing and new farms, while allowing for land use change, can keep modelled nutrient losses at a catchment level at close to pre-intensification levels.
- The adoption of GMP mitigation strategies cost money. However, there is significant variation in both the cost and effectiveness of different GMPs. Some strategies are highly cost-effective, while others are very expensive and could render some individual farms uneconomic.
- While there is an obligation on farmers to mitigate contaminant flows, for average performing farms (in terms of profitability) there is a limit to the number of GMPs that farmers can implement and remain economically viable. Farmer performance is highly variable, however, and the best performing farmers will find it easier to adopt GMPs and remain viable.
- A relatively intensive technology transfer programme is required (i.e. significantly more than is occurring at the present) in order to achieve adoption of the GMPs in a reasonable time span. Such a programme, if well-resourced and targeted, would also have positive spin-offs in lifting farm profitability.
- Implementation timeframes are highly influential. Faster implementation of nutrient loss limits will result in higher overall costs and potentially more social disruption due to variability in the ability of farmers to afford mitigation practices.
- If economic development from land use intensification remains an important value for communities, then there are some cost effective mitigation strategies that could be implemented/required now that will allow further land intensification to occur over time.

10 Recommendations for further study

1. The environmental benefits following on from the introduction of GMP mitigation strategies have not been costed in this study mainly due to data constraints. Such work would help gain a wider perspective of the costs and benefits of mitigation strategies applied on-farm.

2. The mitigation strategies investigated in this study were limited to those GMPs where most data was available. Further studies could include other possible mitigation strategies.

3. There are limitations of using Overseer in aggregating farm based data to estimate catchment losses from pastoral farming. In order to obtain a full picture of potential impacts on total catchment loads and understand the best ways of managing those, a catchment based model would need to be used accounting for all sources and all contaminants.

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Appendices

APPENDIX 1 – ADOPTION RATES

20 years		
	% change by year	Cumulative % of farmers
Yr 1	7%	7%
Yr 2	10%	17%
Yr 3	10%	27%
Yr 4	8%	35%
Yr 5	8%	43%
Yr 6	7%	50%
Yr 7	7%	57%
Yr 8	5%	62%
Yr 9	5%	67%
Yr 10	5%	72%
Yr 11	4%	76%
Yr 12	4%	80%
Yr 13	4%	84%
Yr 14	3%	87%
Yr 15	3%	90%
Yr 16	2%	92%
Yr 17	2%	94%
Yr 18	2%	96%
Yr 19	2%	98%
Yr 20	2%	100%

	10 years	
	% change by year	Cumulative % of farmers
Yr 1	15%	15%
Yr 2	15%	30%
Yr 3	15%	45%
Yr 4	12%	57%
Yr 5	10%	67%
Yr 6	9%	76%
Yr 7	7%	83%
Yr 8	7%	90%
Yr 9	6%	96%
Yr 10	4%	100%

5 years		
	% change by year	Cumulative % of farmers
Yr 1	25%	25%
Yr 2	22%	47%
Yr 3	20%	67%
Yr 4	18%	85%
Yr 5	15%	100%

APPENDIX 2 – TECHNOLOGY TRANSFER [FURTHER INFORMATION]

Introduction

Technology transfer programmes, or extension, are a critical aspect of enabling farmers to adopt new innovations or systems. There has been significant research, as discussed in Journeaux (2009) to show the value of farm extension in assisting farmers to adopt innovations or new systems.

There are a number of factors that influence the uptake of innovations. These include the characteristics of the innovation such as relative advantage, complexity, ability to trial and ease of observing any result(s). In addition, the characteristics of the individual such as time available and their personal and family circumstances are also influential.

The means of communication are important. Mass media extension, such as field days, monitor farms, and printed media, are good at raising awareness of innovations, but the greatest level of adoption follows one to one interaction between a farmer and an adviser.

Most current extension activities, including environmental programmes, are very much based around mass media approaches rather than intensive one to one interactions. Environmental factors are also usually seen as add-ons to normal farm management, as opposed to being integral to the whole system, and are seldom presented in the context of whole farm systems.

The social component of environmental issues is crucial, as adoption is very much a social process. The traditional top down/lineal approach to extension has significant limitations, and social factors must be taken into account in designing and carrying out extension programmes. The use of participatory or collaborative approaches with farmers, and the inclusion of social marketing will enhance farmer understanding and acceptance of the issues in question, and result in a greater rate of adoption of GMPs.

Farmers mostly see environmental factors as a compliance cost as opposed to providing any profit and/or market advantage. While ideally market incentives would drive adoption, the reality is that the current main driving force is domestic societal pressure and regulation.

The net result therefore is that most factors are working against the ready adoption of environmental GMPs, and in the absence of any significant changes in these fundamentals, long time lags are likely before the majority of farmers adopt environmental GMPs (Journeaux, 2009).

The Need for a Technology Transfer Programme

Implicit behind the adoption curves is the need for an intensive technology transfer programme. In order to attain such adoption rates, the ratio of advisers to farmers would need to be in the order of one adviser per 50 farms, at least initially, and then building out to say one adviser per 100 farms once the programme was fully up and running. This would allow a programme of say four by one day visits by the adviser per year for the initial 2 – 3 years, stretching out to two by one day visits per year thereafter. It also means a mix of field days and seminars/workshops would also be held.

Obviously there would be a direct cost involved in providing such a technology transfer programme. However, such an intensive advisory effort would also have direct spin-offs on farm profitability. A number of evaluations of individual extension programmes, discussed in

Journeaux (2009) have shown financial returns of between plus 20 percent through to greater than plus 100 percent from farm extension activities (i.e. the dollar return to farmers relative to the cost of the extension programme). In order to both enhance the adoption of environmental GMPs and improve the profitability of the farm business, it is crucial that the farm adviser provide a mix of advice on environmental GMPs and on improving farm profitability (as discussed in Journeaux 2009).

As noted earlier, the challenge with environmental/natural resource issues is that they are complex and may provide little market advantage. A good example is nutrient management, which is certainly much more than just doing a nutrient budget to decide how much fertiliser to apply – which is what many people seem to believe. It is a relatively complicated mix of applying the right nutrients at the right time, coupled with good grazing management, and stocking rates that vary at different times of the year. While the benefits can be demonstrated by computer models, the landowner has no way to readily monitor the outcomes they are achieving – especially given the effects often taken decades to manifest themselves.

The complexity and difficulty in readily observing outcomes is compounded by the general lack of explanation as to how GMPs fit within a farming system. If landowners have a more holistic understanding of how a new technology or innovation impacts on the system as a whole – how it either fits into the current system, or how the current system can be altered to accommodate it, then this enhances its probability of adoption.

This whole farm approach is perhaps one of the key factors in the adoption of environmental management factors. The complexity and difficultly in readily observing outcomes is not likely to be readily overcome, which reinforces the desirability of having a whole farm systems approach such that farmers can see how the innovation fits within their farming system.

One of the significant factors around adoption of environmental practices relates to the costs and benefits of it – part of the “relative advantage” of an innovation. The issue that arises is that often the cost of environmental action is borne on-farm, while much of the benefit accrues off-farm. In this respect therefore often the affordability of implementation of environmental practices on-farm need to be judged against the current income of the farm. Because the benefits are often hard to gauge, most environmental work is judged as a cost.

The question of economic/environmental trade-offs is a real one, and one that needs to be worked through with farmers. This in itself requires that the adviser understands the farm business side as well as the environmental, a capability that needs to be considerably enhanced. This again underscores the importance of providing advice in a whole-farm context.

In a study of the North Waikato River catchment by Journeaux *et al*. (2011), an intensive technology transfer programme was included to assist with the adoption of best management practices to reduce nutrient losses from farm land. The technology transfer programme was calculated to have a present value cost of $17.2 million, against a present value benefit (via enhanced farm profitability) of $19.9 million. Hence the net present value was $2.7 million.

The 2011 North Waikato River catchment study (Journeaux *et al*. 2011) also modelled a scenario whereby a major change in the farm system for dairy farmers was instigated. This involved a 10 percent reduction in stocking rate, a 45 percent reduction in bought-in supplementary feed, but maintaining current level of production. This scenario assumed that <u>all farmers</u> could lift their grazing management to ensure that pasture quality is maintained.

The impact of this strategy resulted in the NPV of mitigation strategies rising from -$138 million to +$65 million; i.e. the improvement in profitability from this change in management outweighed the cost of the other mitigation strategies. This change would only be possible through a combination of technology transfer, and improvement in farmer skills and ability. There is also uncertainty about its application to all dairy farms in all regions of New Zealand, and obviously it’s potential in drought years.

Another recent example comes from the “Dairy Push” programme operated by DairyNZ in the South Waikato. Within this, a group of 50 farmers received relatively intensive advice (one half day visit four times a year) plus three group meetings per year over a 3 year period. The cost of this was $5,000 per farmer per year, with the average benefit per farmer estimated at $50,000 (Brazendale pers. com).

While the two examples cited are dairy farms, the principles of payback on technology transfer in other sectors are also likely to hold.

APPENDIX 3 – ECONOMIC PARAMETERS

Aparima Catchment

Discount Rate:		8.0%	
Average dairy payout:		$6.19	Kg MS
Average dairy gross margin/ha:		$4,217	
Average dairy EFS/Ha:		$3,217	
Intensive S&B EFS/Ha:		$374	
Hill Country S&B EFS/Ha:		$300	

APPENDIX 4 – ASSUMPTIONS UNDERLYING REDUCTION IN WINTER NITROGEN

Reduction in Nitrogen

Strategy is to reduce nitrogen fertiliser application on dairy farms over the critical months (May/June/July/)
So instead of 5 applications, apply 4 applications in autum/spring - April, August/September/October
ie take out the 1 winter application.

Normal application of N =			154	KgN/ha excluding the effluent area				
New application of N =			123	KgN/ha excluding the effluent area				
Saving equivalent to		67.0	Kg/ha of urea.					
						Loss of pasture production		
Cost of urea applied:		$1,000	tonne			Assume	8	kgDM/Kg N
						=	246	KgDM/ha
						Assume	75%	utlilization
Number of farms:						Assume	15	KgDM/KgMS
	Exisiting:	150				Cost of N =	$0.27	KgDM
	Area	157	Ha					

3.7% scenario											
Saved Costs										**Loss of Production**	
	Existing Farms				New farms						
Assume 10 year adoption rate				No. farms	Av size (ha)	Saved Cost				Existing Farm	New farms
Yr 1	236,524			6	214	85,972			Yr 1	269,391	97,919
Yr 2	473,048			6	222	175,091			Yr 2	538,783	199,422
Yr 3	709,572			6	230	267,424			Yr 3	808,174	304,586
Yr 4	898,791			6	238	363,105			Yr 4	1,023,687	413,562
Yr 5	1,056,473			6	247	462,268			Yr 5	1,203,281	526,505
Yr 6	1,198,388			7	256	582,187			Yr 6	1,364,916	663,088
Yr 7	1,308,766			7	265	706,458			Yr 7	1,490,632	804,628
Yr 8	1,419,143			7	275	835,216			Yr 8	1,616,348	951,277
Yr 9	1,513,753			7	285	968,660			Yr 9	1,724,104	1,103,265
Yr 10	1,576,826			8	295	1,126,744			Yr 10	1,795,942	1,283,317
Yr 11	1,576,826			8	306	1,290,587			Yr 11	1,795,942	1,469,927
Yr 12	1,576,826			8	317	1,460,389			Yr 12	1,795,942	1,663,324
Yr 13	1,576,826			9	329	1,658,379			Yr 13	1,795,942	1,888,827
Yr 14	1,576,826			9	341	1,863,601			Yr 14	1,795,942	2,122,567
Yr 15	1,576,826			9	353	2,076,255			Yr 15	1,795,942	2,364,771
Yr 16	1,576,826			10	366	2,321,115			Yr 16	1,795,942	2,643,657
Yr 17	1,576,826			10	379	2,574,880			Yr 17	1,795,942	2,932,685
Yr 18	1,576,826			1	393	2,601,194			Yr 18	1,795,942	2,962,656
Yr 19	1,576,826					2,601,194			Yr 19	1,795,942	2,962,656
Yr 20	19,290,078					31,821,666			Yr 20	21,970,627	36,243,604
NPV =	$15,041,917					$15,746,929			NPV =	$17,132,142	$17,935,122
Total Savings	$30,788,845							Total Lost Revenue		$35,067,263	

APPENDIX 5 – ASSUMPTIONS UNDERLYING EFFLUENT STORAGE

Effluent Management - Storage Ponds					
Assume that existing farms will put in a storage pond at the time of renewing their discharge consent					
New farms will put in a storage pond at the time of conversion					
Storage capacity is 90 days, and irrigation is low volume					
Consent cost:		$1,000	per farm		
Cost of pond:		$300	per cow		
Maintenance:		$5	per cow per year		
Existing farms:		409	cows		
3.7% Scenario					
		Existing Farms		New Farms	
	Yr 1	2,471,841		1,008,600	
	Yr 2	2,375,381		1,062,010	
	Yr 3	2,276,650		1,116,812	
	Yr 4	1,763,675		1,173,800	
	Yr 5	1,928,243		1,233,001	
	Yr 6	996,484		1,495,335	
	Yr 7	1,284,754		1,569,398	
	Yr 8	1,302,916		1,645,868	
	Yr 9	2,694,323		1,725,553	
	Yr 10	2,185,889		2,039,840	
	Yr 11	981,752		2,137,718	
	Yr 12	306,480		2,239,058	
	Yr 13	306,480		2,601,796	
	Yr 14	306,480		2,724,609	
	Yr 15	306,480		2,851,171	
	Yr 16	306,480		3,269,088	
	Yr 17	306,480		3,420,532	
	Yr 18	306,480		808,338	
	Yr 19	306,480		505,582	
	Yr 20	$3,749,320		$6,185,025	
	NPV:	$15,163,880		$17,102,389	
	Total:	$32,266,269			
	Earthworks - low water table - $30-50/cow				
		- high water table $200-300/cow			150
	Liner - $70-150/cow				110
	Connect to shed - $1000 -$20,000				15

	Benefit											
	Storage & low volume application can reduce loss of nutrients applied by 15% - ie from 16% loss to 1% loss											
	Deferred storage = 90 days =			33%	of total effluent							
	Assume	90%	of saved loss occurrs over winter/early spring period									
	Nutrient loss per 100 cows - no irrigation											
	668	Kg N		$1,452		Urea =	$1,000	per Tonne applied =		$2.17	per Kg N	
	80	KgP		$180		Super =	$450	per Tonne applied =		$2.25	per Kg P (& S)	
	668	Kg K		$1,276		Muriate of Potash =		$955	per Tonne applied =		$1.91	per Kg K
				$2,908								
	With irrigation - 16% loss. With storage & low volume application - 1% loss.											
	With Irrigation, loss =			$465.29	per 100 cows							
	With Storage, loss =			$29.08	per 100 cows							
	"saved" loss with storage =			$436.21	per 100 cows							
	Existing Farms		New Farms									
Yr 1	32,085		13,120									
Yr 2	62,388		26,721									
Yr 3	90,909		40,812									
Yr 4	112,299		55,414									
Yr 5	135,472		70,547									
Yr 6	146,167		88,848									
Yr 7	160,427		107,813									
Yr 8	174,687		127,463									
Yr 9	206,772		147,828									
Yr 10	231,728		171,953									
Yr 11	240,640		196,957									
Yr 12	240,640		222,871									
Yr 13	240,640		253,086									
Yr 14	240,640		284,405									
Yr 15	240,640		316,859									
Yr 16	240,640		354,227									
Yr 17	240,640		392,954									
Yr 18	240,640		396,970									
Yr 19	240,640		396,970									
Yr 20	$2,943,871		$4,856,324									
NPV:	$2,148,873		$2,403,149									
Total:	$4,552,022											

APPENDIX 6(A) – ASSUMPTIONS UNDERLYING WINTERING FACILITIES

Provision of wintering facilities							
Provision of a physical structure to use as on-off grazing over the winter months.							
Average Cost =		$2,000	per cow	Includes effluent system			
Maintenance/operating =		$50	per cow				
Assume	20%	of existing farms have such factilities					
New conversions will construct such facility at the time of conversion							
Existing farms adopt over a 20 year period							
Consent cost		$1,000	per farm				
Depreciation Rate:		2.5%					
Percentage feeding in-shed:		80%					
				Feed Wastage Rate			
Feed cost =		$0.35	per kg DM	10%			
Feeding level =		10.00	KgDM/Cow				
3.7% Scenario							
	Capital/Operating Cost						
	Existing farms				New farms		
	Capital	Mtce/Op	Feed Costs		Capital	Mtce/Op	Feed Costs
Yr 1	6,873,555	171,629	592,051		6,690,000	167,100	576,428
Yr 2	9,819,364	416,813	1,437,838		6,934,664	340,317	1,173,956
Yr 3	9,819,364	661,997	2,283,625		7,184,533	519,780	1,793,033
Yr 4	7,855,492	858,144	2,960,255		7,444,813	705,750	2,434,556
Yr 5	7,855,492	1,054,292	3,636,885		7,715,505	898,488	3,099,424
Yr 6	6,873,555	1,225,921	4,228,936		9,330,243	1,131,569	3,903,460
Yr 7	6,873,555	1,397,549	4,820,987		9,668,607	1,373,109	4,736,677
Yr 8	4,909,682	1,520,141	5,243,880		10,017,383	1,623,369	5,599,973
Yr 9	4,909,682	1,642,734	5,666,774		10,381,776	1,882,738	6,494,693
Yr 10	4,909,682	1,765,326	6,089,667		12,298,439	2,189,999	7,554,621
Yr 11	3,927,746	1,863,399	6,427,982		12,746,121	2,508,452	8,653,156
Yr 12	3,927,746	1,961,473	6,766,297		13,209,421	2,838,488	9,791,647
Yr 13	3,927,746	2,059,547	7,104,612		15,401,981	3,223,312	11,119,138
Yr 14	2,945,809	2,133,102	7,358,348		15,964,187	3,622,192	12,495,113
Yr 15	2,945,809	2,206,657	7,612,084		16,542,009	4,035,517	13,920,920
Yr 16	1,963,873	2,255,694	7,781,241		19,046,907	4,511,440	15,562,662
Yr 17	1,963,873	2,304,731	7,950,399		19,739,252	5,004,671	17,264,113
Yr 18	1,963,873	2,353,767	8,119,556		2,046,804	5,055,816	17,440,543
Yr 19	1,963,873	2,402,804	8,288,714			5,055,816	17,440,543
Yr 20	1,963,873	2,451,841	8,457,871			61,850,249	213,358,619
Yr 21		29,994,561	103,469,237				
NPV:	$58,515,063	$19,107,815	$65,914,317		$94,821,758	$30,606,552	$105,580,360
Total:	$374,545,865						

Further details on the costs of different wintering facilities

Free stall facility = $1,500 to $3,000 per cow

Herd Home = $1,700 to $3,000 per cow

Loose house = Tunnel house and sawdust floor @ $800 to $1,000 per cow + effluent system

Stand off pad = $500 per cow

APPENDIX 6(B) – ASSUMPTIONS UNDERLYING WINTERING FACILITIES (BENEFITS)

Benefits					
1. Saved grazing fees					
With winter factilities, no need to graze cows off the farm over the winter.					
Assume 100% of cows off the farm for				8	weeks
Grazing fee =		$28	per cow/week		
Assume	20%	of existing farms graze off under contract			
New farms with run-off		100%			
2. Reduction in pugging damage on run-off					
Severe pugging damage can reduce DM production by 20-40%					
Assume "saved"pasture growth is				500	Kg DM/Ha
Valued at equivalent to buying in feed				$0.35	/KgDM
3. Reduced Travel					
Assume	20	Km round trip per day			
Cost per km:		$1.00			
Normal time on run-off:			8	weeks	
4. Increased milking period					
Assume	70%	of herd			
milked for	3	weeks extra			
GM/Cow	$10.00	per week			
5. Reduce bought in supplementary feed					
Assume extra feed = equivalent to that normally					
grazed by the cows.					
Assume cost to buy in = twice cost of on-farm supplement					
Cost of bought in feed:			$0.35	KgDM	
Cows fed	12	KgDM pasture			
6. Improved cow condition					
Assume cows are $^{1}/_{2}$ condition score better at calving					
1 condition score =		30	KgMS		
7. Reduced dry/empty cows					
Assume replacement rate drops by			4%		
(ie from 20% to 16%)					
Value of R 1 yf Heifer		$706	(10 yr Herd Scheme Av)		

APPENDIX 7 – UNDERLYING ASSUMPTIONS FOR FENCING-OFF STREAMS

Fencing off Streams

Length of streams on dairy/dairy drystock farms (km) =	407	Covers river orders 1-6	
Length of streams on sheep & beef farms (km) =	1113	Covers river orders 1-6	

River orders 1 are often dry during summer - more ephemeral streams
Therefore fencing/riparian management only considered on Order 2+ streams

Length of Order 2+ streams on dairy farms =	206	km	Length to be fenced =	412	Km
Length of Order 2+ streams on sheep & beef farms =	544	km	Length to be fenced =	1088	Km

Length of streams already fenced on dairy farms =	89.9%	(MPI data)
Length of streams already fenced on sheep & beef farms =	10%	(guess)
Length of streams not possible to fence on sheep & beef farms =	25%	

Exisiting dairy farms will fence remaining areas quickly due to Fonterra pressure: assume finished next 2 years
Dairy conversions will fence at time of conversion
Sheep & Beef farms will fence over 20 year adoption period

			Length of streams 2-6 on S&B farms, for LUC 2-4 =	448	Km
Dairy: remaining length to be fenced =	41.6	Km	Length of streams 2-6 on S&B farms, for LUC 5-8 =	96	Km
S& B: length to be fenced =	979.1	Km			

Cost of fencing:	Dairy	$9.00	per metre	9
	S&B	$16.00	per metre	16
Cost of maintenance	Dairy	$0.30	per meter per year	
	S&B	$0.50	per meter per year	

3.7% Scenario

		Existing Dairy		New Dairy		S & B	
				Capital	Mtce	Capital	Mtce
Yr 1	2012	251,120		290,774	9,692	139,582	4,362
Yr 2	2013	123,686		298,299	19,636	199,403	10,593
Yr 3	2014			305,985	29,835	199,403	16,825
Yr 4	2015			313,991	40,302	159,522	21,810
Yr 5	2016			322,317	51,046	159,522	26,795
Yr 6				386,044	63,914	139,582	31,157
Yr 7				396,452	77,129	139,582	35,519
Yr 8				407,179	90,701	99,702	38,634
Yr 9				418,388	104,648	99,702	41,750
Yr 10				491,561	121,033	99,702	44,866
Yr 11				505,332	137,877	79,761	47,358
Yr 12				519,582	155,197	79,761	49,851
Yr 13				601,242	175,238	79,761	52,343
Yr 14				618,535	195,856	59,821	54,213
Yr 15				636,308	217,066	59,821	56,082
Yr 16				727,415	241,313	39,881	57,328
Yr 17				748,711	266,270	39,881	58,575
Yr 18				77,017	268,838	39,881	59,821
Yr 19					268,838	39,881	61,067
Yr 20					3,288,822	39,881	747,064
Yr 21							
			NPV:	$3,838,874	$1,654,442	$1,188,273	$481,099
			Total:	$7,162,688			

APPENDIX 8 – UNDERLYING ASSUMPTIONS FOR RIPARIAN MANAGEMENT

Riparian Planting				
	Riparian Planting:	$1,148	per 100m x 5 m depth	
		1,148	1,837	
Assume	5	meter depth of planting on dairy farms		
Assume	8	meter depth of planting on S&B farms		
Assume	50%	of dairy land is productive		
Assume	75%	of land on S&B farms is productive		
Assume	10%	of exisiting dairy farms already planted		
Assume	5%	Sheep & beef farms on LUC 2-4 already planted		
Assume	25%	of S&B land unable to be planted, %	10%	already fenced/planted (from fencing scenario)
Assume plantings follow 20 year adoption curve				

3.7% Scenario				Opportunity Cost of lost grazing		
	Riparian Planting					
	Existing Dairy	New Dairy	S & B	Existing Dairy	New Dairy	S & B
Yr 1	298,212	352,353	160,240	20,892	24,685	1,694
Yr 2	426,018	361,473	228,915	50,737	50,008	4,113
Yr 3	426,018	370,786	228,915	80,582	75,984	6,533
Yr 4	340,814	380,487	183,132	104,459	102,640	8,469
Yr 5	340,814	390,577	183,132	128,335	130,002	10,404
Yr 6	298,212	467,799	160,240	149,227	162,775	12,098
Yr 7	298,212	480,411	160,240	170,118	196,431	13,792
Yr 8	213,009	493,411	114,457	185,041	230,997	15,002
Yr 9	213,009	506,993	114,457	199,964	266,516	16,211
Yr 10	213,009	595,663	114,457	214,887	308,246	17,421
Yr 11	170,407	612,350	91,566	226,825	351,145	18,389
Yr 12	170,407	629,618	91,566	238,763	395,254	19,357
Yr 13	170,407	728,572	91,566	250,701	446,295	20,325
Yr 14	127,805	749,527	68,674	259,655	498,805	21,051
Yr 15	127,805	771,064	68,674	268,608	552,823	21,776
Yr 16	85,204	881,465	45,783	274,577	614,575	22,260
Yr 17	85,204	907,271	45,783	280,546	678,135	22,744
Yr 18	85,204	93,327	45,783	286,515	684,674	23,228
Yr 19	85,204		45,783	292,484	684,674	23,712
Yr 20	85,204		45,783	298,454	684,674	24,196
Yr 21				3,644,763	8,361,346	24,196
Yr 22						294,930
Yr 23						
Yr 24						
Yr 25						
NPV:	$2,538,702	$4,651,862	$1,364,137	$2,324,659	$4,224,401	$188,820
Total	$15,292,581					

APPENDIX 9 – ASSUMPTIONS UNDERLYING CONSTRUCTED WETLANDS

2. Contructed Wetlands

Assume:

1. That it is possible to constuct a wetland to intercept tile drainage outflows.
2. Assume that on existing farms 1 x2.5Ha wetland is constructed to cover 100 Ha - i.e. approx 67% of the farm is covered
3. Assume that on converted farms 2 x 2.5ha wetlands are constructed - i.e. covers 70% on average of the farm
4. Proportion of farms wetlands installed on: 50%
5. Assume 50% of the wetland is on productive land, with 50% on "waste" land

A 2.5ha wetland per 100ha of catchment would intercept ~40% of N , ~20% P discharge via the tile drains

Cost of constructed wetland: $3,250 per Ha of catchment - 2007 cost

inflated to 2012: $3,699 CPI from June 2007 to June 2012 = 13.8%

Maintenance cost: $15.0 per Ha of catchment - 2007 cost

inflated to 2012: $17

Assume wetlands installed over a 20 year adoption curve

	Existing Dairy farms		Loss of Productive land	New dairy farms		Loss of Productive land
	Construction	Maintenance		Constructio	Maintenance	
Yr 1	1,941,713	7,875	42,223	7,249,060	33,457	15,763
Yr 2	2,773,875	19,125	102,542	10,355,800	81,253	38,282
Yr 3	2,773,875	30,375	162,861	10,355,800	129,049	60,801
Yr 4	2,219,100	39,375	211,116	8,284,640	167,286	78,817
Yr 5	2,219,100	48,375	259,371	8,284,640	205,523	96,832
Yr 6	1,941,713	56,250	301,594	7,249,060	238,980	112,595
Yr 7	1,941,713	64,125	343,817	7,249,060	272,437	128,358
Yr 8	1,386,938	69,750	373,976	5,177,900	296,335	139,618
Yr 9	1,386,938	75,375	404,136	5,177,900	320,233	150,877
Yr 10	1,386,938	81,000	434,295	5,177,900	344,131	162,137
Yr 11	1,109,550	85,500	458,423	4,142,320	363,250	171,144
Yr 12	1,109,550	90,000	482,550	4,142,320	382,368	180,152
Yr 13	1,109,550	94,500	506,678	4,142,320	401,486	189,160
Yr 14	832,163	97,875	524,773	3,106,740	415,825	195,915
Yr 15	832,163	101,250	542,869	3,106,740	430,164	202,671
Yr 16	554,775	103,500	554,933	2,071,160	439,723	207,175
Yr 17	554,775	105,750	566,996	2,071,160	449,282	211,679
Yr 18	554,775	108,000	579,060	2,071,160	458,842	216,182
Yr 19	554,775	110,250	591,124	2,071,160	468,401	220,686
Yr 20	554,775	112,500	603,188	2,071,160	477,960	225,190
Yr 21		112,500	603,188		477,960	225,190
Yr 22		112,500	603,188		477,960	225,190
Yr 23		112,500	603,188		477,960	225,190
Yr 24		112,500	603,188		477,960	225,190
Yr 25		1,362,195	7,303,636		5,787,332	2,754,858
NPV:	$16,529,936	$882,186	$4,729,988	$61,711,763	$3,747,997	$1,769,975
Total:	$22,142,110			Total:	$67,229,735	
Overall Total:		$89,371,845				

APPENDIX 10 – UNDERLYING ASSUMPTIONS RE TUSSOCK DEVELOPMENT IN HILL COUNTRY

2. Hill Country development - tussock into grassland									
Development cost: crop rotation into pasture:					$2,000	per ha			
Fencing/Tracking:					$800	per ha			
Capital Stock:					$600	per Ha	5su @ $120/su		
Area of tussock =					1279	Ha			
Assume	50%	developed over next 20 years in linear fashion, ie					2.5%	per year =	
							32.0	Ha per year	
	Devel Cost		Income		Net				
Yr 1	108,739		9,610		-99,129				
Yr 2	108,739		19,219		-89,520				
Yr 3	108,739		28,829		-79,910				
Yr 4	108,739		38,438		-70,301				
Yr 5	108,739		48,048		-60,691				
Yr 6	108,739		57,657		-51,081				
Yr 7	108,739		67,267		-41,472				
Yr 8	108,739		76,876		-31,862				
Yr 9	108,739		86,486		-22,253				
Yr 10	108,739		96,096		-12,643				
Yr 11	108,739		105,705		-3,034				
Yr 12	108,739		115,315		6,576				
Yr 13	108,739		124,924		16,185				
Yr 14	108,739		134,534		25,795				
Yr 15	108,739		144,143		35,405				
Yr 16	108,739		153,753		45,014				
Yr 17	108,739		163,362		54,624				
Yr 18	108,739		172,972		64,233				
Yr 19	108,739		182,582		73,843				
Yr 20	108,739		192,191		83,452				
Yr 21			192,191		192,191				
Yr 22			2,347,069		2,347,069				
NPV:	$1,067,614		$1,228,171		$160,557				

APPENDIX 11 – UNDERLYING ASSUMPTIONS ON ECONOMIC GAIN FROM LAND USE CHANGE

Economic gain from dairy conversion				
Based on gain in EFS per hectare for dairying vs loss from S&B.				
Dairy EFS/Ha:	$3,217			
Run-off EFS =	25%	of dairy EFS		
S&B EFS/ha	$374	(Intensive S&B from LUC 2-4)		
3.7% Scenario				
	Dairy Gain			S&B loss
	Milking platform	Run-off		
Yr 1	4,130,628	427,861		678,801
Yr 2	8,412,455	855,722		1,375,171
Yr 3	12,848,698	1,283,583		2,089,482
Yr 4	17,445,791	1,711,444		2,822,483
Yr 5	22,210,168	2,139,305		3,574,921
Yr 6	27,971,815	2,637,940		4,476,127
Yr 7	33,942,567	3,136,575		5,401,630
Yr 8	40,128,858	3,635,210		6,352,176
Yr 9	46,540,339	4,133,845		7,328,887
Yr 10	54,135,676	4,704,058		8,476,421
Yr 11	62,007,675	5,274,272		9,656,100
Yr 12	70,165,987	5,844,485		10,869,046
Yr 13	79,678,656	6,486,276		12,272,625
Yr 14	89,538,761	7,128,068		13,716,573
Yr 15	99,755,953	7,769,859		15,202,012
Yr 16	111,520,522	8,482,425		16,900,137
Yr 17	123,712,952	9,194,990		18,647,976
Yr 18	124,977,233	9,265,764		18,827,769
Yr 19	124,977,233	9,265,764		18,827,769
Yr 20	1,528,907,061	113,352,585		230,329,219
NPV:	$756,578,568	$60,156,605		$115,867,140
Total dairy:	$816,735,174			
	Nett gain =	$700,868,034		

APPENDIX 12 – PRODUCTION AND PHYSICAL PARAMETERS FOR OVERSEER® VERSION 6.1.1 ANALYSIS

MPI Southland Dairy Model *(modified to reflect average dairy farm size and cow numbers in the Aparima catchment)*

Area	157ha
Effluent area	15.7 ha
Cow numbers	409 cows
Production	149,150kgMS
Supplement imported	200tDM pasture silage; 378tDM PKE
N Fertiliser use	154kgN/ha applied to non-effluent area (137kgN/ha over the whole farm)
Winter grazing	All cows grazed off for June and July
Rainfall	1250mm
Effluent system	Irrigated from Sump
Soil Type	Eureka (Sedimentary, Gley)

Base Nutrient loss: 40 Kg N/Ha/yr, 1.2 Kg P/Ha/yr

MPI Southland-South Otago Hill Country Sheep and Beef Model

Area	723ha
Sheep Stock Units	5951
Cattle Stock Units	938
Wool Production	26,677kg/yr
Supplement imported	0
N Fertiliser use	2kgN/ha (average over whole farm)
Rainfall	1000mm
Soil Type	Sedimentary

Base Nutrient loss: 8 Kg N/Ha/yr, 0.6 Kg P/Ha/yr