Assessment of the agricultural economic impacts of nutrient management policies in Taranaki

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Executive Summary

A freshwater plan (the Regional Fresh Water Plan for Taranaki, or RFWP) has been in effect in Taranaki since October 2001, and Taranaki Regional Council is currently reviewing this plan. As part of the review the Council is assessing the economic costs and benefits of including different nutrient management options into a reviewed Taranaki Regional Freshwater Plan. This report provides an assessment of the agricultural economics associated with the options to be considered

There are three policy options that the council wishes to consider in respect of its review:

- Option1 - Status quo which involves continuation of the voluntary Riparian Management Programme
- Option 2 - On farm mitigation, which involves timely full completion of the Riparian Management Programme and land disposal of dairy farm effluent; and
- Option 3 – Nutrient Cap which involves setting nutrient caps at either 48 kg N/ha/year or 30 kg N/ha/year plus the mitigations in Option 2.

The analysis addresses land use change and intensification, riparian fencing and planting; dairy effluent discharges to land; the costs of meeting caps on N emissions; and administrative cost. The results are aggregated for the region taking into account variation in land use, climate, soils, and current infrastructure to the extent possible. The costs should be treated with some caution as the analysis was developed from a limited number of case studies and data.

The results for the analysis are shown in Table 13 below and in greater detail in the appendix. Option 1, which equates to the current situation, incurs total costs for the agricultural sector of approximately $40 million over 25 years or $17 million in NPV(8%) terms, which is the costs of completing the riparian fencing and planting programme to 90%.

Option 2 incurs additional costs for riparian planting and dairy effluent management. The riparian planting costs increase from $40 to $54 million in aggregate expenditure and also in NPV terms to $42 million because of the earlier implementation of the policy in Option 2. The dairy effluent imposes additional costs of NPV $64 million, which is the cost of constructing and lining ponds, and installing irrigation systems for disposal to land. These costs are partially offset by the nutrient benefits associated with the effluent, which is equal to $48 million NPV. The total cost of Option 2 is $58 million NPV, which is $41 million more than Option 1.

Option 3 with a cap at 30kgN/ha will have costs that are more than an order of magnitude greater than Option 1, with total costs of $1010 million NPV(8%). The majority of this ($560 million NPV) is mitigation cost for dairy properties, but reducing the potential for intensification and development will also impose costs in the order of $360 million NPV.

Option 3 with the cap at 48kgN/ha will have lower cost than the 30kgN/ha cap, but these will still be significant at $340 million NPV total. Again the majority of this is costs from mitigation ($170 million NPV) and costs associated with restrictions on intensification ($96 million NPV). This option has a cost that is $326 million NPV greater than Option 1.

Table 1: Summary NPV results for agricultural impacts ($million NPV, 8%)

		Option			
Item	**Subitem**	**1**	**2**	**3 (30 kgN/ha)**	**3 (48 kgN/ha)**
Riparian fencing and planting		$17	$42	$42	$42
Dairy effluent	Costs	$0	$64	$64	$64
	Benefits	$0	-$48	-$48	-$48
Nutrient management	Mitigation	$0	$0	$579	$174
	Development and intensification	$0	$0	$359	$97
	Administration	$0	$0	$15	$13
Total		**$17**	**$58**	**$1,011**	**$343**
Cost relative to Status Quo (Option 1)			**$42**	**$994**	**$326**

Sensitivity testing was undertaken on the key assumptions made during the analysis. The major sensitivity is to the exclusion of intensification and changes to the discount rate. However overall the ordering of options is not changed by alteration to the assumptions, and it appears reasonable to state that the overall outcomes are reasonably robust to changes in individual assumptions.

The results indicate the relative ranking of the options in terms of cost to the farming community: Option 1 > Option 2 >>Option 3 (48) >> Option 3 (30). The N caps in particular will impose significant cost on the dairy and dairy support sectors, with the majority of this borne by the dairy operations. The dairy effluent and riparian protection requirements will also impose costs, but these costs are significantly smaller. Therefore Options 1 and 2 are strongly preferred from an agricultural point of view.

Given the size of costs associated with the N caps their imposition would seem to require very strong justification in terms of environmental gains. However a decision on the relative trade-off between costs and environmental gains remains a political decision and not one that is amenable to quantitative analysis.

1 Introduction

1.1 Background and scope

A freshwater plan (the Regional Fresh Water Plan for Taranaki, or RFWP) has been in effect in Taranaki since October 2001. Taranaki Regional Council is currently reviewing its management of freshwater under this plan in the region to ensure that its plans and policies will comply with the requirements of the National Policy Statement for Freshwater Management (NPSFM) and more broadly reflect the region's current status, trends, and expectations around water quality. As part of the review of the Regional Freshwater Plan for Taranaki, the Taranaki Regional Council (the Council) is examining options for maintaining and enhancing water quality through improved nutrient management on land where dairy farming occurs. This examination needs to be to a level that satisfies the recently amended Section 32 of the Resource Management Act 1991 (RMA). This examination includes consideration as to whether nutrient management measures are necessary, and the relative costs and benefits of options for nutrient management.

The Council is preparing an Economic Costs & Benefits Report with the purpose of assessing the economic costs and benefits of including different nutrient management options into a reviewed Taranaki Regional Freshwater Plan. The Economic Costs & Benefits Report will then form the basis of a Section 32 Evaluation Report of the objectives and policies adopted in the reviewed Taranaki Regional Freshwater.

There are four contributory reports to the Economics costs and benefits report. These reports address:

- The state of freshwater quality in Taranaki.
- An assessment of dairy farm practices and management
- Nutrient management tools/models and practices
- Agricultural economics.

This report provides an assessment of the agricultural economics associated with the options to be considered. It draws on the other three reports as source document and is intended to:

1. Broadly describing the key agricultural economics elements and financial modelling as they relate to nutrient management on dairy farms;
2. Review the findings of the other three focus areas and using these findings to inform the assessment of agricultural economic aspects of nutrient management on dairy farms;
3. Assess the three policy options identified below and determining the economic costs and benefits of the options (in accordance with the recently amended s.32 of the RMA) , with emphasis primarily (but not exclusively) on the on-farm economic consequences;
4. Providing an opinion on the three policy options from a primarily on-farm agricultural economics perspective, and recommending a preferred option;
5. Addressing any other matters considered relevant in the Agricultural Economics Report.

1.2 Policy options

There are three policy options that the council wishes to consider in respect of its review:

1.2.1 Option One – Status Quo

This option involves continuation of the voluntary Riparian Management Programme which involves the following initiatives:

- Eventual completion across an anticipated 90% of the region of existing voluntary fencing of waterways
- Eventual completion across an anticipated 90% of the region of existing voluntary planting of waterways
- On-going liaison and support
- Encourage the existing trend of increasing disposal of farm dairy effluent to land
- Encourage good management practices (GMP) on dairy farms (including feed pads and nutrient budgeting)
- Control the application of farm dairy effluent onto or into land not exceeding 200kg N/ha/yr and with separation zones between application areas and waterways

1.2.2 Option Two – On-farm Mitigation

This option involves the regulating the effects of land uses by:

- Making fencing and riparian management mandatory for all waterways through intensive pastoral land use
- Requiring timely full completion of the Riparian Management Programme
- Requiring land disposal of dairy farm effluent in all except exceptional circumstances
- Encourage good management practices (GMP) on dairy farms (including feed pads and nutrient budgeting)
- All by 2020

1.2.3 Option Three – Nutrient Cap plus other on-farm mitigation

This option involves a scenario for setting nutrient caps e.g.:

- Set a nitrogen baseline of either 48 kg N/ha/year or 30 kg N/ha/year (defined as the discharge of nitrogen below root zone as modelled by OVERSEER expressed in kg/ha/yr) and any activity (i.e. any farm) that causes the nitrogen baseline to be exceeded is a discretionary or even non-complying activity
- Other on-farm mitigations as per Option 2.

1.3 Key impacts

The major impacts of the policies are in relation to:

- Land use change and intensification;
- Riparian fencing and planting;
- Dairy effluent discharges to land, and storage costs for deferred irrigation; and
- Costs of meeting caps on N emissions.
- Administrative costs

The approach to assessing the size of these impacts is outlined below in the Method section, and the results are collated into a cashflow analysis. The discussion section outlines the broad trends from the analysis and describes the way in which the different options impact on the region.

2 Method and assumptions

2.1 Land use and land use change

Current estimates of land use for the ring plain area in the Taranaki region are shown in Table 2 below. It shows that dairy is by far the dominant land use, with approximately half the total area and three quarters of the pastoral land use.

The trend in land use change over the last decade in Taranaki has been a decline in sheep and beef numbers, and little change in dairy cattle numbers (Figure 1). Data from LIC and DairyNZ [1] suggests that in 2004 there were 176,000 ha in dairy effective area with 2081 herds producing 166 million kg of milksolids. In the 2013/14 season there were 173,000 effective ha in dairy, with 1719 herds producing 184 million kg of milksolids. So during that decade there appears to have been a small reduction in area, a consolidation of land so that herd numbers reduce but herd size increased, (from 237 to 287 cows/herd), and an increase in production from the slightly smaller area indicating a more intensive system (from 950 to 1068 kgMS/ha). This suggests a compounding average increase in intensity of 1.2% per annum for the decade in the dairy sector.

[1] New Zealand Dairy Statistics 2013 – 2014. LIC and DairyNZ

Table 2: Estimated land use 2015 (ha) Source: TRC.

	Rainfall			
Land use	<1500mm (ha)	1500-2500 (ha)	>2500 (ha)	Total (ha)
Dairy	86,000	62,000	25,000	172,000
Dairy support	7,000	7,000	2,000	16,000
Sheep and beef	19,000	19,000	4,000	41,000
Other	19,000	21,000	70,000	111,000
Total	**131,000**	**110,000**	**100,000**	**341,000**

While there has been a decrease in sheep and beef sectors, it is unclear why this has occurred since in the normal run of events it would be associated with an increase in dairy due to the higher profitability of dairy operations over that period. However in this case the absolute area of dairy has not increased, but it is likely that the reductions in numbers has been a result of increased focus on per animal performance, loss of marginal hill country land from pastoral production, and substitution with dairy support.

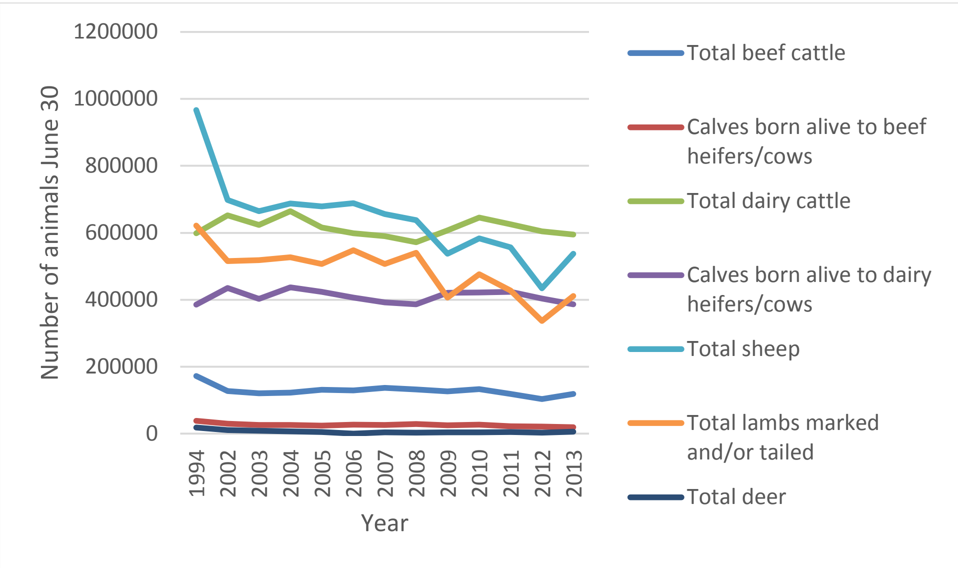

Figure 1: Livestock numbers in Taranaki 1994 - 2013. (Source: Statistics NZ)

The Parliamentary Commissioner for the Environment (PCE) assessed[2] nutrient trends and management in New Zealand, and estimated the historical and future changes in land use in

[2] Water Quality in NZ Land use and nutrient pollution A report by Parliamentary Commissioner for the Environment November 2013, available at http://www.pce.parliament.nz/assets/Uploads/PCE-Water-quality-land-use-web-amended.pdf

Taranaki along with other regions. They estimate a reduction in dairy area in the Taranaki region of 11,800 ha between 1996 and 2008, although this is not a consistent trend and closer investigation shows a gradual decline to 2006, then a small increase subsequently. The drivers of this change are not apparent, and historical relationships between land in dairy and payout over the period between 2003/04 and 2013/14, do not show a strong relationship (Figure 2).

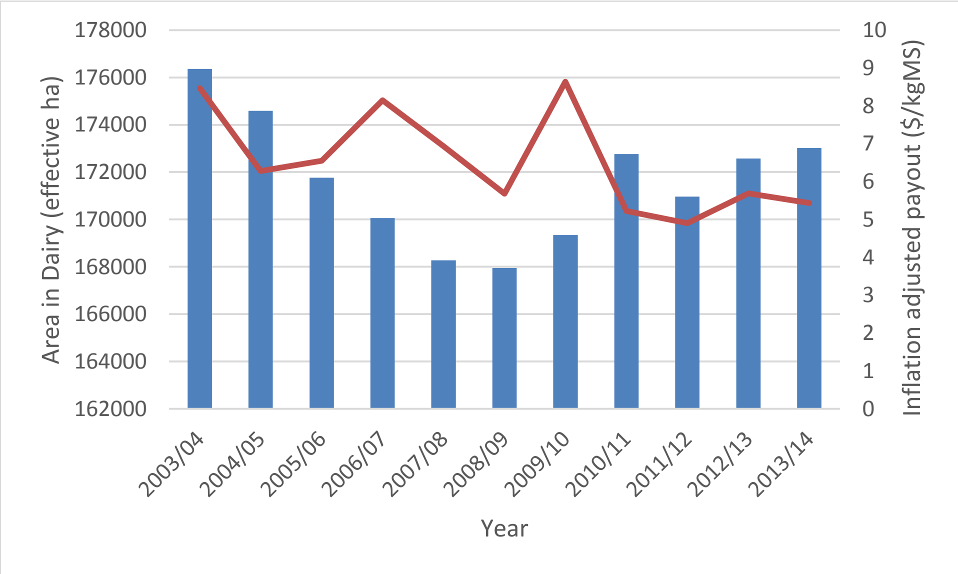

Figure 2: Dairy area and payout 2004 - 2014 in Taranaki (Source LIC Dairy Statistics)

The process of predicting land use change is not simple, since there are many factors that will cause such a change. The PCE use the LURNZ model to predict future land use change. The LURNZ model uses estimates of relative profitability and historical estimates of elasticities of changes between land uses to predict likely future movement. The model predicts an approximately 10% increase (17,700ha) in dairying area between 2008 and 2020, a reduction in sheep and beef of 32,000 ha, and an increase in plantation forestry of 14,900 ha (Table 3). As we are now halfway through that prediction period it seems safe to assume that such a level of projected change is unlikely to occur. Since 2008 there has been an increase in dairy land use of ~4,700 ha, which is approximately half the predicted increase if pro-rated over the forecast period.

Table 3: Change in land use 1996 – 2008 and 2008 - 2020 (Source PCE, 2013)

Period	Sheep and Beef	Dairy	Plantation Forestry	Scrub
1996 – 2008	7,600	-11,800	4,700	-500
2008 – 2020	-32,000	17,700	14,900	-600

For the purposes of this exercise the trend rate from 2008 – 2014 is used and it is assumed this is replicated over the following 10 years to 2025. This would give an annual increase in dairy area of a further 7,800 ha over the plan period to 2025 in the absence of any controls or policy interventions that affected behaviour, and this is used as the base rate of increase for the Option 1 scenario. This increase in dairy area is assumed to occur on the ring plain area, and is assumed to result from conversion of sheep and beef to dairy, so there will be a corresponding decrease in sheep and beef as a result.

For policy option 2 the increased stringency of riparian fencing and planting requirements will apply to all farms with cattle, regardless of whether they are dairy, dairy support or beef. The effluent requirements will make conversion more expensive, but discharge of effluent to land is seen as best practice and it is unlikely that further discharge to water would be allowed even under Option 1. Therefore dairy effluent requirements are also not expected to affect conversion behaviour, and we expect any change in land use for the 2015 – 2025 to be unaffected by Option 2 requirements.

Option 3 will implement N caps, which will alter the profitability of dairy farming for those on higher rainfall and more intensive systems. The work from DairyNZ[3] estimates that 27% of properties meet the 48 and 30 kgN/ha cap already, 53% meet the 48kgN/ha cap but not the 30kgN/ha, and 20% do not meet either cap (i.e.>48kgN/ha). That is, 73% of dairy farms in Taranaki currently do not meet a 30kgN/ha threshold, but 80% of farms are less than 43kgN/ha. Of these all are able to meet the 48kgN/ha cap with some cost to the farm profitability, but 40% of properties are not able to meet the 30kgN/ha cap without significant changes to the farm system and major impacts on farm profitability.

In order to generate a simple scenario of potential effect of the N caps in Option 3 on land use change, it has been assumed that the proportion of farms able to achieve the 30kgN/ha cap (60%) is multiplied by the area of new dairying in Option 1 to give an area of 4,700 ha of new dairying between 2014 and 2025 in Option 3 (30kgN/ha). It is assumed that most (3900 ha) of this new conversion in Option 3 (30kgN/ha) occurs in the <1500mm rainfall zone[4], with the remainder (800 ha) occurring in the 1500 – 2500mm annual rainfall band.

Because all dairy farms are able to meet the 48kgN/ha cap with mitigation, even if at some cost to profitability, it is assumed that the rate of land use change in this scenario is unaffected by the imposition of a cap, and there is no difference in the land use estimates between Options 1, 2 and 3 (48kgN/ha). The land use estimates for the ring plain area are given in Table 4 and Table 5.

It is highly likely that some of the existing properties who exceed the cap will become financially non-viable. Some of these will be purchased for a lower value and remain viable dairy operations, and some will need to convert to lower emitting land uses such as sheep and beef. However for the purposes of this exercise no land use change for existing properties is included and the costs as estimated by DairyNZ for existing properties is used.

Effects on changes in intensity are not assumed to occur for landholders in Options 1 and 2, since the riparian protection and effluent management will not affect the ability to intensify. However for Option 3 it has been assumed that only properties which are below the N cap (27% for a 30kgN/ha cap, and 80% for a 48 kgN/ha cap) will be able to intensify because the other properties will be in a position of needing to mitigate to achieve the cap. Estimates of the effect of stopping intensification were made from the operating profit/milksolids

[3] *Dairy Farm Practices and Management Report*, DairyNZ, May 2015

[4] This is the area of land that would have converted in Option 1 without restriction, and generally the sub 1500mm rainfall properties are able to achieve the 30kgN cap with smaller costs than the higher rainfall properties.

production relationship shown in the 2010/11 - 2012/13 DairyNZ Economic Surveys, which equates to a $3.0/ha increase in operating profit with each kg increase in milksolids[5]. The assumption therefore is that the annual increase in operating profit from intensification is equal to $6.4 million, which is allowed each year for the 10 years of the plan life. Thus there will be a loss of 73% of this ($4.7 million per annum) for the 30kgN/ha cap and 20% of this total ($1.3 million per annum) with the 48kgN/ha cap. The losses from intensification are assumed to increase linearly at this rate for 10 years of the planning horizon, then remain at that level for the remainder of the period to 2040.

Table 4: Option 1, 2 and 3 (48kgN/ha cap) estimated land use 2025 (ha) (ring plain only - these options are all assumed to have the same level of land use change as the policy measures are unlikely to affect willingness to convert to dairy)

	Rainfall			
Land use	<1500mm (ha)	1500-2500 (ha)	>2500 (ha)	Total (ha)
Dairy	89,000	65,000	26,000	180,000
Dairy support	7,000	7,000	2,000	16,000
Sheep and beef	15,000	16,000	3,000	34,000
Other	19,000	21,000	70,000	111,000
Total	131,000	110,000	100,000	341,000

5 The r2 value in the DairyNZ relationship (Figure 5.8, page 12) is only 0.3995, however for the purposes of this high level assessment the relationships are assumed to hold. It should be noted that high operating profits are achievable at a range of intensities, so it may be possible to increase returns without increasing production. However this will be greatly dependent on farmer skill, and it is assumed that the reason the trend increase in intensity is occurring is because the average farmer is experiencing an increase in operating profit as they increase intensity.

Table 5: Option 3 (30kgN/ha cap) estimated land use 2025 (ha) (ring plain only – land use in this option is assumed to be affected by the 30kgN/ha cap)

	Rainfall			
Land use	<1500mm (ha)	1500-2500 (ha)	>2500 (ha)	Total (ha)
Dairy	89,000	63,000	25,000	177,000
Dairy support	7,000	7,000	2,000	16,000
Sheep and beef	15,000	18,000	4,000	37,000
Other	19,000	21,000	70,000	111,000
Total	131,000	110,000	100,000	341,000

2.2 Riparian fencing and planting.

TRC has had a major initiative underway since 2004 to undertake fencing and planting of all areas within the ring plain. The required distances to complete all recommended fencing and planting are shown in Table 6, with the required distance dependent on whether 90% of the fencing and planting is to be completed (Option 1) or 100% (Option 2 and 3).

A cost of $8.25/m for fencing is assumed, which is based on the mid-point of TRC cost estimates, but is broadly in line with Lincoln Farm Budget Manual costs for 2010, updated using the Capital Goods Price index for land development ($8.54/m). A cost of $6.25/m for planting is included again based on the mid-point of TRC cost estimates, but this is in line with costings based on Waihora Ellesmere Trust planting costs ($5.10 assuming a 1m wide strip[6]).

The timing for fencing and planting to be completed is assumed to be 2020 in Option 2 and 3 based on the specification for the option, and in 2040 Option 1 using approximate current rates of planting.

Table 6: Estimated distance required for completion of riparian fencing and planting (Source: TRC pers.comm.)

Distance	**Fencing**	**Planting**
Length (km) to complete to 90%	2,467	2,888
Length (km) to complete to 100%	2,742	3,638

2.3 Dairy Effluent

The dairy effluent requirements that are assumed to apply to Options 2 and 3 will involve best practice disposal involving the use of deferred irrigation discharge to land and lined ponds for storage. Farmers discharging to water currently will need to install an irrigation

[6] Source: Waihora Ellesmere Trust Riparian Flier, 2011. http://www.wet.org.nz/wp-content/uploads/2011/03/2011-March-riparian-restoration-flyer.pdf. Costs of 4500 plants/ha at $6.54/plant (including planting) plus $4/plant for maintenance over 2 years. These costs were updated using the Capital Goods Price index

system, and those with insufficient storage to undertake deferred irrigation will need to install a storage pond. In addition there are a proportion of existing ponds which will need to be lined to prevent leakage of effluent into groundwater.

All costs for storage ponds were derived from Red Jacket Ltd (2014)[7]. The costs for irrigators were derived from Houlbrooke (2008) [8] and updated using the Capital Goods Price Index for irrigation and land development. These costs were referenced against other known costs for storage ponds and irrigation, and found to be sufficiently close for the purposes of this analysis. The costs and other critical assumptions are shown in Table 7 below.

The costs are incurred in three ways.

- Those consents for discharge to water only are assumed to require an irrigator.
- Those consents who are estimated to have insufficient storage to allow for deficit irrigation are assumed to require the installation of a pond. TRC estimated that 261 consents fall into this category, and these were pro-rated across the soil and rainfall bands in proportion to area in each band.
- A proportion of existing soil ponds (10%) are assumed to require liners to prevent leakage of effluent into the soil and groundwater. This is based on feedback from TRC regarding their expectation regarding the likely impact of the measure. However a sensitivity test is undertaken in which 70% of the soil ponds require liners, which is derived from a Tonkin and Taylor site assessment of existing storage pond adequacy[9]. It is assumed that 97% of ponds are soil only (i.e. no geomembrane or concrete). While there is no specific data on which to verify this assumption, TRC inspectorate staff have indicated that there are fewer than 50 geomembrane or concrete ponds in the region.

DairyNZ estimated the storage requirements and pond sizes for a range of soil types and rainfall zones, together with the number of properties in each category. These estimates were used to calculate the total cost of dairy effluent upgrade required in Taranaki as shown in Table 8, Table 9 and Table 10.

[7] Red Jacket Ltd 2014. Engineering report on dairy effluent ponds for benefit/cost analysis. Red Jacket Ltd contract report prepared for Taranaki Regional Council. RPT-1208-1-A
[8] Houlbrooke, D.J. 2008 Best Practice management of Farm Dairy Effluent in Manawatu-Wanganui region. AgResearch Report prepared for Horizons Regional Council. February 2008. The irrigator costs are based on the upper range of costs for a 500 cow farm cited in Holbrooke, with the upper range used because herds are typically much smaller in Taranaki and therefore lower economies of scale are expected.
[9] Cited in the DairyNZ report for this study.

Table 7: Key assumptions in estimate of dairy effluent management costs

Item	Cost	Source
Proportion requiring a liner	10%	10% of soil ponds, with sensitivity test based on Tonkin and Taylor: 5/7 of soil ponds inspected unlined. 97% of ponds soil ponds.
Liner cost/m3	$38	Assumed to require pond rebuild – cost as per original construction cost (based on discussions with Red Jacket Ltd).
Construction cost /m3	$38	Costs from Red Jacket assumed to be for 400m^{3}soil pond.
Irrigator cost/cow	$190	Costs from Houlbrooke (2008)
Per ha benefit from dairy effluent discharge to land rather than water	$68	Source: DairyNZ report
Total additional benefit from conversion of current discharges to water	$5,250,000	Source: DairyNZ report average benefit times herds

Table 8: Estimate of dairy effluent pond requirements and costs for Low Risk soils (less than 7 degrees):

Rainfall	**<1500**	**1500-2500**	**2500-5000**	**>5000**
Volume of pond (m^3)	400	779	1690	1690
Construction costs per pond	$15,000	$29,000	$63,000	$15,000

Table 9: Estimate of dairy effluent pond requirements and costs for High Risk soils (greater than 7 degrees)

Rainfall	**<1500**	**1500-2500**	**2500-5000**	**>5000**
Volume of pond (m^3)	3759	4399	4399	4399
Construction cost per pond	$141,000	$165,000	$165,000	$165,000

Table 10: Estimated affected consents, and costs for ponds, liners and irrigators - Low Risk Soils

Rainfall	<1500	1500-2500	2500-5000	>5000	Total
Consents for discharge to water	226	206	102	3	537
Consents for discharge to land	390	177	51	1	619
Consents for discharge to land and water	62	50	26	4	142
Number of herds requiring pond	92	66	26	184	369
Number of herds requiring liner	403	257	106	5	771
Number herds requiring irrigator	226	206	102	3	537
Cost ponds	$2,750,000	$3,880,000	$3,350,000	$0	$9,980,000
Cost additional liners	$860,000	$1,070,000	$960,000	$0	$2,900,000
Cost irrigators (assume completely new)	$12,350,000	$11,260,000	$5,570,000	$160,000	$29,340,000
Total Cost	**$15,960,000**	**$16,210,000**	**$9,880,000**	**$160,000**	**$42,220,000**

Table 11: Estimated affected consents, and costs for ponds, liners and irrigators - High Risk Soils

Rainfall	<1500	1500-2500	2500-5000	>5000	Total
Consents for discharge to water	87	110	26	0	223
Consents for discharge to land	70	55	15	0	140
Consents for discharge to land and water	23	34	6	0	63
Number of herds requiring pond	38	28	11	0	77
Number of herds requiring liner	107	118	28	0	253
Number herds requiring irrigator	87	110	26	0	223
Cost ponds	$6,360,000	$5,420,000	$2,150,000	$0	$13,930,000
Cost additional liners	$400,000	$530,000	$120,000	$0	$1,060,000
Cost irrigators (assume completely new)	$4,750,000	$6,010,000	$1,420,000	$0	$12,180,000
Total Cost	**$11,510,000**	**$11,960,000**	**$3,700,000**	**$0**	**$27,170,000**

2.4 Nutrient management costs

The nutrient management costs were investigated in reports by DairyNZ (dairy) and Graeme Ogle (sheep and beef, dairy support). The sheep and beef models investigated by Ogle were found to be under the 30kgN/ha cap, except for the very highest rainfall areas. Because the area of sheep and beef in the very high rainfall areas is small (244 ha in areas of >5000mm rainfall), and because mitigation costs were not calculated in the Ogle report, nutrient management costs for sheep and beef has been ignored. However both dairy and dairy support models showed properties exceeding the 30kgN/ha cap and 48kgN/ha caps, and costs for these land uses have been assessed and included in the analysis for the Option 3 cap alternatives.

2.4.1 Dairy

Option 3 requires that nutrient losses be capped at either 30kgN/ha or 48kgN/ha. The costs for nutrient management are derived from DairyNZ report[10] (dairy) and from the Ogle report[11] (sheep and beef and dairy support). These reports model current farm losses and the costs of mitigation for those properties over the respective 30kgN and 48kgN/ha nutrient losses.

For dairy at the 30kgN/ha cap there are a large proportion (73%) of properties that are above the cap. An additional 33% are able to mitigate to below the cap, 20% are able to mitigate to with 10% of the cap, and a further 20% are not able to mitigate to within 10% of the cap using the approaches modelled by DairyNZ. The cost of the modelled mitigations are adopted as per the $52 million per annum estimated by DairyNZ. However it should be noted that this is an underestimate because it not all properties met the 30kgN/ha cap in the DairyNZ analysis, indicating either further mitigation or land use change would be required.

For the 48kgN/ha there are fewer properties over the cap (20%) and all properties are able to mitigate below the limit. The costs associated with are estimated from linear interpolation from the mitigation figures, including intermediate points, provided by DairyNZ. The cost using this method across the three properties they identified as being above 48kgN/ha currently is $464/ha on average.

Although the occurrence of properties >48kgN/ha was restricted to higher rainfall areas (>1500mm/annum) there was no effective difference between taking the proportion of all properties in the Dairy NZ sample and the proportion of sample properties >1500mm/ha times the proportion of land >1500mm, which in both cases is 18 - 20%[12]. Extrapolating this cost across all dairy properties gives a net cost of $16 million per annum to meet the 48kgN/ha cap for dairy properties affected.

2.4.2 Dairy Support

The moderate rainfall property modelled by Ogle shows nutrient losses at 33kgN/ha and the high rainfall property is at 56kgN/ha currently (Table 12). Although solely pasture based systems are lower losses, when forage cropping activities are included in the rotation the losses for the whole farm are significantly higher, with losses from swedes and kale exceeding 150kgN/ha.

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[10] DairyNZ, 2015. Dairy Farm Practices and Management. An Analysis of three policy options for future nutrient management on Taranaki.

[11] Ogle, G. 2015. Modelling losses of Nitrogen and Phosphorus – Taranaki Region. A description of losses from 4 farm systems in Taranaki. Contract report prepared for Taranaki Regional Council.

[12] Indicating the DairyNZ sampling was very a very good stratified sample.

Table 12: Nutrient losses and mitigation costs for dairy support in Taranaki ring plain (Source Ogle, 2015)

Slope class	Dairy support moderate rainfall (<1500mm)	Dairy support high rainfall (>1500mm)
Flat	23	45
Rolling	14	26
Whole Farm	33	56
Cost per ha to mitigate to 30kgN/ha	$35	$144
Cost per ha to mitigate to 48kgN/ha	$0	$44

The mitigations for these dairy support properties to achieve the N cap involved removal of the forage cropping and a reduction in nitrogen fertiliser application. The estimated cost for the moderate rainfall property is $35/ha/annum in reduced profit, which is $255,000/annum in aggregate over the ring plain area, and $144/ha/annum for the high rainfall property, which aggregates to $1.28 million/annum over all the high rainfall dairy support properties in the ring plain.

For the 48kgN/ha cap only the high rainfall dairy support property would be required to mitigate, which would cost $44/ha/annum or $390,000/annum over the ring plain area.

2.5 Administrative costs

Options 1 and 2 are unlikely to incur any additional administration costs because there are programmes (riparian planting) or consent requirements (dairy effluent) that are not markedly changed by the policy options. While there may be some minor additional costs for compliance associated with the more stringent conditions, these may be partially offset by reduced compliance costs elsewhere (e.g. fewer discharges to water) and are not considered sufficiently significant to be included.

Option 3 will incur significant additional costs for farmers and these have been included in the analysis. It has been assumed that in order to meet the cap farmers will be required to develop a farm plan showing stocking and cropping intensities, management practices and including a nutrient budget. This approach has been adopted in other regions where individual farm nutrient limits have been implemented (e.g. ECan, Horizons) and is a reasonable assumption for the Taranaki region in similar circumstances.

Costs for farm plans were sourced from Claire Mulcock (pers.comm.), and are based on work undertaken for irrigation schemes in Canterbury developing farm plans for management of irrigation systems[13]. While there will be aspects of the farm plans that will differ for the Taranaki situation, the overall scope is unlikely to be significantly reduced and the addition of more stringent nutrient requirements may increase costs. Auditing has been assumed for a proportion of plans (once every 2 – 3 years), and it has been assumed that as

[13] Current costs for farm plans for irrigation schemes in Canterbury are ~$800/farm, which

properties change ownership and management or systems there will be a need for new farm plans. For the latter an assumed rate of 15% per annum has been assumed.

For properties which are unable to meet the nutrient cap it has been assumed that a consent will be required showing how the cap will be met in the future. This cost has been included for the 40% of dairy properties that were unable to meet the 30kgN/ha cap.

2.6 Cashflow analysis

The impacts of the policy options are investigated over the 25 years. The changes in area and intensity are converted to annual cashflows. The capital costs associated with dairy effluent are included over a 5 year transition period, and the riparian fencing and planting over the assumed period over which this takes place. The nutrient management costs are included for existing operations only as an annual cost with no phase in period.

All costs are taken from a societal point of view. They are aggregated across all enterprises, and no specific account is taken of where they are incurred. Thus for example costs for the riparian planting programme are treated equally regardless of whether they are incurred by the individual or the regional council.

Costs are discounted to the present day using a discount rate to produce a Net Present Value (NPV). A NPV gives an equivalent current day lump sum to a future stream of cashflows – this differs from an aggregate of the costs over the period of analysis. This is because the value of a $ in the future is less than one in the present day, because one in the present day we can either do something with, or put invest it and earn a return. The discount rate is used to represent the opportunity cost of those funds in an alternate use – the equivalent for example of the value that might be earned in an alternate investment. The discount rate is typically the risk free rate of return on capital plus some premium to reflect the volatility of returns in a particular use. The discount rate chosen here is 8% which is the Treasury standard rate for public sector projects. However other discount rates could be chosen, and a sensitivity test is undertaken to test the impact of a 5% and 10% discount rate.

2.7 Costs not included

Land use change to meet cap – the analysis includes only costs for mitigation as described in the contributory DairyNZ and Ogle reports. For the DairyNZ report there were a number of properties that were unable to meet the 30kgN/ha cap, and these properties would incur either additional mitigation costs or if the mitigation costs were too severe, would need to change land use. These costs have not been included in the analysis.

Additional dairy effluent costs for land development – we have assumed that all new properties are established at the highest level of practice, which reflects the requirements of Option 2. So effectively there would be no difference in costs between the options in this regard for new development.

Administration costs – no costs have been included for the administration of the different policy options at a regional level, as these have been considered out of scope.

Regional flow on impacts – there are a range of flow on impacts through the regional economy that would be associated with the policy options considered. In some respects these would be positive in the short term because some measures (e.g. dairy effluent requirements) would require capital expenditure that would be funded by equity or debt and increase activity in the region. However a number of other impacts would be negative, caused by increased debt or lower equity, reduced profitability, and limitations on flexibility, which would cause impacts to farm suppliers, household income and the wider community. These costs have been considered out of scope, and greater detail would be required in terms of revenue and expenditure impacts before they were able to be calculated.

2.8 Caveats

The costs associated with development and intensification are predictions of futures that are in no way certain. Furthermore the operating profit implications of intensification are based on limited data, and have relatively low explanatory power from the data. Therefore these costs should be treated as indicative.

The mitigation costs are based on a limited number of case studies, and with a limited range of mitigation options applied. There is some potential for lower cost to achieve the outcome, and while this is tested to some degree by the sensitivity testing this area is relatively new in terms of empirical data from typical farms aiming to achieve different levels of mitigation. Therefore the results should be treated with some caution.

It should be noted that the versions of Overseer are continually changing, so if the cap were to remain as a fixed figure, the cost of achieving that cap would vary from year to year. This would vary the cost of meeting the cap from year to year, but also introduce an additional inefficiency as land managers had to continually adjust their system to achieve a varying cap. These costs have not been quantified in this report, but are a significant potential additional set of costs with a fixed cap system outlined in Scenario 3.

Dairy effluent costs and riparian protection costs are derived from a limited number of sources, and applied across a large and diverse area. In reality the range of actual costs is likely to vary significant depending on the circumstances of the property.

3 Results

3.1 Base case analysis

The analysis for the Base case is shown in Table 13 below and in greater detail in the appendix. Sensitivity testing of these results is undertaken in Section 3.2 below. The results show that:

- Option 1, which equates to the current situation, incurs costs for the agricultural sector of approximately $17 million in NPV (8%) terms. This is approximately $1.5 million per annum for the period of the analysis, which is the costs of completing the riparian fencing and planting programme to 90%.

- Option 2 incurs additional costs for riparian planting and dairy effluent management. The riparian planting costs increase both in absolute terms (from $40 to $54 million in aggregate expenditure) and also in NPV(8%) terms because of the earlier implementation of the policy in Option 2. This increases the annual costs over the first 5 years from $1.5 million per annum to $9.1 million per annum, and the NPV(8%) cost from $17 million to $42 million. The dairy effluent imposes additional costs of NPV(8%) $64 million, the majority of which is the cost of constructing and lining ponds, and installing irrigation systems for disposal to land. These costs are partially offset by the nutrient benefits associated with the effluent, which is equal to $48 million NPV(8%). The total cost of this option is $58 million NPV, which is $41 million more than Option 1.

- Option 3 with a cap at 30kgN/ha will have costs that are more than an order of magnitude greater than Option, with total costs of $1010 million NPV(8%). The majority of this is mitigation cost for dairy properties ($52 million per annum over the period of analysis), but reducing the potential for intensification and development will also impose costs in the order of $360 million NPV.
- Option 3 with the cap at 48kgN/ha will have lower cost than the 30kgN/ha cap, but these will still be significant at $340 million NPV(8%) total. Again the majority of this is costs from mitigating to the 48kgN/ha cap for high emitting properties, which is a cost of ~$16 million per annum over the period of the analysis. There are no assumed impacts on development in this scenario, but the costs associated with restrictions on intensification are still a significant contributor to the total cost at $96 million NPV(8%). This option has a cost that is $326(8%) million NPV greater than Option 1.

It should be noted that the impacts are not equally spread amongst landholders in the region. Mitigation and dairy effluent costs are markedly higher for those in the higher rainfall areas, and effluent costs increase for those on high risk soils (steeper). The incidence of costs for riparian planting will also vary according to the shape and location of properties in relation to waterways. The costs for dairy effluent properties in different zones are shown in Table 8 and Table 9, and the mitigation costs for different case study properties are discussed in detail in the DairyNZ report. No information is available about the range of costs for riparian protection.

Table 13: Summary NPV results for agricultural impacts ($million NPV, 8%)

		Option			
Item	**Subitem**	**1**	**2**	**3 (30kgN/ha)**	**3 (48kgN/ha)**
Riparian fencing and planting		$17	$42	$42	$42
Dairy effluent	Costs	$0	$64	$64	$64
	Benefits	$0	-$48	-$48	-$48
Nutrient management	Mitigation	$0	$0	$579	$174
	Development and intensification	$0	$0	$359	$97
	Administration	$0	$0	$15	$13
Total		**$17**	**$58**	**$1,011**	**$343**
Cost relative to Option 1			**$42**	**$994**	**$326**

Table 14: Summary aggregate over 25 years for agricultural impacts ($million)

		Option			
Item	**Subitem**	**1**	**2**	**3 (30kgN/ha)**	**3 (48kgN/ha)**
Riparian fencing and planting		$40	$54	$54	$54
Dairy effluent	Costs	$0	$83	$83	$83
	Benefits	$0	-$126	-$126	-$126
Nutrient management	Mitigation	$0	$0	$1,392	$419
	Development and intensification	$0	$0	$1,052	$282
	Administration	$0	$0	$32	$28
Total		**$40**	**$12**	**$2,488**	**$741**
Cost relative to Option 1			**-$5**	**$2,471**	**$724**

3.2 Sensitivity

Sensitivity testing was undertaken on the key assumptions made during the analysis. These are shown in Table 15 below. The major differences are a result of the exclusion of intensification and discount rate. Removing intensification reduces the cost by $350 million NPV from Option 3 (30kgN/ha) and $100 million from Option 3 (48kgN/ha). Removal of the land development costs results in some change, but these are significantly smaller because the gains from land use change are smaller than those from intensification because of the inclusion of capital costs.

Changes to the discount rate also have significant impacts on the costs of Option 3, with the 30kgN/ha option altering by -$160 million (10% discount rate) and plus $370 million (5%). The 48kgN/ha option has a smaller range with alteration to the discount rate, moving -$40 million (10%) and +$100 million (5%) in costs.

Altering the profitability of dairying, such as might be expected through changes to the payout, has a reasonably significant effect at about ±$80 million for Option 3(30kgN/ha), and by about ±$20 million for Option 3 (48kgN/ha). This is important, but suggests that other factors such as discount rate and the inclusion of intensification are more critical to the overall result.

Mitigation costs are the next most sensitive assumption, with the costs altering by $120 million NPV for Option 3 (30kgN/ha) and by $35 million NPV for the 48kgN/ha option. Altering the riparian costs, effluent costs and effluent benefits by 20% changes the total results by ~$5 - $10 million NPV, but does not alter the overall relativity between options.

The uncertainty regarding the proportion of ponds which will require lining is shown to have some impact, but this is in the order of $20 million and as with other sensitivity tests would not affect the overall conclusions of the study.

Given the results from the sensitivity analysis, it appears reasonable to state that the overall outcomes are adeqautely robust to changes in individual assumptions. Changing the two most sensitive assumptions, discount rate and removal of intensification shows significant movement in Option 3 (30kgN/ha) particularly, but overall does not change the ranking or significance of the increase in costs associated with the N cap options.

Table 15: Sensitivity tests of outcomes by option

		Option			
	Assumption	**1**	**2**	**3 (30kgN/ha)**	**3 (48kgN/ha)**
Discount rate	8%	$17	$58	$1,011	$341
	10%	$14	$61	$847	$299
	5%	$22	$50	$1,384	$438
Inclusion of intensification	Yes	$17	$58	$1,011	$341
	No	$17	$58	$659	$245
Inclusion of land development and intensification	Yes	$17	$58	$1,011	$341
	No	$17	$58	$652	$245
Mitigation costs	Base	$17	$58	$1,011	$341
	+20%	17	58	1127	376
	-20%	17	58	895	306
Riparian costs	Base	$17	$58	$1,011	$341
	+20%	$20	$66	$1,019	$349
	-20%	$13	$50	$1,003	$333
Effluent costs	Base	$17	$58	$1,011	$341
	+20%	$17	$63	$1,016	$346
	-20%	$17	$54	$1,007	$337
Effluent benefits	Base	$17	$58	$1,011	$341
	+20%	$17	$49	$1,002	$332
	-20%	$17	$68	$1,021	$351
Discount rate with intensification removed	8%	$17	$58	$1,011	$341
	10%	$14	$61	$495	$203
	5%	$22	$50	$1,032	$342
Proportion requiring a liner	10%	$17	$58	$1,011	$341
	69%	$17	$80	$1,033	$363
	3%	$17	$56	$1,009	$339
Impact of changing payout (profitability change)	Base	$17	$58	$1,011	$341
	+20%	$17	$58	$1,097	$361
	-20%	$17	$58	$934	$322

4 Discussion

The results above clearly indicate the relative ranking of the options in terms of cost to the farming community: Option 1 > Option 2 >>Option 3 (48) >> Option 3 (30). The figures used have a range of uncertainty around them, but the conclusion regarding ordering and the significance of difference between options has been shown to be not sensitive to changes in the major assumptions used. The N caps in particular will impose significant cost on the dairy and dairy support sectors, with the majority of this borne by the dairy operations. The dairy effluent and riparian protection requirements will also impose costs, but these costs are significantly smaller. Therefore Options 1 and 2 are strongly preferred from an agricultural economics perspective.

The imposition of a 30kgN/ha reduces losses of N by ~2,000 tonnes out of a catchment dairy loss from the root zone of ~7,400 tonnes. This is a reduction of 28%, which is a highly significant reduction. For the 48kgN/ha cap the reduction would be a lesser 800t, or 11% of the dairy losses from the root zone.

The Bedford report identifies P rather than N as the more important of the water quality issues, and this is not addressed by the N cap, but only by the riparian fencing and planting (Options 1 and 2), and by improved management of dairy effluent (Option 2). These gains are achieved at an order of magnitude lower cost than the N cap requirements in Option 3.

There are also difficulties associated with administration of a cap on N as set out in the policy, which are additional to the administration costs identified in the analysis. These include the requirements for large numbers of farm plans and Overseer budgets to be completed with associated administrative and capacity constraints, and the drag on investment that comes with changing relationships between each new version of Overseer and the specified cap. While the second could be overcome by specifying the cap in a way that responds to changes in Overseer, the administrative and capacity constraints associated with a large number of comprehensive farm plans will take some time to work through.

Given the size of costs associated with the N caps and the lower priority as a problem in the region, their imposition would impose a range of costs on the farming community that would require very strong justification that is not apparent in the report on water quality in the region (Bedford 2015). However a decision on the relative trade-off between costs and environmental gains remains a political decision and not one that is amenable to quantitative analysis.

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5 Appendix: Cashflows years 1 – 11

			Year	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Option 1		**Total**	**NPV**											
Riparian planting		**$39.90**	**$16.60**	$1.54	$1.54	$1.54	$1.54	$1.54	$1.54	$1.54	$1.54	$1.54	$1.54	$1.54
Dairy effluent		**$0.00**	**$0.00**	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Nutrient management	Dairy	**$0.00**	**$0.00**	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	Dairy support	**$0.00**	**$0.00**	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	Sheep and beef	**$0.00**	**$0.00**	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Total		**$39.90**	**$16.60**	$1.54	$1.54	$1.54	$1.54	$1.54	$1.54	$1.54	$1.54	$1.54	$1.54	$1.54
Option 2														
Riparian planting		**$54.40**	**$41.90**	$9.07	$9.07	$9.07	$9.07	$9.07	$9.07	$0.00	$0.00	$0.00	$0.00	$0.00
Dairy effluent	Capital	**$83.30**	**$64.20**	$13.88	$13.88	$13.88	$13.88	$13.88	$13.88	$0.00	$0.00	$0.00	$0.00	$0.00
	Dairy effluent benefits	**-$126.00**	**-$47.70**	-$1.05	-$2.10	-$3.15	-$4.20	-$5.25	-$5.25	-$5.25	-$5.25	-$5.25	-$5.25	-$5.25
Nutrient management	Dairy	**$0.00**	**$0.00**	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	Dairy support	**$0.00**	**$0.00**	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	Sheep and beef	**$0.00**	**$0.00**	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	Restriction on development	**$0.00**	**$0.00**	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	Restriction on intensification	**$0.00**	**$0.00**	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Total		**$11.70**	**$58.40**	**$21.90**	**$20.85**	**$19.80**	**$18.75**	**$17.70**	**$17.70**	**-$5.25**	**-$5.25**	**-$5.25**	**-$5.25**	**-$5.25**
Option 3 - 30kgN/ha cap														
Riparian planting		**$54.40**	**$41.90**	$9.07	$9.07	$9.07	$9.07	$9.07	$9.07	$0.00	$0.00	$0.00	$0.00	$0.00
Dairy effluent	Capital	**$83.30**	**$64.20**	$13.88	$13.88	$13.88	$13.88	$13.88	$13.88	$0.00	$0.00	$0.00	$0.00	$0.00
	Dairy effluent benefits	**-$126.00**	**-$47.70**	-$1.05	-$2.10	-$3.15	-$4.20	-$5.25	-$5.25	-$5.25	-$5.25	-$5.25	-$5.25	-$5.25
Nutrient management	Dairy	**$1,352.00**	**$562.10**	$52.00	$52.00	$52.00	$52.00	$52.00	$52.00	$52.00	$52.00	$52.00	$52.00	$52.00
	Dairy support	**$39.90**	**$16.60**	$1.54	$1.54	$1.54	$1.54	$1.54	$1.54	$1.54	$1.54	$1.54	$1.54	$1.54
	Restriction on development	**$24.90**	**$7.20**	$0.07	$0.14	$0.21	$0.28	$0.35	$0.43	$0.50	$0.57	$0.64	$0.71	$0.78
	Restriction on intensification	**$1,027.30**	**$352.10**	$4.78	$9.56	$14.34	$19.11	$23.89	$28.67	$33.45	$38.23	$43.01	$47.78	$47.78

			Year	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
	Administration	**$31.60**	**$14.60**	$3.89	$1.11	$1.11	$1.11	$1.11	$1.11	$1.11	$1.11	$1.11	$1.11	$1.11
Total		**$2,487.40**	**$1,011.00**	**$84.17**	**$85.19**	**$88.99**	**$92.79**	**$96.59**	**$101.44**	**$83.34**	**$88.19**	**$93.04**	**$97.89**	**$97.96**
Option 3 - 48kgN/ha cap														
Riparian planting		**$54.40**	**$41.90**	$9.07	$9.07	$9.07	$9.07	$9.07	$9.07	$0.00	$0.00	$0.00	$0.00	$0.00
Dairy effluent	Capital	**$83.30**	**$64.20**	$13.88	$13.88	$13.88	$13.88	$13.88	$13.88	$0.00	$0.00	$0.00	$0.00	$0.00
	Dairy effluent benefits	**-$126.00**	**-$47.70**	-$1.05	-$2.10	-$3.15	-$4.20	-$5.25	-$5.25	-$5.25	-$5.25	-$5.25	-$5.25	-$5.25
Nutrient management	Dairy - mitigation	**$409.00**	**$170.10**	$15.73	$15.73	$15.73	$15.73	$15.73	$15.73	$15.73	$15.73	$15.73	$15.73	$15.73
	Dairy support - mitigation	**$10.20**	**$4.30**	$0.39	$0.39	$0.39	$0.39	$0.39	$0.39	$0.39	$0.39	$0.39	$0.39	$0.39
	Restriction on development	**$0.00**	**$0.00**	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	Restriction on intensification	**$281.50**	**$96.50**	$1.31	$2.62	$3.93	$5.24	$6.55	$7.85	$9.16	$10.47	$11.78	$13.09	$13.09
	Administration	**$28.20**	**$13.20**	$3.89	$0.97	$0.97	$0.97	$0.97	$0.97	$0.97	$0.97	$0.97	$0.97	$0.97
Total		**$740.60**	**$342.50**	**$43.22**	**$40.56**	**$40.82**	**$41.08**	**$41.34**	**$42.65**	**$21.01**	**$22.32**	**$23.63**	**$24.94**	**$24.94**