“Achieving Outcomes by Building Capability”

Nutrient Performance and Financial Analysis of Horticultural Systems in the Waimea Catchment

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Please Read

1 Executive Summary

This report was commissioned by Horticulture NZ (HortNZ) because it was felt that there is a need to further develop our knowledge of the Nutrient Performance and the financial impact of adopting mitigation techniques in order to minimise the impact of leaching of nutrients for Horticultural growers operating within the Waimea Catchment in the Nelson District.

The objective of the study was to collect primary physical, financial and environmental data from growers in the Waimea Catchment and to provide representative models of Horticultural systems and to analyse the impact of mitigation practices on the environmental and economic performance of the farms.

HortNZ is working to extend knowledge on good management practice to growers, to develop a better understanding of the practical tools for nutrient management, and the cost of choices that growers have around mitigation practices. The work will also inform a broader New Zealand wide HortNZ Nutrient Management Programme which aims to identify and codify good management practices for nutrient management.

Methodology

The methodology used in gathering the base data for this work was based on the provision of survey information gained from interviewing 12 growers of horticultural crops within the Waimea Catchment. These growers ranged across the land uses of vegetable growing, Pipfruit, Kiwifruit and Vineyard production. Base models of the horticultural systems and mitigation options to be modelled were created from information gained from the surveys. Gross Margins were created from a range of sources including data gained from the survey and from MPI Horticultural Monitoring surveys.

Rotations Modelled

Four representative rotations were modelled;

- **Rotation 1 – Vegetable Cropping**
  Horticultural cropping is the primary purpose of this land use with no break to allow for grazing. The rotation is relatively simple with only four crops grown but is quite intensive in that the area is almost constantly under a cropping regime with very little break from cropping.

- **Rotation 2 – Pipfruit**
  The Pipfruit model was based on the MPI Pipfruit Model.

- **Rotation 3 – Kiwifruit**
  The Kiwifruit model was based on the MPI Kiwifruit Model.

- **Rotation 4 – Vineyard**
  The Vineyard model was based on the MPI Vineyard Model.

Mitigation Techniques Modelled.

Five mitigation techniques were originally identified as worthy of modelling.

- **Mitigation 1 – Limiting N application**.

This mitigation technique limited any one application of N to 80 kg N / ha per month.

- **Mitigation 2 – Altering the amount of N and the yield.**

This mitigation option altered the amount of N applied to the crop in 10% deductions from 0 to a 30% reduction in the amount of N applied. The amounts of yield reductions modelled were created by reference to some research reports and grower experience.

- **Mitigation 3 – Method Only Irrigation**

This mitigation option was initially chosen to test the impact of altering the irrigation practices. It involves setting the option in OVERSEER from defining the actual amount of irrigation water applied to choosing the option of "method only" for the application of irrigation water. In this way the model chooses to apply only the amount of water which is required by the crop.

Summary of Findings

Table 1: Whole Orchard N leaching results (kg N / ha / annum)

	Status Quo	M 1	M2 10%	M2 20%	M2 30%	M 3
Vegetables	24	24	22	21	19	23
Pipfruit	24	24	23	23	22	17
Kiwifruit	37	37	35	34	32	35
Vineyard	6	6	6	5	5	5

Summary of the N leaching results:

- Mitigation 1 has no effect on the total amount of N leaching.
- The result of reducing the amount of N applied in phases of 10% has a significant effect on the amount of N leaching in the Vegetable and Kiwifruit models which are relatively high users if Nitrogen fertilisers but little or no impact on Pipfruit and Vineyard models which are relatively low users of Nitrogen fertilisers.
- Mitigation 3 has a significant impact on the Pipfruit model but little impact on the other three.

Financial Impacts

Table 2: Whole Farm Financial results (Average Gross Margin return $ / ha)

	Status Quo	M 1	M2 10%	M2 20%	M2 30%	M 3
Vegetables	4,478	4,478	2,261	464	- 1,510	4,478
Pipfruit	14,196	14,196	11,604	7,669	2,393	14,196
Kiwifruit	17,989	17,989	14,214	8,514	- 3,270	17,989
Vineyard	7,867	7,867	7,123	6,380	5,636	7,867

Summary of Financial Results

- Mitigation 1 has no effect on the Gross Margin return for any of the rotations modelled.

- Mitigation 2 has a differing result for each of the land uses modelled. However it should be noted that for the majority of land uses the losses in Gross margin are quite severe.;
    - For vegetable production the losses in Gross Margin result start at 50% for the 10% reduction in N application and go through to 134% at the 30% reduction.
    - For pipfruit production the losses in Gross Margin result start at 18% for the 10% reduction in N application and go through to 83% at the 30% reduction.
    - For kiwifuit production the losses in Gross Margin are the most severe starting at 21% for the 10% reduction in N application and go through to 118% at the 30% reduction.
    - For vineyard production the losses in Gross Margin are less severe but are still significant starting at 9% for the 10% reduction in N application and go through to 28% at the 30% reduction.
- Mitigation 3 has no impact on the Gross Margin results.

2 Background

This report was commissioned by Horticulture NZ (HortNZ) because it was felt that there is a need to further develop our knowledge of the Nutrient Performance and the financial impact of adopting mitigation techniques in order to minimise the impact of leaching of nutrients for Horticultural growers operating within the Waimea Catchment in the Nelson District.

2.1 Purpose

The objective of the study was to collect primary physical, financial and environmental data from growers in the Waimea Catchment and to provide representative models of Horticultural systems and to analyse the impact of mitigation practices on the environmental and economic performance of the farms.

HortNZ is working to extend knowledge on good management practice to growers, to develop a better understanding of the practical tools for nutrient management, and the cost of choices that growers have around mitigation practices. The work will also inform a broader New Zealand wide HortNZ Nutrient Management Programme which aims to identify and codify good management practices for nutrient management.

2.2 Methodology

2.2.1 Survey

The methodology used in gathering the base data for this work was based on the provision of survey information gained from interviewing 12 growers of horticultural crops within the Waimea Catchment. These growers ranged across the land uses of vegetable growing, Pipfruit, Kiwifruit and Vineyard production.

The survey was designed to collect both physical inputs required to carry out the required modelling and physical outputs in terms of the yields achieved in growing the individual crops and also included a range of questions about growing practice parameters which were of interest to HortNZ.

A letter was sent out to a representative sample of growers informing them of the purpose of the survey information and informing them that they would be contacted to take part. The growers were then contacted by AgFirst consultants who conducted the surveys face to face with the growers.

Base models of the vegetable grower systems and mitigation options to be modelled were created from information gained from the surveys. Gross Margins were created from a range of sources including data gained from the survey participants, by reference to MPI's old Pipfruit and Kiwifruit Orchard monitoring models and by reference to the latest MPI Vineyard monitoring model and two similar surveys carried out in the Pukekohe and the Horizons Regions.

2.2.2 OVERSEER Modelling

The modelling of the nutrient performance of the four farm systems was carried out using the OVERSEER 6.1.3 model. The use of OVERSEER as a means of accurately depicting the performance of Horticultural systems has some challenges that are noted in Appendix 1.

As highlighted by the FAR (2013) review, the accuracy of the OVERSEER 6.1 model has not been tested against actual N leaching results for Horticultural properties. So the results presented here should be regarded as appropriate for use at this point of time but could change as further research information becomes available and is able to better inform the model.

An alternative model (APSIM) is available and it may be able to better model the performance of N leaching and P output in Horticulture. APSIM is primarily a research tool that is under commercial licence to Plant and Food in New Zealand, as opposed to the Overseer model which is freely available to the public.

2.2.3 Financial Models

The financial models were created based on the standard methodology for Gross Margin analysis. Gross revenue is created with the total yield for the crop multiplied by the price received. From this the Total Variable Revenue is deducted which is all of the expenditure items which are used to grow the crop but excluding items which are related to land ownership. The resultant figure (Revenue minus Expenditure) is the Gross Margin return from growing that crop.

The Vegetable Gross Margins used in this study are based on the data gained from the survey participants plus by reference to the two previous survey’s information. Gross Margins used in the Pipfruit, Kiwifruit and Vineyard sectors were created from information gained from the survey participants and by reference to the MPI Orchard Monitoring information.

To create the vegetable model, which included all of the crops grown in the farm system which was then multiplied by the percentage area of each crop to give the average annual Gross Margin return for that vegetable system. These models are included in Appendix 3.

2.3 Background on N leaching in Horticulture

It is recognised that there are a number of issues related to horticulture production which result in high N leaching and relative inefficiency of N use compared to other pastoral land uses. However, many horticulture growers have continued to refine their use of N inputs, which has resulted in reduced use of N and therefore the total amount of N leaching over time.

Vegetable Crops

The following quote on the nature and impact of horticultural land use on the rate of N leaching is taken from a report prepared for Environment Bay of Plenty[1] and explains the relative inefficiency of the use of N in horticultural systems. It is concluded that the major source of N leaching is derived from fertiliser and crop residue and that fertiliser N management strategies are key when devising mitigation strategies. The analysis of mitigation techniques in this report concentrates on the two strategies of timing and volume of N application.

The main factors responsible for nitrate leaching in these systems are: high N use (fertiliser and manure), frequent cultivation, relatively short periods of plant growth, low nutrient use efficiency by many vegetable crops, and crop residues remaining after harvest (Di and Cameron, 2002a).

[1] Meneer J C, Ledgard S F, Gillingham A G: Land use impacts on nitrogen and phosphorous loss and management options for intervention.

Compared to other agricultural systems, market gardens are the most intensively fertilised and cultivated production systems - hence their propensity to leach N. N application rates used in vegetable crops can be as high as 600 kg N ha-1 yr-1 (Wood, 1997). Large application rates are used to ensure maximum growth because vegetable crops have sparse root systems that are inefficient at recovering applied fertiliser. Also, vegetables typically have short growing periods and are also grown over winter when plant growth and N uptake is slow (Haynes and Francis, 1996; Haynes, 1997). Therefore, the recovery of applied N by vegetable crops is often less than 50%, and can be as low as 20% (Di and Cameron, 2002a). Consequently, a large quantity of fertiliser N remains in the soil surface layers and is susceptible to leaching during rainfall or irrigation. Additionally, following crop harvest large amounts of plant residues are usually incorporated into the soil which, following decomposition, release mineral N into soil. The amount of mineral N derived from fertiliser and crop residue that is present in the soil after harvest can be as high as 200-300 kg N ha-1, and is the major source of leached N, indicating that fertiliser N management strategies are the key to nitrate leaching intervention in these systems.

The issues which cause N leaching in vegetable growing operations therefore are:

- High use of applied N as a result of sparse root systems for the crops (particularly when they are immature).
- Poor N use efficiency.
- Short growth periods and therefore (in some cases) multiple crops in one year.
- Grown over winter when leaching rates are high due to high rainfall and saturated soils.
- Large amounts of crop residue left in the paddock after harvest which is worked into the soil.

Pipfruit Systems

Pipfruit systems are relatively high users of Nitrogen (175 kg N / ha) in the growing years of the crop (years 1 to 3) when its use is to try and accelerate the growth of the crop in terms of achieving the maximum amount of growth on which to set the fruit. Once the crop reaches its mature size then very little Nitrogen fertiliser (40 kg N / yr) is used on the crop. It is not used to accelerate growth in the growing season and therefore to increase yields. The amount of N used is driven by the results of leaf analysis and is used to influence the amount of fruit set in the following season. This is a very difficult thing to get correct. If the leaf analysis of the crop is too low in terms of Nitrogen then there is the danger of forcing the crop into a biennial swing through poor bud development or not having enough leaf quantity and quality to size the crop therefore producing small fruit, if the amount of N is too high then there is the danger of causing excessive growth in the tree and producing fruit of poor colour and quality.

The amount of N used in mature crops is relatively small but has a significant impact on the next years yield.

Kiwifruit Systems

Kiwifruit has a relatively high requirement for Nitrogen fertiliser on an annual basis. The average use of Nitrogen fertiliser (120 kg N / ha) is primarily during the growth phase of the vines in the early part of the season (spring). This is in order to maximise the growth of the plant and therefore to maximise the amount of fruit grown.

Vineyard System

The vineyard uses a relatively small amount of Nitrogen fertiliser during the growing of the young vines (65 kg N / ha) in order to accelerate the growth of the plant but then once the vine is mature it uses very little Nitrogen fertiliser(14 kg N / ha). The major aim of management is to limit the total amount of growth from the plant. Therefore a small amount is used at the beginning of the growing season in order to get the growth of the plant started.

3 Nutrient Performance

3.1 OVERSEER Modelling

3.1.1 Defining the core models.

The definitions and scopes of the four core models were developed as a result of the results from the survey. Each model was set up with the parameters (as expressed in Appendix 4) set to be standard with all of the key parameters like Soil Type and the climatic variables being a reflection of those experienced in the growing area.

Rotation 1 – Vegetable Cropping

Horticultural cropping is the primary purpose of this land use with no break to allow for grazing. The rotation is relatively simple with only four crops grown but is quite intensive in that the area is almost constantly under a cropping regime with very little break from cropping. The rotation used is as follows:

Onions > Cabbage > Lettuce > Squash

The individual crop parameters such as planting date, fertiliser type and rate, fertiliser timing, harvest date and yield were all set as shown in appendix four.

Rotation 2 – Pipfruit

The pipfruit model is relatively large being 40 ha. Three stages of developing trees take up 6 ha in total (2 ha each) with the remainder (34 ha) being in mature orchard. The mature orchard produces 75 tonnes / ha.

Rotation 3 – Kiwifruit

The total area of the kiwifruit orchard is 15 ha with the mature plants taking up 12 ha and three years of developing vines each occupying 1 ha each. The mature vines produce 8,000 trays / ha (28.8 t / ha).

Rotation 4 – Vineyard

The total area of the vineyard model is 50 ha with 8 ha taken up as immature vines (year 1 to 4) and the remainder as mature vines. The yield is 11 tonnes / ha.

3.1.2 Choice of Area Cropped

The choice of the area that is cropped has a significant influence on the amount of N leaching which OVERSEER calculates over the total area of the farm. For each crop choice there are three choices of what can be made with the land In OVERSEER. The “cultivated area” is the area of land on which the calculation of the impact of the farming activity is calculated. “Headlands and Tracks” are areas that are cultivated but there is no crop grown on them and “Other areas” are defined as areas where the land is not cultivated.

The issue with horticultural land use is that there are often significant areas within a paddock where the crop is not grown. This is mainly taken up with the beds that are formed to grow the crops in which have a significant area taken up with the areas where tractors, sprayers and harvesters run over the paddock. The headlands and track area are also quite significant areas because of the need to turn quite large machinery. The adoption of technology to spread fertiliser which utilises banding and side application also means that a significant portion of the area also doesn't have fertiliser applied to it.

Therefore in this modelling exercise we have adopted a policy that for all cropping land uses there is 80% of the total area taken up with the cultivated area, 10% is taken up by headlands and tracks and 10% is taken up by other areas.

This is why we see that for the vegetable rotation the results expressed for the whole farm N leaching figure is less than any of the individual cropping figures.

3.1.3 The Impact of Soil type

The soils on the Waimea Plains can be classified into either shallow, light soils (Ranzau, Maori) or deep heavy soils (Waimea, Richmond). These two classifications of the soils differ greatly in terms of their soil moisture holding capacity. The light soils are able to hold 40 mm of soil moisture per 500mm of soil depth while the heavy soils are able to hold 120mm of soil moisture per 500mm of soil depth. The two soil types have vastly different depths of the soils where the light soils are relatively shallow whereas the heavy soils have a much greater depth of soil. Therefore the two different soil types have much different water holding capacity with the heavy soils being able to provide for much more water because of their higher soil moisture holding capacity and their much greater depth while the lighter soils have a much lower moisture holding capacity and a much lower depth of soil that the plants can access it from.

Observation of the soil maps of the area indicate that the soil types are evenly split between the soils that are classified as light and the soils that are classified as heavy.

To show the impact of the soil types on the Overseer results Table 3 displays the four rotations modelled in both of the dominant soil types in the region.

Table 3: Overseer results on each of the dominant soil types.

	Ranzau	Waimea
Pipfruit	24	19
Vineyard	6	6
Kiwifruit	44	37
Vegetables	24	23

As can be seen from Table 3 the results on the Ranzau soils are higher than the results on the Waimea soils. The differences are greater for the two deeper rooting varieties (Pipfruit and Kiwifruit) and are the same for the other deep rooting plant (Vineyard) which is relatively low anyway. There is very little difference for the shallower rooted vegetable rotation.

3.1.4 Mitigation Techniques Modelled

Background research suggests that the mitigation options available to horticultural growers are based around improving nutrient use efficiency. These include:

- Nutrient management planning,
- Proper fertiliser material selection,
- Better application timing and placement,
- Improved irrigation scheduling.

The use of slow release fertilisers and the use of DDE's which act as a retardant to N leaching are both potential mitigation techniques that should be considered. The issue with slow release fertilisers is that there are certain times when vegetable crops have very high demand on N and therefore slow release fertilisers would not be able to adequately meet the crops requirement. Also, it is not possible to model the types of slow release fertilisers that are available at present in OVERSEER.

Our analysis of the current mitigation practices of growers in the Waimea Catchment was that they are carrying out nutrient management planning, fertiliser material selection and better timing and placement of N application. However, they are limited by the type of system which they could use in terms of improved irrigation scheduling.

Having modelled the Status Quo option which modelled what they were doing now, it became obvious that the major impacts on N Leaching was related to the amount and timing of application of N. Therefore, the following mitigation techniques were trialled:

Mitigation 1 – Limiting N application.

This mitigation technique limited any one application of N to 80 kg N / ha per month. This mainly entailed the splitting of the first application of N by either moving some of it forward into the pre planting cultivation phase and incorporating it into the soil or by evening out the amount of N in subsequent fertiliser applications up to the maximum of 80 kg N / ha. No impact on yield was modelled from this mitigation technique it was assumed that the evening out of the N applications did not have a negative impact on the yield of the crop. This was partly driven by the relatively regular N applications that are made in horticultural crops and the fact that in OVERSEER the smallest window of applications are on a monthly basis. Current best practice is for the application of N to be more regular than once per month, particularly in the early growing stages when the plants are relatively small and growing rapidly and have a high requirement for N.

There is also the requirement to get the application of N on relatively early in the growth phase of many of the crops because experience shows that later application of N can lead to reduced yield and a deterioration of quality of many of the crops as a result of being pushed along later in their maturity.

In the survey carried out no growers indicated that they were applying more than the rate of 80 Kg / N / ha. One of the vegetable applications came relatively close at 72 kg N / ha. Therefore in testing the mitigations this option returned the same figures as the status quo option.

Mitigation 2 – Altering the amount of N and the yield.

This mitigation option altered the amount of N applied to the crop in 10% deductions from 0 to a 30% reduction in the amount of N applied. The amounts of yield reductions modelled were created by reference to some research reports[2] on the impact of N on yield and informed by

[2] Pearson, Renquist, Reid (1999): MAF vegetable fertiliser trails – A re appraisal using a new model.
Wood (1998): Effect on crop yields from reduced N inputs to selected winter vegetable crops.
Wood (1997): Reduced N inputs to winter vegetable crops – Pukekohe district 1997.
Thomas, Obreza, Sartain : Improving N and P fertiliser use efficiency for Floridas horticultural crops.
MAF (1979): Celery production in Hutt Horowhenua.
Sher (1997): Nutrient uptake of vegetable crops. Summary of results 1993 – 1996.

the experienced opinion of some of the growers in the previous areas in which this exercise was carried out. The assumptions for Pipfruit, Kiwifruit and Vineyards were developed in consultation with the growers who took part in the survey. It should be pointed out that these assumptions are made up or growers estimates of the sorts of reductions that they would expect it is not science based because research to determine the level of reductions in yields which would occur as a result of reductions in N applied have not been carried out.

The assumptions as to average yield reduction by individual crop are attached in Appendix 1.

Many of the research reports referenced refer to trials which occurred from the mid 1960's to the late 1980's. In that time period the amount of N used was much higher than what is used now. Although very little research has been carried out recently into N use on horticultural crops, many of the growers have continued to develop their knowledge on the timing and volume of N application to be able to maximise crop growth and to try and improve N use efficiency and at the same time reduce costs. This has resulted in much lower rates of N usage than those quoted in the old research reports.

Mitigation 4 – Method Only Irrigation

This mitigation option was initially chosen to test the impact of altering the irrigation practices. It involves setting the option in OVERSEER from defining the actual amount of irrigation water applied to choosing the option of "method only" for the application of irrigation water. In this way the model chooses to apply only the amount of water which is required by the crop and therefore limits the amount of excessive water running out the bottom of the soil profile or runoff from the top of the soil profile.

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3.2 Results

The results of the OVERSEER modelling are displayed with the results for each of the crops that were modelled going down the rows and then the whole farm total last (highlighted). Across the columns the results are shown for the status quo option first and then for each of the mitigation options.

3.2.1 Vegetable Cropping

Table 4: N leaching results for Vegetable Cropping (kg N / ha / annum)

	Status Quo	M 1	M2 10%	M2 20%	M2 30%	M 3
Onion	28	28	26	23	21	26
Cabbage	28	28	25	24	22	25
Lettuce	35	35	32	29	26	35
Pumpkin	17	17	17	16	17	16
Whole Farm	24	24	22	21	19	23

Interpretation of the results of the vegetable rotation N leaching indicate that;

- The whole farm result of the status quo at 24 kg N /ha is a relatively low result which is a reflection of the relatively low amounts of N fertiliser applied as well as the total area in crop.
- Mitigation 1 has no effect on the total amount of N leaching.
- Mitigation 2 has a significant impact starting at a reduction of N leaching of 8% at the 10% reduction through to a 23% reduction at the 30 % reduction.
- Mitigation 3 has a minor impact.

3.2.2 Pipfruit

Table 5: N leaching results for Pipfruit (kg N / ha / annum)

	Status Quo	M 1	M2 10%	M2 20%	M2 30%	M 3
Whole Orchard	24	24	23	23	22	17

Interpretation of the results of the Pipfruit rotation N leaching indicate that;

- The whole farm result of the status quo at 24 kg N /ha is a relatively low result which is a reflection of the relatively low amounts of N fertiliser applied.
- Mitigation 1 has no effect on the total amount of N leaching.
- Mitigation 2 has a minor impact on the whole farm situation at each of the graduations.
- Mitigation 3 has a more significant impact on the total amount of N leaching.

3.2.3 Kiwifruit

Table 6: N leaching results for Kiwifruit (kg N / ha / annum)

	Status Quo	M 1	M2 10%	M2 20%	M2 30%	M 3
Whole Orchard	37	37	35	34	32	35

Interpretation of the results of the Kiwifruit rotation N leaching indicate that;

- The whole farm result of the status quo at 37 kg N /ha is a higher result which is a reflection of the higher amounts of N fertiliser applied.
- Mitigation 1 has no effect on the total amount of N leaching.
- Mitigation 2 has a significant impact starting at a reduction of N leaching of 5% at the 10% reduction through to a 14% reduction at the 30 % reduction.
- Mitigation 3 has a minor impact.

3.2.4 Vineyard

Table 7: N leaching results for Vineyard (kg N / ha / annum)

	Status Quo	M 1	M2 10%	M2 20%	M2 30%	M 3
Whole Vineyard	6	6	6	5	5	5

Interpretation of the results of the Vineyard rotation N leaching indicate that;

- The whole farm result of the status quo at 6 kg N /ha is a realy low result which is a reflection of the very low amounts of N fertiliser applied.
- Mitigation 1 has no effect on the total amount of N leaching.

- Mitigation 2 has virtually no impact on the whole farm situation at each of the graduations.
- Mitigation 3 has no impact.

4 Financial Analysis

4.1 Gross Margin Analysis

The Gross Margins created resulted in the financial outcomes as shown in Table 8. There is no doubt that there will be considerable variation around the results shown in Table 8 and what individual crops and growers achieve but these numbers are considered to express an average result. The full Gross Margins are displayed in Appendix 3.

Table 8: Gross Margins ($ / ha)

	Total Revenue	Total Variable Expenses	Gross Margin
Onion	22,500	18,450	4,050
Cabbage	21,000	17,160	3,840
Lettuce	31,500	25,164	6,337
Pumpkin	12,500	9,962	2,538
Pipfuit	50,525	36,329	14,196
Kiwifruit	41,600	23,611	17,989
Vineyard	16,500	8,633	7,867

The financial adjustments made to the mitigation results are:

Mitigation 1
For each additional application of N an amount of $50 / ha was added to the fertiliser costs. The $50 / ha was the amount shown for each fertiliser application in the Lincoln Budget Manual[3].

Mitigation 2
The yield of the crop grown was adjusted by the percentages shown in appendix one. This then flowed through to a reduction in expenditure for those expenditure items which are influenced by the yield of the crop and a reduction of the Nitrogen fertiliser saved.

Mitigation 3
No adjustment was made to the financial outcome as a result of more accurate irrigation practice.

4.1.1 Results

4.1.2 Gross Margin Results

Table 9: Financial results of mitigation strategies on vegetable production. ($ / ha / annum)

	Status Quo	M 1	M 2 10%	M 2 20%	M 3 30%	M 3
Gross Revenue	23,275	23,275	19,975	17,301	14,348	23,275
Variable Expenses	18,797	18,797	17,714	16,837	15,858	18,797
Gross Margin	4,478	4,478	2,261	464	-1,510	4,478

[3] Lincoln University: Financial Budget Manual

Table 10: Financial results of mitigation strategies on Pipfruit production. ($ / ha / annum)

	Status Quo	M 1	M 2 10%	M 2 20%	M 3 30%	M 3
Gross Revenue	50,525	50,525	45,473	37,894	27,789	50,525
Variable Expenses	36,329	36,329	33,869	30,225	25,396	36,329
Gross Margin	14,196	14,196	11,604	7,669	2,393	14,196

Table 11: Financial results of mitigation strategies on Kiwifruit production. ($ / ha / annum)

	Status Quo	M 1	M 2 10%	M 2 20%	M 3 30%	M 3
Gross Revenue	41,600	41,600	37,440	31,200	18,720	41,600
Variable Expenses	23,611	23,611	23,226	22,686	21,990	23,611
Gross Margin	17,989	17,989	14,214	8,514	- 3,270	17,989

Table 12: Financial results of mitigation strategies on Vineyard production. ($ / ha / annum)

	Status Quo	M 1	M 2 10%	M 2 20%	M 3 30%	M 3
Gross Revenue	16,500	16,500	15,675	14,850	14,025	16,500
Variable Expenses	8,633	8,633	8,552	8,470	8,389	8,633
Gross Margin	7,867	7,867	7,123	6,380	5,636	7,867

Mitigation 1 has no effect on the Gross Margin return for any of the rotations modelled.

Mitigation 2 has a differing result for each of the land uses modelled. However it should be noted that for the majority of land uses the losses in Gross margin are quite severe.;

- For vegetable production the losses in Gross Margin result start at 50% for the 10% reduction in N application and go through to 134% at the 30% reduction.
- For pipfruit production the losses in Gross Margin result start at 18% for the 10% reduction in N application and go through to 83% at the 30% reduction.
- For kiwifuit production the losses in Gross Margin are the most severe starting at 21% for the 10% reduction in N application and go through to 118% at the 30% reduction.
- For vineyard production the losses in Gross Margin are less severe but are still significant starting at 9% for the 10% reduction in N application and go through to 28% at the 30% reduction.
- Mitigation 3 has no effect on the Gross Margin return for any of the rotations modelled.

Appendix One: Average Estimated Reduction in yield with reduction in applied N.

Reduction in N	Onions,	Pumpkin, Lettuce	Cabbage	Pipfruit	Kiwifruit	Vineyard
10%	10%	15%	15%	10%	10%	10%
20%	20%	25%	30%	25%	25%	20%
30%	30%	40%	40%	45%	55%	30%

Appendix Two : Challenges related to modelling horticultural crops in OVERSEER 6.1

The Foundation for Arable Research[4] carried out an independent review of the use of OVERSEER in the arable sector, which incorporated consideration of the horticultural sector. It came up with the following conclusion:

OVERSEER® is the best tool currently available for estimating N leaching losses from the root zone across the diversity and complexity of farming systems in New Zealand. This review sets out a pathway for improving its fitness for this purpose in the arable sector (see recommendations). It also highlights that the new challenges facing OVERSEER® place demands on the development team and model owners that need to be acknowledged and resourced appropriately.

The review came up with the following recommendations which are relevant to the horticultural sector:

OVERSEER® crop model estimates of N leaching should be evaluated against measurements of N leaching to identify whether there are any systematic errors in predictions.

OVERSEER® crop model estimates of N leaching should be evaluated against predictions of longterm leaching produced by established, detailed research models e.g. APSIM.

The testing outlined in recommendations (1) and (2) is likely to identify and justify areas for further development of OVERSEER® to improve N leaching predictions.

The following list of challenges identified in this modelling exercise is not new as they have been identified in previous modelling of horticultural crops. The challenges are listed here to allow consideration of the impact of these issues on the modeller's ability to correctly model the practices undertaken by the growers. In some cases these practices are undertaken to improve the efficiency of use of N and P, the impact of which are not shown in these results.

Crops that can be modelled.

OVERSEER has a reasonable range of crops that can be modelled, however this is limited from a horticultural perspective. This has meant that the rotations used in Rotation 2 and the Traditional Market Garden were somewhat compromised by the range of crops chosen. This has meant that the rotation does not represent what would actually be grown. However, we have chosen a similar crop both in terms of inputs and outputs so the end result may not be much different. However it may not appear to be logical from a growing perspective.

Monthly time steps.

OVERSEER works on monthly time steps of data entry for items such as cultivation, fertiliser applications and irrigation inputs. Horticultural operations work on much finer time steps which are unable to be incorporated into OVERSEER. Therefore the results would appear to be much more at a gross level than you would expect for horticulture.

Incorporating side dressings.

[4] FAR (2013) : A peer review of OVERSEER in relation to modelling nutrient flows in arable crops.

It is not possible to incorporate the application of fertiliser as a side dressing in OVERSEER. This is a horticultural practice which directly applies the fertiliser into the root zone of the plant, which are predominantly grown in rows. Therefore this practice results in more efficient plant uptake and reduces the total gross amount of fertiliser applied.

Limited range of irrigation options.

The choice of irrigation options is limited to those that are available for pastoral farming. This means that options that are available to horticulturalists such as soak mats etc. cannot be modelled. This can be overcome by selecting the actively managed option which means that the correct amount of irrigation required can be applied. However, this still would apply much more than would be applied if the alternative options were available which just apply water to the root zone of the crop.

Currently work being undertaken which will investigate and compare the way that irrigation is modelled in OVERSEER by including a daily time series for irrigation practice which will more accurately reflect the water balance of the soil.

Fertiliser options limited.

One of the mitigation options which we wished to test in this exercise is the use of slow release fertilisers. The range of fertiliser options available is limited to the standard range from each of the two major companies. Therefore it was not possible to test the impact of the application of slow release fertilisers. However, slow release fertilisers may not be able to adequately meet the crops requirement as there are certain times when vegetable crops have very high demand on N.

Appendix Three: Gross Margins

Vegetable

	Onion			Cabbage			Lettuce			Squash
Income			**Income**			**Income**			**Income**	
Yield	45		Yield	30000		Yield	45000		Yield	25
Price	500		Price	0.7		Price	0.7		Price	500
Total Reve	**22,500**		**Total Reve**	**21,000**		**Total Reve**	**31,500**		**Total Reve**	**12,500**
Expenses			**Expenses**			**Expenses**			**Expenses**	
Seed	675		Seed	2,750		Seed	2,820		Seed	700
Cultivatio	1,550		Cultivatio	1,800		Cultivatio	2,200		Cultivatio	1,190
Fertiliser	1,750		Fertiliser	1,000		Fertiliser	750		Fertiliser	880
Agri Chem	2,150		Agri Chem	750		Agri Chem	1,015		Agri Chem	760
Irrigation	500		Irrigation	250		Irrigation	250		Irrigation	350
Harvestin	1,800		Harvestin	3,500		Harvestin	4,850		Harvestin	1,375
Land lease	2,000		Land lease	660		Land lease	2,000		Land lease	2,000
Grading	3,375		Grading		0.0233	Grading	1,049	24	Grading	600
Packing	3,375		Packing		0.054	Packing	2,430	30	Packing	750
Freight	1,125	0.084	Freight	2,520	0.05	Freight	2,250	54	Freight	1,350
Commision		0.126	Commisio	3,780	0.12	Commisio	5,400		Commision	
Levys.	150		Levys.	150		Levys.	150		Levys.	7
Total Expe	**18,450**		**Total Expe**	**17,160**		**Total Expe**	**25,164**		**Total Expe**	**9,962**
Gross Mar	**4,050**		**Gross Mar**	**3,840**		**Gross Mar**	**6,337**		**Gross Mar**	**2,538**

Pipfruit

	Pipfruit		
	Income		
	21.5	2350	50,525
		Total	**50,525**
	Variable Costs		
	Seed		
	Cultivation		1,350
	Fertiliser		352
	Agri Chem		2,893
	Irrigation		200
2.679	Harvesting		6,296
	Land Lease		-
	Labour		7,500
7.4	Packing		17,390
	Freight		348
	Commision		
	Levy		
	Total Costs		**36,329**
	Gross Margin		**14,196**

Kiwifruit

	Kiwifuit		
	Income		
	8000	5.2	41,600
		Total	**41,600**
	Variable Costs		
	Seed		
	Cultivation		1,700
	Fertiliser		1,323
	Agri Chem		4,600
	Irrigation		200
0.386	Harvesting		3,088
	Land Lease		
	Labur		12,100
	Packing		
	Freight		600
	Commision		
	Levy		
	Total Costs		**23,611**
	Gross Margin		**17,989**

Vineyard

	Vineyard		
	Income		
	11	1500	16,500
		Total	**16,500**
	Variable Costs		
	Seed		200
	Cultivation		823
	Fertiliser		400
	Agri Chem		850
	Irrigation		300
72.72	Harvesting		800
	Land Lease		
	Labour		4,950
	Packing		
	Freight		30
	Commision		
	Levy		280
	Total Costs		**8,633**
	Gross Margin		**7,867**

Appendix Four: Core assumptions made in modelling in OVERSEER.

The standard location parameters for the Waimea Plains were selected and all models were modelled on the appropriate soil types which were taken from SMap descriptions.

Rotation choice details are as follows.

Vegetable Rotation

Crop	Planted	Harvested	Yield	Fertiliser	Timing	Irrigation
Onion	April	Dec	45	500kg Pot Gold Super	April	Nov 50
				300kg CAN	June	Dec 80
				300 kg Nitrophoska Blue 12-2-14	July	Jan 80
				300Kg Nitro Blue	Sept.	
Cabbage	Jan	March	70	1000 kgs/mix 5.5-5.5-14.6	Jan broadcast	Jan 80
				187 kg Nitro blue	Feb side banded	Feb 80
				187 nitro blue	March side banded	Mar 80
Lettuce	May	Jul - Aug	25	1000 kg mix	May	Aug 40
				280 kg Nitro Blue	Jun	Sept 40
				280 kg Nitro Blue	Jul	
Pumpkin	Oct	March	25	500 kg Smix	Oct	Dec 80
				187 kg Nitro Blue	Nov	Jan 80
						Feb 80