BEFORE THE HEARING COMMISSIONERS

IN THE MATTER	of the Resource Management Act 1991 ("**the Act**")
AND	
IN THE MATTER	of the Resource Management Act 1991 and the Environment Canterbury (Temporary Commissioners and Improved Water Management) Act 2010
AND	
IN THE MATTER	of the hearing of submissions on Variation 2 of the Proposed Land and Water Regional Plan

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STATEMENT OF EVIDENCE BY STUART JOHN FORD FOR HORTICULTURE NEW ZEALAND

15 MAY 2015

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QUALIFICATIONS AND EXPERIENCE

1. My full name is Stuart John Ford. I am a Director of The AgriBusiness Group and work as an agricultural and resource economist based in Christchurch. I have a Diploma in Agriculture and Bachelor of Agricultural Commerce from Lincoln University and have undertaken post graduate studies in Agricultural and Resource Economics at Massey University.

2. I am a member of the New Zealand Agriculture and Resource Economics Society and the Australian Agriculture and Resource Economics Society. I am also a member of the New Zealand Institute of Primary Industry Management.

3. I have spent over thirty years as a consultant in the primary industries, with the last fifteen years specialising in agricultural and resource economics and business analysis

4. I have undertaken a wide range of economic impact and cost benefit assessments of proposed statutory planning proposals.

5. As part of my work I have been extensively involved in the calculation of nutrient discharges through the use of OVERSEER® and the economic assessment of mitigation strategies that farmers can use to reduce their discharges and runoff. Some relevant pieces of work include "The Impact of Water Related Management Changes" which was written for the (then) Ministry of Agriculture and Forestry and "Selwyn Te Waihora Nutrient Performance and Financial Analysis" which was prepared for ECan and Irrigation NZ.

6. T*hree* particular pieces of work which I have carried out for the Horticultural sector are "Nutrient Performance and Financial Analysis of Lower Waikato Horticulture Growers" which was prepared for the Ministry of Primary Industries and Horticulture New Zealand and "Nutrient Performance and Financial Analysis of Horticultural Systems in the Horizons Region" *and* "Nutrient Performance and Financial Analysis of Horticultural Systems in the *Waimea Plains*" which was prepared for Horticulture New Zealand.

7. In *each* case I developed example grower rotations across a range of growers which were then modelled in OVERSEER® and then a range of mitigation techniques were modelled

across the representative models. At the same time budgets were created for each model and the impact of the mitigations was tested to determine the financial impact of each mitigation.

8. I have prepared evidence and presented it to Regional Council Hearings Panels as well as the District and Environment Courts and Special Hearing Panels on Conservation Orders.

9. I have been asked by Horticulture New Zealand to provide this evidence.

10. I have been provided with a copy of the Code of Conduct for Expert Witnesses and I have read and agree to comply with that Code. This evidence is within my area of expertise, except where I state that I am relying upon the specified evidence of another person. I have not omitted to consider material facts known to me that might alter or detract from the opinions that I express.

CONTEXT AND SCOPE OF MY EVIDENCE

11. My evidence is given in support of the submission by the Horticulture New Zealand in relation *to* Variation 2 (*Hinds Plain*) to the Proposed Land and Water Regional Plan ("**Variation 2**"). In particular I will be providing evidence regarding the work I have done that provides an overall analysis of the cost of Variation 2 to the horticultural sector in the region.

12. In the evidence that follows I consider the following matters:

    (a) The nature of horticultural land in the region;

    (b) My analysis of the economic impact on the horticultural sector of Variation 1;

    (c) My conclusions and recommendations.

13. By way of a high level overall summary it is my evidence that there is a much higher adverse economic effect on the horticulture sector than is currently demonstrated by the evidence from the Council

THE NATURE OF HORTICULTURAL LAND IN THE REGION

14. My evidence relates to vegetable growers noting that there are a number of fruit growers in the zone and Ms Halliday refers to them in her evidence.

15. Vegetable growers range from intensive permanent crops and market garden operations which have a combination of a wide number of crops which include leafy greens, brassicas, root crops and cucurbits through to the more traditional arable farmer who includes a relatively small area of process crop or root vegetables in their rotation.

16. *T*hese growers operate on a range of soils which range from relatively deep soils through to medium depth soils which has a major impact on limiting the amount of N leaching which occurs in their operations.

MY ANALYSIS OF THE ECONOMIC IMPACT ON THE HORTICULTURE SECTOR OF VARIATION 2

OVERSEER Issues

17. The Foundation for Arable Research carried out an independent review[1] 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.*

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

    (a) OVERSEER® crop model estimates of N leaching should be evaluated against measurements of N

[1] Foundation for Arable Research(2013) Review of the use of OVERSEER in the arable sector

leaching to identify whether there are any systematic errors in predictions.

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

(c) 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.

19. OVERSEER® is not what I would call being in a "steady state" as yet. I believe that it is a work in progress rather than an accurate modelling tool at present. I expect that as it improves by the rectifying of its current modelling errors and includes more sophisticated ways of more accurately calculating the N leaching performance of the various land uses we will gain much greater confidence in the results which it generates. Nevertheless it is the only freely available modelling tool available to us at present and therefore it is the best available tool.

20. Horticulture New Zealand is part of a team that is currently funding a research programme that is designed to determine which of two options to model N leaching results is the best for horticultural operators. They are comparing the operation and results of OVERSEER® and an Australian modelling tool which has had the necessary changes made to make it relevant for New Zealand soils and climatic conditions called APSIM.

21. Limitations to the use in OVERSEER® for horticultural operations were identified in my work on modelling grower rotations in the Lower Waikato region and included:

(a) The crops that can be modelled

(b) Working in monthly time steps

(c) Incorporating side dressings

(d) Limited range of fertiliser options.

22. In order to get a degree of commonality in the way that OVERSEER® is used the owners put out a protocol "The OVERSEER Best Practice Data Input Standards (August 2013)"

which lists the recommended best practice options for entering data into OVERSEER®. However it should be noted that many of these options have a number of choices of methods which are listed from first choice to last choice and give the operator a choice of which option that they choose.

23. In my experience most statutory requirements for rule setting used in other Regions which are connected to an OVERSEER® result specify which version of OVERSEER® that they are referring to. Presumably as the version of OVERSEER® is updated the resultant figures are updated to reflect the newer more accurate result.

24. At present we know that there are quite major changes in the results that come out of the various versions of OVERSEER®. This is as a result of corrections of known bugs in the programme and the inclusion of more accurate data and means of calculating the impacts of various options. Some of the changes in results can be quite extreme between different versions of OVERSEER®.

Issues with determining the 'Nutrient Baseline"

25. In the Land and Water Regional Plan it is stated that the "nutrient baseline" figure for existing farms should be averaged over the four years from 2009 to 2013.

26. As we have reported already this creates problems with the version of OVERSEER® that the historic data was calculated in. At the very least this would mean that each of the budgets need to be updated to reflect what the latest version of OVERSEER® results shows. We would also recommend that the budget was brought up to the standard of the Best Practice Data Input standards.

27. Our experience in carrying out 40 of these "nutrient baseline" exercise for Central Plains Water was that it was practically difficult to collect enough accurate information to do four years worth of budgets.

28. This is particularly difficult for vegetable growers and arable farmers as their annual rotations vary significantly between years so it will be very difficult for them to do either a full four years accurate calculation or provide for an average year in calculating their nitrogen baseline.

The results of OVERSEER modelling on Horticultural properties

29. Plant and Food Research has carried out OVERSEER® modelling for Horticulture New Zealand on eight properties in Canterbury which represent the range of vegetable growers from intensive market gardeners on deep soils to traditional arable farmers who incorporate some vegetable crops into their rotation on the medium depth soils across the plains.

30. The results from the actual data gathered by Plant and Food are shown in Table 1.

Table 1: N leaching values taken from Plant and Food results. (kg N / ha)

	Vegetables Lincoln	Arable Lincoln	Arable Darfield
Medium Depth		22	26
Deep Soils	13	13	
Poorly Drained Soils	4		

31. What these results show is that for the majority of horticultural operations their N leaching figures are below the 15 kg N / ha / year .

32. As I noted in my evidence for the report[2] on the Selwyn Te Waihora catchment "is the very low, levels of N leaching from arable farm systems. This is due to the heavy soils that they are predominantly carried out on, the continuous nature of the cropping rotation, the adoption of minimum tillage techniques, the application of N and irrigation during the growing season (spring) of the crop, the application of N and irrigation at rates that meet the growing demands of the crop, the use of cover crops during the winter and the relative lack of animals on the property".

The potential loss of land use flexibility

33. As it stands at present the calculated nutrient base line cannot be exceeded and if the rules related to Good Management Practice the allowable N leaching figures will remain with the property.

[2] The AgriBusiness Group (2013): Selwyn Te Waihora Nutrient Performance and Financial Analysis.

34. In the case of Arable and Vegetable growers the nutrient baselines are relatively much lower than those calculated for other land uses such as Dairy farming and Dairy Support operations. The class of land which most of these operations are carried out on is highly flexible and is suitable, subsequent to some modification, to convert to those other land uses.

35. As the relative profitability of the various land uses changes in the future there will be real economic pressure for the land use to change. As the rules stand at present it will not be possible to make the changes because the property has too low a nutrient baseline to be able to make the change to a higher N leaching land use.

36. This will create financial hardship for the individual who will be stuck with the land with the highest adaptive ability but the lowest baseline figure. Therefore there will be little if any demand to purchase the land by higher returning and higher leaching land uses. Therefore the value of the land will drop according to the returns that can be made by the land uses which are possible within the relatively low baseline figures.

37. There will also be a negative impact on the total economic output possible from within the catchment because the land uses will be forced to remain at the lower economic land use because they have a low (but highly efficient) N leaching allowance.

38. As this situation has not occurred in New Zealand it is not possible for me to quantify the financial impacts on individuals or the economy as a whole.

39. I believe that there are two possible solutions. The first is the adoption of a trading mechanism for N leaching, which I cover later in my evidence. The second is the retention of some of the allowable N leaching within the catchment to be allocated as required. Both of these options are highly dependent on the rules under which they operate which would have to be designed with extreme caution.

Commentary on the reliability of irrigation water

40. As I understand it the reliability of irrigation water is worked out off Schedule 10 Reasonable use test in the LWRP. It is 9 years out of 10. The rules for water takes require an

assessment based on Schedule 10 – taking the 9/10 into account. I do not believe that this level of reliability is satisfactory for Horticultural production.

41. The irrigated crops that I refer to in my evidence include the full range of vegetable crops which are grown in the catchment. In the rotation there are different times for planting and harvest. Irrigation demand depends on the time of planting and the time that a crop is in the ground. Crops have different water demands at different times of the year with the highest occurring in the summer months of December through to March. However water demand can occur outside this time period.

42. These crops require irrigation of some sort during the periods when they are grown that coincide with the periods when evapotranspiration exceed the available soil moisture. The irrigation is for two purposes. The first is to maintain the yield of the crop and the second is to maintain the quality parameters of the crop. Both elements are equally important in terms of the effect that they have on the economics of growing the crop. Without the yield component they are uneconomic to grow and without achieving the quality parameters they are uneconomic to grow. The availability of highly reliable Irrigation water is essential to the continued viability of growing these crops in the Canterbury Region.

43. For example in the case of growing onions there is the important element of the grading criteria for the size of the onions. There could be up to double the value depending on the size grades that onions fit into. The objective is to get as many as possible into the desired range. This is set up by drilling but is maintained by irrigation. If irrigation is missed during a crucial growth period the crop will fail to meet the size requirement.

44. For potatoes quality parameters are first influenced by the size of tubers that are grown but then quality is also influenced by the shape and the look of potatoes for the fresh market. For process potatoes there is a range of other attributes that are tested for to ensure that the processed product achieves the desired standards which are essential to meet the requirements of the processed product. All of these characteristics have a large influence on the price paid for the crop.

45. Unfortunately the cost of growing them is virtually the same if they meet the quality standards or not. Therefore any downgrading of quantity of yield and / or the quality of the crop can put the grower into the situation of making a loss on the growing of the crop.

46. The economics of growing carrots depends on achieving relatively high yields while also meeting tight specifications as to carrot size. Missing one or two irrigations could mean that the specifications for the crop fall outside those required. At this point there is virtually no alternative use other than stock feed for the crop.

47. Greens are also subject to very tight specifications. Both retailers and consumers require a certain quality product as to size, taste and the look of the product. Failure to achieve these specifications means that the product is rejected from sale and there are very few alternative outlets for the crop. Certainly there are none that offer sufficient returns that would mean that the grower was able to make a profit on the inferior crop.

48. All of these crops have a dependence on irrigation for both yield and to meet stringent quality specifications. The amount of irrigation may not be large but it is absolutely vital to the continued growing of them as it is the difference between a profit and a loss. Therefore consideration of the need for reliability of access to irrigation water needs to be given to these horticultural crops.

49. There are three major types of efficiency of water use . The first is **Technical Efficiency** which determines the rate at which resources, capital, labour are converted into goods. More goods produced for a given set of resources equates to higher technical efficiency. The next is **Allocative Efficiency** in which resources are optimally allocated to the production of different sets of goods in such a way that the welfare of society is maximised. The third is **Dynamic Efficiency** which allows use patterns to evolve over time.

50. Because of the nature of the crop rotations and the need to move areas cropped and irrigators from location to location they sometimes will not be as technically efficient as we would expect from say a centre pivot irrigator. Nevertheless many of the irrigation applications on horticultural crops are of a lower volume, and are generally applied more regularly

than that for pastoral agriculture and therefore achieve a higher technical efficiency than most pastoral farming irrigation practices.

51. Horticulture is also very efficient when it comes to allocative efficiency. This relates to the value generated from the use of the water resource. This is generally measured as dollars generated per cubic meter of water used ($ / m3). The combination of high Gross returns and the relatively low total amount of irrigation water used mean that Horticulture achieves measures three to eight times that of alternative uses of the water.

52. I would also point out that pastoral agriculture is not solely dependent on irrigation and has alternative means of providing for the feed to produce the gains made from irrigation. These range from purchasing or making hay and silage to introducing a range of alternative purchased feed sources such as molasses, grain meal, maize silage, palm kernel etc.

53. In terms of establishing priority to horticultural use I believe that there is good justification for horticultural use to be granted priority status at times of water shortages or low flows over all other users. The times when water is essential to crops coincide with times when water shortages occur. If water was shut off to those crops the growers could suffer a complete loss of revenue or at the least their revenue would be lower than their costs of production.

54. At present, as proposed, horticultural irrigators would need to cease irrigating along with pastoral irrigators once trigger levels are reached. As already explained the pastoral irrigators have alternative means to provide for the feed that they would lose. This would mean that the only people who would suffer financially would be the horticulturalists. Considering the high returns to horticulture per unit of water consumed this would cause considerable losses. I therefore believe that the horticulturalists should receive priority in terms of access to irrigation water over the pastoral uses. This would require pastoral users to lose access to water before horticulturists in times of water restrictions.

55. In my view the current proposed rule structure disadvantages horticultural land use as it treats Horticultural irrigation rights the same as irrigation rights from all other land

uses when it is obvious that their reliance on irrigation is much higher than other uses and their return to irrigation is much greater. I believe that there is no justification for this treatment of horticulture and believe that there is a strong imperative to have horticulture elevated to a position of priority.

The value of Transfers

56. I am a very keen advocate of the opportunity to instigate emissions trading into the catchment. In 2006 I wrote a paper "Options for efficiency gains through trading within a community irrigation scheme" for The Ritso Society which was a group of dryland farmers within the catchment of the Central Plains Water scheme. In that paper I examined the possibility of both water and emissions trading.

57. In that report I concluded that:

> *Market based instruments (MBI) are seen as a tool to achieve sustainable resource use goals through the use of market signals rather than through explicit directives (command and control regulatory mechanisms). The international experience is that MBI are a next step tool when Best Management Practices are unable or inadequate to achieve the desired efficiency outcomes from resource use. Basically they work on the concept that they are able to efficiently encourage behaviour towards total efficiency goals through operation of a market. Markets work best when access to the resource is constrained or emissions are capped or restricted therefore there is a degree of scarcity of the resource. They also work best where there are significant differences in the individual's opportunity costs of resource use or emission reduction (significantly different values).*

58. I believe that we are now in the situation where the three major considerations have been met; BMP is inadequate; the market is constrained; and there are significantly different opportunity costs between users.

59. Therefore, if a market can be set up which enables low emission operations to trade or transfer their unused credits to high emissions operations. In that way total emissions are capped but no one is necessarily restricted from carrying out high value land use options because of relatively high associated emissions levels.

60. One of the key outcomes of setting up the ability to trade is to incorporate resource use values and resource use efficiency thinking into the individual business decision making process at the individual enterprise level as well as at the total resource use level.

61. The advantages of market based instruments are seen as:

(a) They have the potential to reduce the overall cost of achieving a certain level of environmental outcomes because they drive resource use to the most efficient outcome economically by allowing individuals flexibility to strive for efficiency.

(b) They stimulate the rapid development of innovation in resource use technologies or management practices that reduce use below regulatory standards. This advantage is driven by the response of resource users to understanding the value of the resource that they are using and therefore having an economic imperative to maximise the return from the resource. In command and control systems the achievement of the regulatory standard is seen as a satisfactory end point and when it is reached there is no incentive provided to continue development of innovation or achieving further levels of resource use efficiency.

(c) Some of the market based instruments are able to raise revenues which can then be used to achieve environmental outcomes through investment in mechanisms outside the market.

62. Therefore from a practical perspective there are a number of trading scheme design issues to be considered. Experience shows that markets work best where:

(a) Scarcity of the resource to be used or limits to emissions.

(b) There is adequate knowledge within the market participants about issues relevant to the market, scientific cause and effect and the range of individual values around the resource use.

(c) There is a wide variety or range of opportunity costs related to resource use with clear economic benefits from movement or transfer within the market.

(d) The rules of trading are simple and transactions are easy to implement.

(e) There are a number of potential market participants. There is much discussion from overseas experience about "thin markets" and lack of trades or transfers in markets as a result of there being a small pool of potential players in the market.

(f) There is opportunity to increase total economic activity through trading as a result of purchasers being able to achieve a higher level of output or profit as a result of the trade than the seller.

63. I believe that there is considerable opportunity to gain further economic activity out of allowing the trading of emissions rights within the catchment. However considerable effort will need to go into the important issue of design of the market and how it would operate.

64. Two of the most important aspects of market design that we can learn from overseas experience are that the market should have simple rules and low transaction costs and that there would need to be education and training programs amongst the potential participants to allow free trading to occur.

Allocation of Rights to Emit

65. I *am* a very strong advocate of an allocation system which recognises the inherent nature of the land resource to emit Nitrogen. This has been described in other exercises as the "natural capital" approach. My advocacy of this approach was primarily because of the huge range of N leaching values across the catchment which are governed by the soil type and climatic location.

66. It is the decision of the Council to go for a grand parenting approach to the allocation of nutrients. This in effect allocates nutrients to a land use according to what is happening on that piece of land at present. In situations like the one that we are in whereby the total amount of emissions are capped and are inadequate for the total

catchment grand parenting is seen as a satisfactory means to allocate emissions at the time it is brought in but it does not allow for the inevitable changes in land use which will be required in the future. In order to maximise the economic output from a Catchment and to ensure that there is equity in land use values some sort of transfer mechanism needs to be put in place at the same time. That has not occurred in this case.

67. As has been outlined in the evidence of Angela Halliday, Horticulture New Zealand has agreed an approach to Nutrient allocation which incorporates the importance of land use flexibility, the need to move nutrients to higher value land uses over time, the incorporation of the natural capital approach and the user / beneficiary pays approach.

68. What is proposed under Variation 2 at present contravenes all of these principles.

69. Therefore the commissioners need to make the choice of allocating the emissions in a different means at present or to continue with the current allocation as an interim position and to make sure that some sort of transition is in place that will ensure that access to emissions are available in the future through a workable transfer or trading mechanism.

70. It would be possible to allow the current grand parenting approach to continue but at the same time require that the allocation system was able to transition over time to one in which the natural capital characteristics of the catchment determine the distribution of N emissions coupled by a means to transfer the emissions as require between the land uses.

71. In this way the catchment will be able to continue to adapt in its land use and fulfil its economic potential over time.

CONCLUSIONS AND RECOMMENDATIONS

72. The use of OVERSEE® as the reporting tool at present requires a degree of caution because of concerns about the accuracy of results produced for horticultural operations.

73. The degree of changes in results from OVERSEER® that occur as a result of version changes to OVERSEER® mean that some sort of version control needs to be created.

74. The current proposed rule structure disadvantages horticultural land use as it treats horticultural irrigation rights the same as irrigation rights from all other land uses when it is obvious that their reliance on irrigation is much higher than other uses and their return to irrigation is much greater. I believe that there is no justification for this treatment of horticulture and believe that there is a strong imperative to have horticulture elevated to a position of priority.

75. I believe that there is considerable opportunity to gain further economic activity out of allowing the trading of emissions rights within the catchment. However considerable effort will need to go into the important issue of design of the market and how it would operate.

76. It would be possible to allow the current grand parenting approach to continue but at the same time require that the allocation system was able to transition over time to one in which the natural capital characteristics of the catchment determine the distribution of N emissions coupled by a means to transfer the emissions as require between the land uses.

Stuart John Ford

15 May 2015

Appendix One: Challenges related to modelling Horticultural crops in OVERSEER 6.1

The Foundation for Arable Research[3] 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

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

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.

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.

Inclusion of total area under crop.

It was not possible to select an option which would allow a lower proportion of the total area available being cropped at any one time as a result of an error in the programme. Once this error is fixed it will then be possible to represent the area cropped as a percentage of the total area available.

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.