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 Plan Change 5 (Nutrient Management and Waitaki)

STATEMENT OF EVIDENCE BY STUART JOHN FORD
FOR HORTICULTURE NEW ZEALAND

22 JULY 2016

ATKINS | HOLM | MAJUREY

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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 over the last ten years 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:

   (a) "The Impact of Water Related Management Changes" which was written for the (then) Ministry of Agriculture and Forestry; and

   (b) "Selwyn Te Waihora Nutrient Performance and Financial Analysis" which was prepared for Environment Canterbury ("**ECan**") and Irrigation NZ.

6. I have calculated the total load allowable under the Rangitata Diversion Race Management Limited's ("**RDRML**") short term consent.

7. I am a member of the OVERSEER Users Advisory Group. This is a group of experienced and regular users of OVERSEER® which gives feedback to the owners of the program on improvements that can be made to the program and the priority of spending required to achieve those improvements.

8. Some particular pieces of work which I have carried out for the Horticultural sector are:

   (a) "Nutrient Performance and Financial Analysis of Lower Waikato Horticulture Growers", which was prepared for the Ministry of Primary Industries and Horticulture New Zealand;

   (b) "Nutrient Performance and Financial Analysis of Horticultural Systems in the Horizons Region", which was prepared for Horticulture New Zealand;

   (c) "Nutrient Performance and Financial Analysis of Horticultural Systems on the Waimea Plains of Tasman District", which was prepared for Horticulture NZ and the Tasman District Council; and

   (d) "Hawkes Bay Horticultural Nutrient and Financial Benchmarking", which was prepared for Horticulture NZ, and which entailed taking the survey results from interviews of 28 Vegetable and Orchard properties and turning them into nutrient budgets utilising OVERSEER® and financial outcomes.

9. In each of the above cases I developed example grower rotations across a range of growers which were then modelled in OVERSEER®, following which 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. I have prepared and presented evidence on the Land and Water Regional Plan for Central Plains Water and Horticulture NZ on Variation 1. I have also prepared and presented evidence on the Land and Water Regional Plan for RDRML and Horticulture NZ on Variation 2, and for Horticulture NZ on Variation 3.

10. I have prepared evidence and presented it to Regional Council Hearings Panels, District and Environment Courts, and Special Hearing Panels on Conservation Orders.

11. I have been asked by Horticulture New Zealand ("**Horticulture NZ**") to provide this evidence.

12. In preparing my evidence I have reviewed:

(a) Plan Change 5 to the Canterbury Land and Water Regional Plan ("**CLWRP**").

(b) Section 32 Evaluation Report for Plan Change 5 (Nutrient Management and Waitaki Sub-region) to the CLWRP.

(c) Submission on proposed Plan Change 5 to the CLWRP by Horticulture NZ.

(d) CLWRP Plan Change 5 Section 42A Report. Report No. R16/23.

(e) Arable and horticultural crop modelling for the Matrix of Good Management - a technical summary. Hume E, Brown H, Sinton S, Meenken E. December 2015.

(f) The Farm Portal – System Description and Requirements Document Environment Canterbury Sam Ragnarsson / Wayne Stiven. 26 January 2016.

(g) Matrix of Good Management project: Overview report.

(h) Addendum to MGM Overview report: OVERSEER® version change 6.2 to 6.

13. I have been provided with a copy of the Code of Conduct for Expert Witnesses contained in the Environment Court's Practice Note 2014. 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

14. My evidence is given in support of the submission by the Horticulture NZ in relation to Variation 5 to the Proposed Land and Water Regional Plan ("**Variation 5**"). In particular I will be giving evidence regarding the work I have done that provides an overall analysis of the implications of Variation 5 to the horticultural sector in the region.

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

(a) The issues surrounding the task of providing an accurate estimation of the leaching of Horticultural properties using OVERSEER®;

(b) The potential for inaccuracies in the estimation of the MGM adjusted figures using the Farm Portal;

(c) Horticulture NZ's proposed response to these issues; and

(d) My summary and recommendations.

16. By way of a high level overall summary, it is my evidence that it is practically very difficult to get any degree of accuracy at all into estimates of the degree of N leaching from a horticultural property using OVERSEER®. This exercise is very expensive for an individual to carry out for very little gain. I believe that the alternative method of registering the required information into the Farm Portal is both a satisfactory and cost effective method of achieving the Council's objectives until a more cost effective and accurate means of modelling the N leaching performance of a Horticultural property becomes available.

THE ISSUES WITH THE ACCURACY OF MODELLING RESULTS USING OVERSEER®

17. The core of my evidence here is a repetition of my evidence given to the commissioners that heard the previous variations to the Land and Water Regional Plan hearings. However in this case I have prepared evidence which incorporates a much more in-depth analysis of the capability of OVERSEER® to accurately model producers from the horticultural sector. This is included here because I believe that in this Plan Change, where the consenting status of a property is determined by its OVERSEER® result, there is an additional requirement to analyse the accuracy of that result.

18. Horticulture NZ is fully in support of the appropriate use of OVERSEER® to model the leaching of properties in New Zealand. To that end they are a member of the OVERSEER® Technical Advisory Group and have employed myself and other consultants in their desire to be fully cognisant with the issues around the potential for N leaching from their constituent growers' properties. They have also fully engaged with Regional Councils throughout New Zealand in

an attempt to represent their growers in coming up with appropriate responses to the issue of N leaching.

19. Horticulture NZ's desire is to have the capability to accurately predict the N leaching performance of a horticultural property in a cost effective manner.

20. OVERSEER® is not what I would call being in a "steady state" as yet. I believe that currently it is a work in progress rather than an accurate modelling tool. I expect that as it improves through the rectification of its current modelling errors and inclusion of more sophisticated ways of increased accuracy in 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, and therefore currently the best, available tool to estimate the N leaching performance of our properties.

Technical Issues with Modelling Horticultural Properties in OVERSEER®

21. The Foundation for Arable Research 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."*

22. 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 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) (3) 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.

23. We note that these recommendations have been the subject of new projects facilitated and led by Horticulture NZ and the Foundation of Arable Research through the "Rootzone Reality" Programme establishing a national network of lysimeters. Of direct relevance is the extension of this project in partnership with Auckland Council and Waikato Regional Council. The extension has led to a series of additional trial sites where groups of fluxmeters have been installed under cropping land in Pukekohe, Pukekawa and Matamata to directly measure nitrogen discharges below the rootzone. The work was commenced in 2014 with the installation of fluxmeters at trial sites. It will take at least 3-4 years to establish measurements that are useful. It will take additional time for the OVERSEER® owners to incorporate the new information into modelling predictions.

24. Horticulture NZ, Foundation for Arable Research and the Fertiliser Association of New Zealand has a contract with Plant and Food Research to test OVERSEER® results in comparison with APSIM. The project has been implemented (initiated in early 2015) and is projected to deliver in October 2016. It will take additional time for the OVERSEER® owners to incorporate any new information that results from this work into modelling predictions.

25. The testing outlined in recommendations 22 (1) and (2) above is likely to identify and justify areas for further development of OVERSEER® to improve N leaching predictions.

26. As far as we are aware none of the three recommendations made in that report have been completed. This is at least partially due to the development of OVERSEER® being limited by the expenditure of available capital, and partially due to the low priority put on the development of vegetable production capability by the OVERSEER® owners.

27. Therefore we still do not know whether there is any justification for the crop model estimates being used by

OVERSEER® and we have not had them verified by comparison to other means of modelling (APSIM).

28. Apart from the basic uncertainty around the accuracy of the crop model estimates used in OVERSEER® there are also concerns about inaccuracy in the results of modelling in the horticultural sector in regards to:

(a) The gross nature of the inputs used in entering data into OVERSEER® (monthly data is the finest input timeframe) which are unable to accurately reflect the complexities of relatively fine scale vegetable production systems;

(b) The fact that OVERSEER® is not currently capable of modelling all possible crop types. In a recent paper written for ECan (Hume)[1], Plant and Food identified in an exercise in crop modelling in Canterbury that approximately half of the crops sown were not named as options in OVERSEER®; and

(c) The fact the OVERSEER® is a long term averaging tool which has a fixed, and somewhat limited, array of long term climatic data which it uses to spread the climatic data entered over. This represents an average of thirty years data.

29. In their report to ECan titled "Arable and horticultural crop modelling for the Matrix of Good Management - a technical summary" ("**The Hume Report**") Plant and Food identified that:

> *"There were challenges when translating grower survey information into the OVERSEER® model. These were mainly due to the inability to fully represent the complexities of cropping farms with the inputs available in OVERSEER®. A key step in the modelling process was the full documentation of the grower information alongside how this was represented in OVERSEER® and the assumptions that had to be made to do this (see Appendix 10 of Overview Report (Robson et al. 2015) for structure followed)...*

[1] Hume et al 2015. MGM Technical Report Arable and Horticultural crop modelling. Report written by Plant and Food for ECan.

The following (1–21) (inserted as Appendix 1 in this evidence) are some examples of complexities that were encountered during the modelling in OVERSEER® and assumptions that were made. For each circumstance, the limitation is documented and the approach taken to address the limitation is detailed. This information was shared with OVERSEER® management to support future model improvements."

30. I would point out to you that the following list which was taken from the Hume report is a list of the key factors which lead to inaccuracies in the ability to model horticultural properties:

- Substitute crops
- Double sowing of crops
- Altering crop growth
- Monthly inputs
- Sequential planting and harvesting
- Multiple vegetable harvests
- Nutrients
- Variable and small crop areas
- Variable rate management.

31. In the Hume Report, Plant and Food further identified that:

"While the principles for resolving the limitations of OVERSEER® modelling of crop blocks apply to both the horticultural and arable industries, the majority of them were issues more specific to the horticultural survey farms. Growers, particularly those in horticulture, have very dynamic, responsive management and rotation structures depending upon multiple factors (e.g. market and industry demand and prices, environmental conditions, crop establishment and health throughout growing season, disease and weeds, seasonal yields, and stock availability). The assumptions above allowed the consistent summarisation of 'typical' current practices in Canterbury within the constraints of the OVERSEER® model. Councils using OVERSEER® for regulatory purposes should consider the listed issues and, along with industry bodies (e.g.HortNZ and FAR), inform growers with guidelines and

expectations for the modelling of their farms to ensure consistency of outputs across the industry.

The ability to model more diverse cropping rotations and range of management practices along with an easy-to-use interface requiring real farm management information will allow more cropping, and especially horticultural, growers to be able to represent their own systems in OVERSEER®".

32. What I believe that we can learn from this summary given by expert modellers is that:

    (a) There were considerable challenges in the ability to fully represent the complexities of horticultural farms with the available inputs into OVERSEER®.

    (b) More than 21 "work arounds" had to be developed in order to represent the farms as accurately as is possible.

    (c) The majority of these "work arounds" were more specific to horticultural properties with their dynamic management and rotation structures.

    (d) The provision of the ability to model more diverse system and management practices would allow horticultural growers to be able to represent their own systems.

33. What I take from this summary is that OVERSEER® is not yet a model which is fit for purpose to be able to accurately model horticultural properties.

34. In addition to the concerns detailed above about the ability to accurately model a vegetable operation in OVERSEER®, the above identified issues also create challenges to our ability to model the range of mitigations which are possible on vegetable properties. In many cases it is not possible to model the mitigation strategy which is available because it is not possible to incorporate it into the OVERSEER® modelling.

The reliability of current results from OVERSEER® modelling

35. OVERSEER® is still in the development stage when it comes to modelling arable and horticultural properties. OVERSEER® is up-dated every six months, with each new version offering improvements in the science which underpins the modelling;

better means of modelling farm management practices; and improvements to the accuracy of the modelling capability by fixing software errors that are present in the model.

36. In the Hume Report Plant and Food detail the changes which have occurred in the N leaching results for a range of both arable and horticultural properties as the version of OVERSEER® has changed (Hume Report Table 1 Page 17). I have put this into Table 1 and have calculated the amount of change that has occurred as each version changes compared against the first result as percentage changes.

Table 1: Summary values of annual average N loss to water (kg/ha) across both surveyed arable farms and full horticultural rotations for OVERSEER® versions 6.1.2, 6.1.3 and 6.2.

	V 6.1.2	V 6.1.3	% Change	V 6.2	% Change
Mean	16	14	-13%	24	50%
Median	16	13	-19%	21	31%
Minimum	3	2	-33%	2	-33%
Maximum	51	35	-31%	74	45%

37. As can be seen from Table 1 the changes which are occurring in the N leaching results from OVERSEER® are still quite extreme, with the changes resulting from the update to version 6.1.3 reducing the N leaching results by 13% for the mean result and 31% for the maximum result. Subsequently, for the version change to version 6.2 all N leaching results increased considerably with the mean result increasing by 50% and the maximum by 45%.

38. This level of variability in results between versions does not indicate to me that we are modelling the N leaching in the arable and horticultural sectors on a stable modelling platform as yet. It does not indicate that we should have any comfort that the results which we are getting are a true indication of the real losses which we are attempting to model. I presume that as the model improves we will be able to move closer to the results indicating the real losses. But at this stage, with the results changing so significantly between versions, I have no way of knowing how close we are to achieving that nirvana.

39. We are now operating in Version 6.2.1 of OVERSEER®. The changes which occurred between the versions was completely made up of fixes to software errors. There was no new science incorporated into the version change.

40. My experience with modelling horticultural properties in Hawkes Bay indicates the variation in leaching results. I had just completed modelling of 28 vegetable growers and orchard properties in Hawkes Bay (half and half) in Version 6.2 and so then was able to open them in 6.2.1. Exactly half of the properties which I had modelled (14) had their N leaching value change as a result of the version change alone.

41. This brings into doubt the current level of accuracy of the OVERSEER® model outputs, but also the uncertainty of such results. There is potential for individual properties results to alter considerably due to the fixing of an error in the model. Such a change may alter their status as to the requirements for them to gain consent for their activities, or their status compared to the GMP figure calculated in the portal.

42. The level of uncertainty of results shown here must cast doubt as to whether the OVERSEER® model is as yet fit for purpose in terms of modelling arable and horticultural properties.

Long term average vs annual predictions

43. One of the big issues yet to be resolved is whether it is appropriate to model a property as a long term average result or as an annual result. This is important because at present the operation of the Farm Portal encourages the latter approach, although I note that if a long term average result is modelled for a property it can be entered into each individual year.

44. In the document "OVERSEER® Best Practice Data Input Standards Ver 6.2.1" it states that:

> *"By default, OVERSEER® estimates an **annual average nutrient budget** (my emphasis) assuming inputs (management, climate etc.) are constant. OVERSEER® uses annual rainfall, PET and average annual temperature, with default PET and average annual temperatures based on the long-term*

climate data and long-term monthly climatic distribution patterns.

*When considering the use of OVERSEER® for forward predictions (e.g. consent applications, fertiliser maintenance requirements) it is recommended that the data that describes the **typical management system** (my emphasis) to be adopted is used with long-term average climate data (rainfall, temperature).*

*For monitoring purposes, it is recommended **annual management data is used with long-term rainfall until this issue is more fully resolved** (my emphasis) (refer to Appendix 9). If annual data inputs are used, it is also recommended that a **rolling average or trend analysis of outputs** (my emphasis) is used to reduce the impact of year-to-year variability when monitoring the degree of compliance with any target or critical value. In addition, the uncertainty of OVERSEER® predictions can be reduced if the focus is on a percentage change over time (rather than an absolute change).*"

45. What this basically means is that OVERSEER® is a tool which is used to calculate the annual average outputs of a farming system. Even if it is used for monitoring purposes (specific year results) the owners of OVERSEER® still recommend that the factors which have one of the biggest influences on the result (rainfall, temperature and evapotranspiration) should still be entered as the long term averages, and that the results of annual exercises should be treated as a rolling average rather than as a single years result.

46. In explaining the reasoning for this recommendation in Appendix 9 "Technical note: Using annual or average climate and production data" they state that:

"Work is required to understand the relationships between using OVERSEER® in predictive mode or annual mode. Thus, we are not sure that the resultant outputs of using long-term climate and annual production is the same as using long-term climate and long-term average production. Work is also required to understand the effects of real practice, whereby management is changed annually due to climate variation and economic conditions. In

addition, these relationships need to be understood when site-specific monthly climate, annual or average patterns are used, and when improved soil data is included.

A full recalibration of the model for the two modes of operation is required, and the relationships between annual and predictive modes of use determined before definitive recommendations are made. Based on the limited data available, when using the model in an annual mode (annual management and production data), we are currently recommending using long-term climate data and patterns. In addition, we recommend that the interpretation of the output should apply to multiple years, for example, using a rolling average, trend analysis, and not be based on a single years output."

47. What this basically says is that the owners of OVERSEER® simply do not know the accuracy of results achieved out of the predictive or annual mode when using the long term average climatic data. Based on (very) limited data they are currently recommending the use of the long term average climatic data. Until they are able to resolve this issue, they are recommending that interpretation of the data should be over multiple years preferably as a rolling average.

48. This recommendation indicates that there is very limited value in requiring growers to model individual year data to try and predict their N leaching performance. This is because the OVERSEER® model still uses the long term (30 year) climate data to average the spread of the climate between months. Therefore any changes which occur in any single year as a result of a variation in the climate are negated by the OVERSEER® model assuming that the climate performs at the long term average. This means that there is considerable potential for the results from OVERSEER® to either over or under represent the real losses according to how the model calculates the individual year performance against the long term average climate data.

49. It is my opinion that, in its current method of modelling, there is no reason to carry out any form of modelling of a property other than the long term average method if one is attempting to maximise the accuracy of their modelling.

Cost effectiveness of the use of OVERSEER®

50. The effectiveness (benefit) of modelling a horticultural property in OVERSEER® in terms of both the accuracy and the uncertainty of the result is severely compromised by:

    (a) The technical issues that create challenges to the way that properties can be accurately described in the OVERSEER® model.

    (b) The unknown reliability of the results which are currently modelled by OVERSEER® compared with the real losses.

    (c) The current requirement by ECan to model annual predictions which are compromised by the way that OVERSEER® models the climate data and the unknown reliability of the results.

51. The costs of compiling a nutrient budget using OVERSEER® are considerable for the land owner. OVERSEER® demands that a substantial amount of data on elements such as fertiliser use, timing of operations, irrigation use etc., has to be compiled for every paddock or block on a farm which is treated differently. For the average horticultural or arable property this would total approximately fifteen blocks. Compiling this information into a usable form for input into OVERSEER® is a considerable task.

52. Following the compilation of a nutrient budget, the modelling has to be carried out by a suitably capable person, which normally entails employment of a consultant. OVERSEER® is not user friendly for the input of data in a cropping or vegetable growing regime. Each block's crop management has to be inputted twice; once for the year being modelled, and once for the crop grown in the previous year. This is both laborious and time consuming. For example, to enter one application of fertiliser requires approximately nine key strokes or mouse clicks. This creates the high likelihood of error of data input, creating yet another potential cause of error in results which, in my experience, has a relatively high likelihood of occurrence.

53. In my experience it would cost approximately $5,000 to employ a consultant to carry out the four years of modelling required to estimate the Nitrogen baseline on a vegetable growing property. Couple this with the cost of the farmers

time to compile the data and meet with the consultant and explain how it should be used and we have a total cost which is somewhere around the $10,000 mark.

54. I believe that, given the level of accuracy that it is possible to get with modelling in OVERSEER® at present, this level of expenditure is not justified. Particularly if an alternative as suggested by Horticulture NZ is available.

55. I note that in the Section 42A report at Appendix E – Robson M. – Farm Portal and Schedule 28 the author acknowledges this point (response to the first question) where they say that: "*I think that they are asking whether it is possible to substitute actual or historic OVERSEER® files with the generic catchment basefiles for ease/time taken to produce the actual ones.*" I think that this recognises that there is considerable time taken in modelling in OVERSEER®. The author then goes on to answer the question by saying "*However, if these farms were deemed as lower risk, then it might be a pragmatic way to get loss estimates and give that industry more time to come up generate actual losses*."

56. This is exactly what Horticulture NZ proposes: a pragmatic way to meet the Council's need to calculate a Total Catchment Load, while at the same time avoiding putting their members to the considerable cost of providing individual OVERSEER® results which are of highly questionable accuracy.

THE POTENTIAL FOR INACCURACIES IN THE ESTIMATION OF THE MGM ADJUSTED FIGURES USING THE FARM PORTAL

57. I believe that the Farm Portal is set up in a very intuitive manner and applaud the way that it first takes you through a series of filters to determine whether you need to proceed any further through the portal. I also believe that it is relatively user friendly in the way that it deals with the input of farm data and the OVERSEER® files. I also applaud the manner in which the result for a property is reported from the portal. It is a far higher quality and informative report than reports currently obtainable from OVERSEER®.

58. As regards to the proxies used to calculate GMP in the portal, I believe that the Nutrient Management proxy used to calculate the amount of Nutrient required by each crop is properly calculated and is based on an accurate formula. I note in the Hume Report they discuss the fact that grower

practices in the arable and vegetable growing sectors are already very highly advanced, and say that: *"Many cropping farmers already meet the narrative GMP of matching nutrient availability to plant demand by using soil mineral N tests and predicted yields to determine N fertiliser requirements. Crop calculators have been developed by research organisations and industry to assist in this assessment of nutrient mass balance*."

59. I note the extensive discussion around choosing an appropriate proxy to model GMP for irrigation in the Hume Report. I also note that the definitions agreed by the industry for GMP in this area both revolve around the use of the word "minimise" in terms of the risk of leaching and the amount of water needed to meet production requirements.

60. I believe that the way that OVERSEER® currently models the application of irrigation water is above what I believe Good Management Practice set out to achieve.

61. For many arable and vegetable properties there is considerable difficulty in being able to meet each crop's water needs exactly because of factors such as the capacity of the system, the spatial nature of the various crops etc. I would also note that it is incredibly laborious to accurately depict the changing crop demand for water throughout the season in terms of the time taken to enter the irrigation practice into the crop management section of OVERSEER®. I believe that the efficiency factor which is adopted in OVERSEER® is not appropriate for use in the arable and vegetable growing sector.

62. Therefore I believe that what we have at present is a standard for irrigation water use which is at Best Practice, not Good Practice, in the arable and vegetable growing sectors.

63. I am aware that Irrigation NZ has submitted evidence to you and I commend their evidence to you.

64. I believe that, given the current inaccuracies in the OVERSEER® modelling on arable and vegetable properties and the highly technical nature of how the GMP's are calculated, there will be very little value in comparison between the actual results and the GMP results for these growers. There will be considerable uncertainty about the accuracy of both sets of figures, which will mean that the

growers will be no better informed about the relative performance of their own properties or the areas that they can improve their performance in.

HORTICULTURE NZ'S ALTERNATIVE METHOD

65. Horticulture NZ has proposed a solution which both meets their industry's concerns about the cost effectiveness of preparing individual nutrient budgets, and the Council's requirement that it is able to receive an entry through the Farm Portal which will be able to calculate their total catchment leaching figure and acknowledge that the grower has engaged with the system.

66. What Horticulture NZ proposes is that for the System 10 rotations identified in the Hume Report, which represents an intensive vegetable rotation, that they adopt the rotation created for the MGM process by Plant and Food as a proxy for their system. They are then able to overlay their own soil type and climate data into the proxy model and submit it into the farm portal.

67. This relieves the growers from the frustration and expense of getting their own OVERSEER® files created, but also meets the Councils requirements.

68. For this class of property OVERSEER® is not able, at present, to model their very intensive rotations including the sequential planting and harvesting regime which they undertake.

69. By Horticulture NZ's calculation this class of operation only consumes approximately 3000ha.

70. Systems 1 to 9 identified in the Hume Report which represent all of the other arable and vegetable combinations are modelled using a representative rotation for the system. The representative rotation would be again based on each of the rotations developed by Plant and Food to test the Farm Portal, but would be modified as seen fit to more closely represent the individual farmer's operation, including the soil type and climate conditions.

71. This approach makes it somewhat easier for the land owners to create a workable OVERSEER® file and meets the Council's requirements.

72. I would also like to point out the relatively high degree of efficiency in terms of nutrient use and irrigation water use in this sector, which is likely to mean that their actual nutrient leaching status will not be far away from their GMP calculation.

73. As long as we are all comfortable that the rotations that were created by Plant and Food are indeed representative of each class of rotation, and reflect an average situation, then in total their contribution to the total catchment calculation will be acceptable.

74. I believe that it is not possible to avoid the fact that the individual growers will not get a good indication of how their operation is performing compared to GMP. As I have already pointed out, due to reasons to do with the accuracy of modelling of their properties in OVERSEER®, this will be the case until OVERSEER® is improved so that it is able to accurately represent their operations or an alternative means of calculation of their N leaching is settled on.

75. At present Horticulture NZ is investigating both of these courses of action and are keen to resolve which the best alternative is as quickly as possible.

CONCLUSIONS AND RECOMMENDATIONS

76. OVERSEER® is not yet a model which is fit for purpose to be able to accurately model horticultural properties because of the challenges that it presents in not being able to accurately model their operations, and the ongoing uncertainty as to how the results obtained represent the real losses.

77. In its current method of modelling there is no reason to carry out any form of modelling of a property other than the long term average method if one is attempting to maximise the accuracy of their modelling.

78. Given the level of accuracy that it is possible to get with modelling in OVERSEER® at present the cost of achieving it is not justified, particularly if an alternative, as suggested by Horticulture NZ, is available.

79. I believe that given the current inaccuracies in the OVERSEER® modelling on arable and vegetable properties, and the highly technical nature of how the GMP's are

calculated, there will be very little value in comparison between the actual results and the GMP results for these growers.

80. I recommend to you the approach as proposed by Horticulture NZ which both meets their industries concerns about the cost effectiveness of preparing individual nutrient budgets and the Councils requirement that it is able to receive an entry through the Farm Portal. At the same time you should recognise that Horticulture NZ is actively working to resolve the issue of inaccurate calculation of the industries leaching performance.

Stuart John Ford
22 July 2016

Appendix 1: Complexities that were encountered during the modelling in OVERSEER® and assumptions that were made. (Taken from the Hume Report).

The following (1–21) are some examples of complexities that were encountered during the modelling in OVERSEER® and assumptions that were made. For each circumstance, the limitation is documented and the approach taken to address the limitation is detailed. This information was shared with OVERSEER® management to support future model improvements.

1. Substitute crops
Limitation: OVERSEER® is not currently capable of modelling all possible crop types grown in NZ. The crop types it does not specifically model are generally specialist vegetables or high value non-herbage seed crops. There is limited research knowledge around the growth and N status of these crops and the area grown in NZ cropping systems is comparatively small.

2. Double-sown crops
Limitation: Double-sowing of crops is a management practice that happens on-farm but cannot be modelled in OVERSEER®; more than one crop management option per month is not allowed therefore multiple crops cannot be grown concurrently.

3. Altering crop growth
Limitation: OVERSEER® assumes a default growth curve and harvest date for each crop which did not always match how growers managed their rotations. For example, this could be due to timing differences between varieties, or practices such as spraying off the tops of root vegetables and then storing in the ground for the following months.

4. Yield units
Limitation: OVERSEER® requires crop yields to be specified in tonnes per ha. However, some crops such as vegetables are counted by other units (e.g. number of heads, cobs, bunches in a crate) and thus growers could not always provide a yield in the appropriate units.

5. Crop failures
Limitation: In reality crops may fail in the field, resulting in poor yields or even a non harvestable crop. This is a particular problem for small scale horticultural crops. OVERSEER® does not model crop failure rates for crop blocks.

6. Monthly inputs
Limitation: Decisions had to be made on how to translate fine-scale (e.g. daily) crop management records into the monthly application scale that OVERSEER® works at. For example, in reality a grower may harvest a

crop on 10 March and sow another on 24 March but multiple management actions (e.g. harvesting a crop and sowing another) within a month cannot be modelled in OVERSEER®.

7. Grazing

Limitation: For farms that graze stock for part or all of the year (e.g. mixed cropping/pastoral farms), unless the whole farm is modelled (not just crop blocks) stock enterprises cannot be modelled due to feed requirements of stock not being met in OVERSEER®. Many of the growers used imported animals to clean up blocks, but some also specialised in the buying and selling of animals, for example store lambs over winter.

8. Part paddock grazing

Limitation: OVERSEER® assumes even distribution of animals over a block that is being grazed. However in reality forages and fodders are likely to be break-fed.

9. ***Residue management options***

Limitation: OVERSEER® cannot model multiple residue management options for a single crop. There is also an assumption in the model that all forages, fodder, green manure and permanent pasture crop types have residues retained.

10. Grazing residues in months post-harvest

Limitation: OVERSEER® does not model grazing of crop residues in months following the final harvest month of a crop (e.g. cleaning up grain stubble and weeds). No animals can be on the block in months where there is no actual crop.

11. Sequential planting and harvesting

Limitation: A specific limitation for horticultural growers using OVERSEER® is the inability to model sequentially planted and harvested crops. This is because management inputs and reporting in the model occur at a whole block level. Crops in the survey that had staggered sowing dates (to varying extents) included broccoli, brussel sprouts, cabbage, carrots, cauliflower, leeks, onions, pak choi/shanghai, silverbeet, spinach, spring onions and sweetcorn.

12. Multiple vegetable harvests

Limitation: There are no harvest options in OVERSEER® for multiple harvests of vegetables crops, e.g. silverbeet in the survey was picked multiple times.

13. Irrigation

Limitation: Information collected from surveyed growers on irrigation included some or all of the following: irrigator type, return period, maximum application depth, number of applications and total seasonal application amount. These factors depend on seasonal conditions, water availability

and farm-wide soil moisture priorities. Due to the long-term annual average climate data used in OVERSEER®, applying actual irrigation amounts was not seen as appropriate for the purposes of capturing typical rotation management and nutrient losses in Canterbury.

14. Nutrients

Limitation: Growers tend to use soil nutrient testing in autumn to determine fertiliser applications required for optimal plant growth in the coming season. However, rather than entering a soil mineral N test value in OVERSEER®, N available for plant growth from the various soil N pools is calculated based on management descriptions of the land use prior to the reporting year and long-term annual average conditions. Therefore, actual fertiliser applications may not align with what is required for the OVERSEER® modelled crops.

15. Variable rate management

Limitation: OVERSEER® cannot model variable rate fertiliser or irrigation applications as management occurs at a block scale.

16. Cultivation

Limitation: The options for cultivation in OVERSEER® (direct drilled, minimum till and conventional) are coarse in comparison with actual practices in cropping systems. The restriction of one management event modelled each month also limits the ability to accurately capture effects of cultivation on residue breakdown and nitrogen mineralisation.

17. Prior land use

Limitation: Land use prior to the two year rotation in the block is a modelled input in OVERSEER®, however the options are limited to pasture, fallow, grain crop, vegetable crop, first year of seed crop and second year of seed crop. OVERSEER® makes assumptions on most of the management of these prior crops. For example, the month of crop end is assumed by the model with grain and vegetable crops tending to 'end' earlier than required.

18. Long-term paddock history

Limitation: OVERSEER® requires the total number of years in pasture three to 12 years prior to the reporting year in the block to be recorded. This value affects the N mineralisation rate in the block, but was not always known or recorded in the farm surveys.

19. Variable and small crop areas

Limitation: A complexity particularly characteristic of horticultural growers is the fluidity of 'paddock' boundaries. Often small areas of crops are grown (e.g. 0.2 ha) or varying sized areas are used throughout the year for different purposes as space becomes available. Figure 3 shows a simple example of the dynamics of changing crop areas across consecutive seasons. OVERSEER® is currently designed to model larger areas and

even combine paddocks into single blocks in the model based on similarities in soil, crop rotation and management of that rotation.

Figure 3: Simplified representation of how crop areas grown (therefore 'paddock' boundaries) may change across three consecutive seasons of the year. Each colour represents a different crop grown.

20. Leased blocks

Limitation: It is common for horticultural growers in particular to move disease-prone crops such as potatoes and broccoli around leased pastoral blocks. Complete paddock history is not always available, creating challenges for representing these situations in OVERSEER®.

21. Soil and climate information

Limitation: Growers provided basic soil information for the surveyed farms, but multiple soil types could occur across the blocks. OVERSEER® models long-term (30 year) annual average climate patterns which is information that a grower is unlikely to be able to provide.