BEFORE INDEPENDENT HEARING COMMISSIONERS APPOINTED BY THE CANTERBURY REGIONAL COUNCIL

IN THE MATTER OF	The Resource Management Act 1991
AND	
IN THE MATTER OF	Submissions and further submissions by Irrigation New Zealand on Proposed Plan Change 5 to the Canterbury Land and Water Regional Plan

STATEMENT OF EVIDENCE OF NICOLE IRENE PHILLIPS

22 JULY 2016

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Introduction

1 My name is Nicole Irene Phillips.

2 I am an Environmental Consultant.

3 Irrigation New Zealand (**INZ**) has asked me to provide evidence in respect of its submission on Plan Change 5 (**PC5**) to the Canterbury Land and Water Plan (**LWRP**).

4 My evidence relates to Schedule 28 of PC5 and the rule for "Irrigation and water use" (**Irrigation Rule**).

Qualifications and Experience

5 I hold a Bachelor of Science degree from Lincoln University and Intermediate and Advanced certificates in Sustainable Nutrient Management from Massey University. I am also a Certified Nutrient Management Advisor. I am a Professional Member of the NZ Industry of Primary Industry Management.

6 I have worked throughout Canterbury and Otago for the past seven years as an Environmental Consultant, with an emphasis on OVERSEER modelling and Farm Environment Plans. In this time, I have gained considerable experience with the auditing and modelling of approximately 500 farms through numerous versions of OVERSEER. These 500 farms represent a range of farming types from piggeries, cropping farms and dairy farms through to complex high country sheep and beef farms.

7 I have provided expert OVERSEER advice to applicants for resource consents as well as consent authorities. I have provided evidence on the application of OVERSEER as a result.

8 I have read the Code of Conduct for Expert Witnesses within the Environment Court Consolidated Practice Note 2014 and I agree to comply with that Code. This evidence is within my area of expertise, except where I state I am relying on what I have been told by another person. To the best of my knowledge I have not omitted to consider

any material facts known to me that might alter or detract from the opinions I express.

Scope of Evidence

9 In my evidence I: -

9.1 Explain how the OVERSEER Irrigation Module works with particular focus on how it estimates N loss due to water use;

9.2 Explain the key differences between the Irrigation Rule in the Portal and the Irrigation Module in OVERSEER;

9.3 In light of this key difference, explain what the Irrigation Rule assumes is happening on the ground in terms of irrigation system and irrigation management; and

9.4 Respond to relevant aspects of the s42A Report.

Abbreviations Used and Definitions

10 Many abbreviations have been used throughout this evidence. These are listed below as well as definitions for the abbreviations.

Profile Available Water (**PAW**) – the rainfall equivalent depth of total available water within a specified depth within the soil (e.g. PAW60 is the profile available water in a given soil to a depth of 60cm). The PAW is soil specific and not determined by plant type or root depth.

Crop Available water (**CAW**) – The rainfall equivalent depth of water (mm) available to a specified crop from its root zone.

Potential Evapotranspiration (**PET**) – the amount of evaporation or transpiration that would occur if a sufficient water source were available and the plant is not at stress point. Generally measured as mm/month.

Actual Evapotranspiration (**AET**) – the quantity of water that is actually removed from the soil surface due to the process of evaporation and transpiration.

Good Management Practices (**GMP**) – industry agreed on-farm practices as defined in the "Industry-agreed Good Management Practices Relating to Water Quality (18 September 2015)".

Deficit Irrigation – operating the irrigation system to ensure that soil moisture is not fully replenished after an irrigation event.

Executive Summary

11 The Irrigation Module in OVERSEER allows specification of both the type of irrigation system (eg, K-line, centre pivot, travelling irrigator) and the management method used by the farm. It only assumes deficit irrigation is occurring (i.e. soil moisture is not fully replenished after an irrigation event) if non-specific inputs are used. Because it allows individual farms to tell it what they are in fact doing, its estimate of N loss reflects how much drainage is occurring as a result of how irrigation water is applied.

12 In contrast, the Portal assumes the majority of farms are using deficit irrigation. This would require soil moisture monitoring or a soil water budget to be used in conjunction with an irrigation system that is able to adjust application depth, as the Portal calculates the amount of water applied based on the difference between 50% and 90% of PAW and does not use the information from the imported file.

13 There is more flexibility to adjust application depth to respond to trigger points and target points with low application systems such as centre pivot when compared to higher application systems such as spray lines or travelling irrigators.

14 The s42A Report suggests the Portal and OVERSEER make the same assumptions. This is true if the default settings in OVERSEER are used, because they assume deficit irrigation. However, a farm can specify the system and management method it uses so that the default settings are not applied. This allows the N loss figure generated to reflect the amount of N lost due to drainage from an irrigation system that is not using deficit irrigation practices.

15 In order to achieve a deficit irrigation output from OVERSEER (without using the defaults) a farm would have to:

15.1 Monitor soil moisture, with a specified trigger and target point when irrigation occurs, over all of the soils on farm and all irrigation methods; and

15.2 Have an irrigation system that is able to adjust the application depth to apply an irrigation amount that is less than 50% of the soil PAW, in order to only refill to 90% of PAW.

16 In my experience there is less than 20% of farms currently monitoring soil moisture, and well less than 20% who monitor over all irrigation systems and soil types on farm, which is the first step to achieving deficit irrigation within OVERSEER.

17 This indicates there are a large proportion of farms that would need to change their irrigation management, to include regular soil moisture monitoring as well as potentially change irrigation systems, to ensure the system had the capability to apply a minimum application depth less than 50% of the soil PAW over different soil types, in order to achieve deficit irrigation.

How irrigation drainage is accounted for in OVERSEER

18 In simple terms, OVERSEER asks for a number of inputs in order to calculate daily soil water content, which is then used to calculate drainage from the soil profile and ultimately N leaching. These inputs include:

18.1 Soil properties – soil water content, PAW or CAW, natural drainage class, current drainage class, pugging, saturated hydraulic conductivity, top soil clay and sub soil clay;

18.2 Climate – snow, rainfall, PET/AET, temperature;

18.3 Irrigation – irrigation inputs determine the volume of irrigation water applied; and

18.4 Topography and average hill slope.

19 OVERSEER version 6.2.0 saw a substantial upgrade of the irrigation sub-model due to concerns with the previous way in which the model considered irrigation. The concerns centred around the limited inputs available in previous versions of OVERSEER and whether these actually reflected common irrigation practices.

20 The upgrade to the model was based on the premise that irrigation can be modelled on the depth per application and the return period, and whether these two factors vary according to soil water content, or are fixed. If they vary then it means that soil moisture monitoring is being undertaken on farm to determine soil moisture content and the irrigation system installed has the ability to vary the application depth.

21 The upgrade allowed for the modelling of actual irrigation systems and management currently used on farm. As an example, take a farm that has a soil with a PAW 80mm. Water is applied when the trigger point is at 50% PAW (in this example 40mm), but the travelling irrigator system can only apply a minimum depth of 45mm. OVERSEER calculates that 5mm is being supplied that exceeds the soils PAW and therefore is directed to drainage. It then assumes the remaining 40mm is evenly applied across the block, with 100% of the 40mm being taken up by the plant.

22 This means irrigation methods that can cause drainage events due to constraints within the system can be modelled even if the trigger for an irrigation event is soil moisture content.

23 Daily inputs for estimating soil water content are undertaken by a simple equation:

Daily Water Inputs = daily rainfall + snowmelt + daily irrigation + dairy effluent applications.

24 The daily rate of irrigation applied to a block is estimated from the block irrigation management/scheduling inputs. The soil water deficit, time since irrigation and the irrigation supplied are all estimated based on the input data for the particular irrigation method specified.

25 The first input required is the type of irrigation system. The options within OVERSEER are:

25.1 Linear or centre pivot;

25.2 Travelling irrigator;

25.3 Spray lines;

25.4 Micro irrigation – drip and sprinkler;

25.5 Solid set;

25.6 Controlled flood; and

25.7 Border dyke.

26 The type of irrigation system installed on farm can constrain the irrigation application depth and return period. By allowing the user to provide this information, OVERSEER allows for irrigation systems that have a less than 100% application efficiency or do not use deficit irrigation practices, to be modelled.

27 OVERSEER also allows the user to specify how the irrigation system is managed. There are four irrigation management options within OVERSEER. These are shown in Table 1 below, and each is explained in **Appendix One** to my evidence.

Table 1: OVERSEER technical note 7 (Version 6.2.0)

		Return period	
		Fixed	**Variable**
Depth per application	**Fixed**	Fixed-Fixed (FF)	Fixed-Variable (FV)
	Variable	Variable-Fixed (VF)	Variable-Variable (VV)

28 OVERSEER has established default application depths and return periods for all of the irrigation system types, as well as trigger points and targets. If accurate irrigation information is not available or supplied, then the default option can be selected in OVERSEER. It is the default option within OVERSEER that assumes deficit irrigation.

29 All of the irrigation management/scheduling options described in Table 1 above can be used by all irrigation system types with the exception of border dyke and controlled flood. These irrigation types are fixed-fixed systems only.

30 Centre pivot, micro drip and solid set irrigation systems are classified as low application systems, where there is more flexibility to alter the application depth to apply a small amount of irrigation water e.g. 5mm.

31 Spray lines and traveling irrigators are generally higher application rate systems, and while the application rate of these systems can be altered, it is often not practical (required to shift more regularly) and the rate could not be altered enough to be classified as a low application rate system.

32 The implications of the different management/scheduling options on irrigation depth, drainage and N leached are shown in Figure 1 below. The example used is the same property but the irrigation management has been modelled using a fixed/fixed system and a variable/variable system. As can be seen, OVERSEER estimates much higher N losses for properties using fixed-fixed systems compared to variable-variable systems – these being at either end of the scale of likely N losses.

Table 4. Irrigation, drainage, and N leached for FF and VV irrigations strategy on a hypothetical dairy farm in Canterbury irrigating from September to February inclusive, using a centre pivot system, and default data.

Strategy	Rainfall (mm/year)	Irrigation (mm/ year)	Drainage (mm/ year)	N leached (kg N/ha/ year)
VV	600	330	134	51
FF	600	660	465	127

Figure 1: OVERSEER Technical Note 7 (Version 6.2.0), April 2015

33 Additional water losses such as delivery system losses from leakage, additional atmospheric losses such as aerial spray drift in windy conditions, and border dyke outwash are also taken into account within OVERSEER. The additional losses are included in the volume pumped to the block but are not considered to be applied to pasture. This is why there are two output figures generated by the model - annual irrigation supplied and that added to pasture.

34 These losses account for approximately 3-5% efficiency loss being applied by the model. These losses occur before the irrigation water reaches the soil and are therefore not attributed to drainage.

35 Losses associated with non-uniform application of water are not currently taken into account within the model. It is assumed that water is applied evenly across a block. From the irrigation evaluation work Irricon has completed[1], water is not often applied evenly across a block. This means some parts of a block are over-irrigated in order to achieve the required level of irrigation at other places. Drainage arising from this is not accounted for in OVERSEER. To this extent it potentially underestimates N loss.

36 Additional soil factors that limit a systems ability to meet a 100% application efficiency are also not currently taken into account.

Key Differences between the Irrigation Rule in the Farm Portal and the Irrigation sub-model in OVERSEER

37 The irrigation and water use modelling proxies used by the Farm Portal are set out in the Table 2 below:

[1] 22 new centre pivot irrigators in Central Otago were evaluated for distribution uniformity (DU) in early 2016. A perfect DU value is 1.0. The DU for these systems ranged from 0.791 to 0.906.

Table 2: Irrigation GMP rules within the Farm Portal

GMP	OVERSEER settings, methodologies and rules applied by the Farm Portal to model GMP.
Manage the amount and timing of irrigation inputs to meet plant demands and minimise risk of leaching and runoff	**Spray Irrigation** <u>Management options:</u> Category based on soil water budget Strategy selected is trigger point, fixed depth applied Management systems – user defined Units set as % PAW Trigger point is set at 50% of PAW **Borderdyke irrigation** <u>Management options</u> No outwash occurs User defined Depth per application = 85 Return period = 14

38 Method s28.4 of PC5 sets out additional methodology used for the application of irrigation water by spray irrigation systems under GMP.

39 I have assumed that Method s28.4 is to be used for all farm systems. Schedule 28 at present only refers to Method s28.4 to be used for cropping scenarios.

40 There are four additional specific rules for cropping blocks in Schedule 28 that I have not included in Table 2.

41 The methodology set out in Method s28.4 appears to allow for drainage to occur due to irrigation by travelling irrigators and spray lines on soils with a PAW of greater than or equal to 40mm and less than 80mm. Hume et al indicates that this setting acknowledges irrigation system constraints. This system would still need soil moisture to be monitored to respond to the 50% trigger point.

42 One key difference between the proxies for irrigation and the OVERSEER model is that the proxy assumes deficit irrigation is used on the majority of farms, with the exception of the system outlined in

paragraph 41 above. The Portal removes the inputted application depth and return period from the original OVERSEER file and instead calculates the application depth based on the difference between 50% and 90% PAW.

43 To achieve deficit irrigation practices soil moisture monitoring is required to be used and an irrigation system that has the ability to alter the application depth.

44 This difference is important because in my experience, there would be a small percentage of farms (less than 20%) that undertake soil moisture monitoring or soil water budgeting to calculate trigger and targets points as required by the Portal and an even smaller percentage that monitor over all soil types and irrigation methods on farm. An even smaller number of farms would do both of the above and would be able to alter the application depth and would therefore be operating at what the portal assumes is GMP.

45 Table 11 of Hume et al also outlines another key difference between OVERSEER and the Farm Portal. OVERSEER places no limitation on the method of irrigation that can occur on different soil PAW’s, whereas the GMP modelling proxy does not allow travelling irrigators or spray lines to be used on soils with a PAW of less than 40mm. The modelling proxy for these soils is a centre pivot. This essentially means that those farmers irrigating with a travelling irrigator or spray lines on soil with a PAW less than 40mm will need to convert to a more efficient means of irrigation such as centre pivot to achieve GMP due to the higher application rates from these irrigation types.

46 Table 3 summarises the key differences between OVERSEER and the Portal:

Table 3: Summary of differences between OVERSEER inputs and Portal rules

OVERSEER irrigation inputs	Portal rules
Input options allow an irrigation system that does not use deficit irrigation practices to be modelled - allowing for drainage to occur from irrigation water applied.	Assumes deficit irrigation is occurring under the majority of irrigation systems. The Portal assumes that soil moisture monitoring is installed and used to schedule irrigation to ensure the majority of farms are using deficit irrigation practices. It also assumes that the irrigation method used has the ability to alter the application rate in response to trigger points and soil PAW. . Takes into account system constraints on soils with a PAW of greater than or equal to 40mm and less than 80mm, using spray line or travelling irrigators, essentially allowing minimal drainage to occur from irrigation water applied under these systems.
Any method of irrigation can be undertaken on any soil type – there are no limitations	On soils with a PAW of less than 40mm, travelling or spray lines are changed within the portal to centre pivot. This means a potential change in irrigation method on some farms to meet GMP on these soils.

Comments on the s42A Report

47 I agree with Appendix D of the s42A Report that it is possible the current OVERSEER model assumptions over-estimate irrigation application efficiency and therefore may underestimate the actual required irrigation amount and drainage under irrigation.

48 I agree application efficiency cannot be changed by the user but the inputs able to be used within OVERSEER allow for a system with less

than 100% application efficiency to be modelled, see paragraph 21 for an example.

49 Appendix D comments that when deficit irrigation is used, OVERSEER assumes that 100% of irrigation water applied to the soil below field capacity is used by the plant. This is correct when using deficit irrigation and default inputs within OVERSEER. However, the input options available allow for irrigation management options that apply more water than field capacity of the soil and therefore some irrigation water is directed to drainage.

50 Ms Robson states the assumption above is inherent in the OVERSEER model and not part of the modelling proxy. Although this is correct, when the Portal, through the modelling proxy, removes the application depth and return period from the original OVERSEER file it does not allow for the limitations of the actual irrigation system to be carried over through to the Farm Portal outputs. This means the Portal is describing an irrigation management system that may not be able to be achieved on farm due to the limitations of the irrigation system even with soil moisture monitoring undertaken.

51 The relevant industry-agreed GMP narratives for irrigation are outlined in Appendix D of the s42A Report. The narratives describe managing the amount and timing of irrigation inputs to meet plant demands and minimise the risk of leaching and runoff.

52 The way in which the modelling proxy has been set up in the Farm Portal essentially eliminates leaching from the farm system by assuming an irrigation system where no drainage occurs from the irrigation inputs.

Nicole Phillips
22 July 2016

Reference:
Hume, E. Brown, H. Sinton, S and Meenken, E. 2015. Arable and horticultural crop modelling for the Matrix of Good Management – a technical summary. A Plant & Food Research report. SPTS No. 12430.

Appendix One: Description of irrigation inputs into OVERSEER

Fixed-fixed Irrigation

53 A fixed-fixed irrigation system is where the application depth and return period are fixed. This is typical for a borderdyke irrigation system supplied by an irrigation scheme. If the depth applied exceeds the soil moisture deficit (the difference between field capacity and soil water content) then drainage will occur and OVERSEER's calculation of N loss will reflect this.

54 The application depth and return period for a fixed-fixed system are inputted into OVERSEER and it calculates how much drainage will occur based on the soil information inputted, which determines the field capacity.

55 Field capacity for the soils is included in the soil information inputted by the user and provided by SMAP.

Fixed-variable Irrigation

56 A fixed-variable irrigation system is typical of travelling irrigators or K line systems, where the application depth is fixed but the return period can be altered depending on soil moisture content. If the depth applied is greater than the deficit, then drainage is likely to occur.

57 The application depth, return period and the trigger point for when an irrigation event commences for a fixed-variable system are inputted into OVERSEER and it calculates the volume of drainage that will occur based on the soil information inputted, which determines the field capacity.

Variable-fixed Irrigation

58 The variable-fixed irrigation management strategy is where the depth is variable with the return period being fixed. This is typical of most centre pivot irrigation systems. Drainage can occur if the depth applied is greater than the deficit.

59 The application depth, return period and the trigger point for when an irrigation event occurs for a variable-fixed system are inputted into

OVERSEER and it calculates the volume of drainage that will occur based on the soil information inputted, which determines the field capacity.

Variable-variable Irrigation

60 Using a variable-variable irrigation management strategy, soil water content is maintained so that the Profile Available Water is retained between a trigger point and a target point. If the target point specified by the soil moisture system is less than field capacity, then very little additional drainage occurs. This is typical of an irrigation system with Variable Rate Irrigation installed.

61 The trigger point and target point for when an irrigation event occurs for a variable-variable system are inputted into OVERSEER and it calculates the volume of drainage that will occur based on the soil information inputted, which determines the field capacity.

62 Soil water content can be used to determine irrigation scheduling and a variable return period between irrigation events. This assumes that soil moisture monitoring is being used on farm. OVERSEER uses a trigger point and a target point to determine how much water is applied based on soil water content.

63 The trigger point is defined as the soil water content expressed as a percentage of PAW. It is the PAW value that initiates an irrigation event. The target point is the soil water content, also expressed as a percentage of the PAW that irrigation is applied to achieve.

64 For example, the trigger point could be 50% of PAW and the target is 95% of PAW. What this means is that an irrigation event will commence when the Profile Available Water falls to 50% and then water will be applied until the soil water content reaches 95% of PAW.