IN THE MATTER OF the Resource Management Act 1991

AND

IN THE MATTER OF The Canterbury Proposed Land and Water Regional Plan.

Evidence of Dr Anthony Davoren, HydroServices Ltd

TABLE OF CONTENTS

Background and Qualifications **3**

Information Sources Relied Upon **3**

Key Issues Addressed in this Evidence **4**

Overall Summary **4**

Definitions **4**

Irrigation Application Efficiency **8**

Water Introduced from Outside the Catchment **9**

Lapse Period **10**

Transfer of Water Permits **10**

Take and use – ground water **10**

Schedule 10 ..... **11**

Summary **12**

Background and Qualifications

1. My full name is Anthony Davoren. I hold the qualifications of Bachelor and Master (First Class) of Science in Earth Sciences from University of Waikato and Doctor of Philosophy in Engineering Science from Washington State University. I am a self-employed consultant, and owner and director of HydroServices Ltd.

2. I have 30 yearsô experience in soil moisture, irrigation management, groundwater and surface water research and other related consulting. After graduating from University of Waikato, I spent two years surveying the peat resources of New Zealand, followed by three years studying for a PhD on a National Advisory Council Fellowship. Water and Soil Division (Ministry of Works and Development) then employed me as a research scientist in the Hydrology Centre in Christchurch (now part of NIWA).

3. Since 1987, I have been involved as a specialist in soil moisture measurement and irrigation management. HydroServices now provides irrigation management advice to more than 350 clients in Canterbury. I have had a large involvement in preparing or supervising the preparation of technical assessments for resource consent applications irrigation.

4. In 2007 I founded HydroTrader Ltd with two other persons, Warwick Pascoe and Gus Walkden. In the five years trading and transferring water permits we have gained invaluable experience and expertise with regard to the transfer, transferee, their reasons to or for transfer, the volume of water transferred and where it is transferred

5. With respect to irrigation and groundwater, I have specialised in crop water requirements for irrigation, irrigation efficiency and irrigation design.

6. I was instrumental in developing Adaptive Management for applicantsô at the Rakaia-Selwyn, Selwyn-Waimakariri and Valetta-Ashburton River Groundwater Zone Hearings.

7. I am a past board member of Irrigation New Zealand and managed a Sustainable Farming Fund project Irrigation System Design Standards and Code of Practice for INZ (Irrigation New Zealand).

8. I acknowledge that I have read the code of conduct for expert witnesses contained in the Environment Courtôs Practice Note dated 31 March 2005. I have complied with it when preparing my written statement of evidence and agree to comply with it when giving oral evidence.

Information Sources Relied Upon

9. In preparing my evidence, I have drawn on the following relevant information sources:

- The Proposed Canterbury Land and Water Regional Plan (pLWRP);

- The Proposed Canterbury Land and Water Regional Plan Section 42A Report - Volume 1; and

- The expertise and experience of, and knowledge gathered by HydroServices Ltd with regard to Canterbury soils, irrigation systems and management, and Canterbury groundwater since 1982.

Key Issues Addressed in this Evidence

10. I have prepared this evidence in consultation with other submitters and where possible have avoided repetition.

11. The fundamental issues addressed in this evidence are:

    a) Inclusion of nonstandard or confused definitions;
    b) Disregard of industry standards for irrigation efficiency;
    c) Conditions relating to the transfer of water permits; and
    d) Revision of Schedule 10.

Overall Summary

12. In relation to the key issues outlined in Paragraph 11 of this submission to the pLWRP I have concluded:

    a) Support for the overall intent of the plan with regard to water quantity and water quality policies and rules;

    b) Definitions need to be internationally accepted, some are overly prescriptive and there are some key definitions missing;

    c) There is an underlying lack of practical understanding with regard to irrigation and application of water;

    d) Some aspects of Schedule 10 were poorly interpreted and other aspects are optimistic and unlikely to be achieved; and

    e) I consider the rules and conditions relating to transfers have the objective to ban transfers rather than acknowledge the benefits (of transfers).

13. HydroTrader does not agree with the reasoning for b) and c). Furthermore, HydroTrader considers Liz White has misunderstood the outcomes of previous hearings that resulted in consent applications granted above the allocation limit.

Definitions

14. Throughout Sections 2 and 4 there are a number of soil characteristic and parameter definitions that are either not the internationally or scientifically accepted definition or are invalid for one or more reasons. Without referring to any scientific literature to support definitions, the S42a authors have dismissed the submissions to use accepted definitions.

15. Several soil properties have definitions that differ from that accepted internationally and some are incorrect; i.e.

a) **Field capacity (FC)** (Recommendation R2.10.61) is not *"the moisture content of soil when addition of further water would result in saturation and/or drainage of water from the soil"*. Depending on the rate water is added to a soil the permeability of the soil may be sufficiently high that saturation will never be reached; and conversely the permeability may be so low that saturation might be reached but little or no drainage occurs. Furthermore, drainage from the soil profile continues under the force of gravity after field capacity has been reached.

Interestingly, ECan have not consulted or referred to the NEMs - Soil Moisture Measurement standard that has been prepared. This standard has been initiated by Regional Councils and ECan is one of these. Field capacity and other soil water characteristics are defined in this standard.

The accepted definition of Field Capacity is
ñthe amount of soil moisture or water content held in soil after excess water has drained away and the rate of downward movement has materially decreasedò; or
ñthe maximum amount of water that a soil or rock can hold under capillary action, before the water is drained away by gravityò.

Drainage from the macro-pores typically occurs within 2ï 3 days after a rain in pervious soils of uniform structure and texture.

There are more technical and/or physical definitions of field capacity that relate the bulk water content retained in soil to hydraulic head or suction pressure. However, for this plan an accepted correct definition should be adopted and not ñinventò another definition.

b) **Wilting Point** is not defined; an oversight given profile available water is an integral part of Schedule 10. Wilting point must be included in the definitions as follows;

Wilting point (**WP**) or **Permanent wilting point** (**PWP**) is defined as;
"the soil moisture content at which (if water is not provided) the plant will dieò.

As with Field Capacity there are more technical and/or physical definitions of wilting point that relate the water content to suction pressure or negative hydraulic head. However, for this plan the above definition should be included.

c) Profile Available Water (PAW)
The ECan Officers rejected the revision of the definition of PAW (Recommendation 2.10.143). PAW is defined in the pLWRP as:
"the difference between field capacity and wilting point and represents the total water available to a depth of 1m expressed as millimetres of water".

The definition is overly specific because it limits the depth of soil to 1m. It is not always a soil depth of 1m, but should always be qualified by the depth of soil for which PAW has been calculated.

PAW is a key parameter in the calculation of annual volumes for irrigation. ECan have adopted the Landcare Research Smap soil descriptions and PAW as the default for this calculation. A soil depth of 60cm is adopted for these

calculations. Defining the soil depth as 1m ignores the current practice.

The definition of PAW should be revised to reflect the various depths of soil used to define PAW; i.e.
ñthe difference between field capacity and wilting point and represents the total water available to a specific depth ~~of 1m~~ expressed as millimetres of waterò.

d) Seasonal Duration

Policy 4.66 and subsequent Recommendation R4.66 states:
"The rate, volume and seasonal duration for which water may be taken will be reasonable for the intended use".

While I support the policy, the choice of ñseasonalò is inappropriate for defining duration. I agree with the S42a report comment *"that many activities do not occur year round"*. However, the choice of *seasonal* clearly implies a calendar restriction to the use of water. While water might be required or used for a specific period or duration in a calendar year, to apply a fixed duration or period restricts when the water might be used.

The simplest analogy is the duration of the irrigation season which is different every season ï some seasons beginning in August and not finishing until May, other (like 2012-13) not beginning until December. Specifying a ñseasonalò duration or fixed period would not allow flexibility for when the water may be used.

The simplest solution is to substitute *annual* for seasonal, or as consent conditions specify *"between 1 July and the following 30 June"*. This would allow use to reflect the season-by-season variability for demand.

e) Irrigation Season

Policy 4.67 and Recommendation R4.67 fails to recognise the dynamic nature of an irrigation season. Furthermore, the pLWRP and the S42a report fails to distinguish between the dynamic nature of an irrigation season and the necessity to define a season for irrigation demand modelling purposes. The wording of Policy 4.67 demonstrates a lack of understanding of irrigation and the variation of demand from season to season.

The original Policy 4.67(b) specified *"abstraction is for the summer (1 October – 30 April) irrigation season unless specified otherwise"* and Recommendation R4.67 *"1 September – 30 April"*. As worded the revised policy would restrict irrigation to 1 September ï 30 April following. This is not a sensible definition, could result in complications with regard to compliance and is recognised as *"a nominal irrigation season"* for modelling purposes in Schedule 10. ECan officers have continued to confuse the need to define a period (1 September ï 30 April) for modelling purposes to calculate irrigation demand with the start and end of irrigation.

Reference to the period over which modelling was carried out should be removed from the Policy and would make 4.67(b) redundant.

f) Changed

The definition of *"changed"* has not been well considered and has been the subject of considerable debate and several interpretations in memos from ECan staff. In particular, the definition relates to Rules 5.42 and 5.45. I am particularly concerned with the assumption that an increase in the volume of water used for irrigation on a property means a change in land use. This has not and cannot be substantiated. Quite the contrary, in two recent analyses of proposed increases in annual volume without a change in the land use (one arable and one dairy), the increase in drainage is significantly less than 10%. These analyses have been carried out using a daily water balance model and not Overseer6. A daily water balance model (e.g. Irricalc, SPASMO or the like) deal with evapotranspiration, rainfall and irrigation events in a way Overseer6 cannot. The result is a better estimate of potential drainage changes and therefore likely nutrient leaching. The results confirm my intuitive conclusion that without changing land use (i.e. arable to intensive pasture), an increase in irrigation volume will not automatically result in greater nutrient leaching.

With regard to the use of Overseer6, I did not make a submission because at the time I had not carried out sufficient analyses or comparative analyses to make an objective judgement. The Federated Farmers' submission states that Overseer results are ± 20%, and I support in full their submission (though I have not viewed their evidence regarding this matter at the time of preparing my evidence).

I recommend caution regarding the definition of *"changed"* and consequently the implementation of Rules 5.42 and 5.45.

g) Irrigation Application Efficiency

The definition of Irrigation Application Efficiency states:
"means the volume of water stored in the plant root zone following irrigation, as a percentage of the total volume applied".

Volume is not the unit used to measure application depth or soil moisture. Depth (mm) is the correct and accepted unit. The definition should be amended accordingly.

h) Outdoor Intensive Farming

The definition is overly prescriptive and targets **ONLY** livestock farming. To restrict intensive farming to ONLY livestock is naïve. What about, for example market gardening or small seeds production or potato production or intensive horticulture?

A more considered definition needs to be considered. The definition needs to relate to the agronomic inputs, particularly fertiliser.

i) Soil moisture deficit

The definition states:
"is the amount of water required to restore the soil to its field capacity".

To be consistent with Field Capacity, Wilting Point, Irrigation Application Efficiency and other parameters, the definition should refer to the depth of water

and the crop root zone; i.e.
"is the amount (depth, mm) of water required to restore the soil moisture to its field capacity in the crop root zone".

Irrigation Application Efficiency

16. Policy 4.69 states:

"Water used for irrigation is applied using good-practice that achieves an irrigation application efficiency of not less than 80%."

The Policy and Recommendation R4.69 fails to recognise or demonstrate any understanding of irrigation system design and management. Potential application efficiency is determined by distribution uniformity, DU_{lq}; i.e.

- A Briggs Roto-rainer irrigator with a DU_{lq} of 0.75 will, if well managed achieve an application efficiency of 75% at best; and
- A center pivot irrigator with a DU_{lq} of 0.87 will, if well managed, achieve an application efficiency of 87%.

Higher application efficiency can (potentially) be achieved if application depth is less than crop demand and/or soil moisture deficit. Unfortunately, the ultimate outcome of this practice is reduced production ï not advised.

17. The Policy and Recommendation R4.69 also fails to understand it is not possible to install high uniformity systems (Linear move and Center pivot irrigators) everywhere. Land shape determines the type of irrigation system that can be installed. For example, a linear move irrigator needs to travel 4-5 times its length and has side slope limitations. A center pivot is best suited to a ñsquareò block. Travelling gun irrigators can irrigate odd shaped land parcels.

18. Table 9 below from the Irrigation New Zealand Irrigation Code of Practice and Irrigation Design Standards shows that the high proportion of irrigation systems used to irrigate in Canterbury (Side Roll, Travelling Gun, Fixed boom medium pressure and Rotary boom) do not have DU_{lq} Ó 0.8 and therefore potential irrigation application efficiency Ó 80%.

The policy should reflect what is potentially achievable, both in terms of potential irrigation application efficiency and the type of irrigation system that can be installed.

19. This is not to say irrigation systems should be permitted to be managed poorly. Quite the contrary. I have long advocated and publically expressed the need for irrigators to manage their systems efficiently, long before it became the subject of an ECan Policy. For example; irrigate to match soil moisture deficit, frequency always betters volume, donôt over-irrigate, measure soil moisture, measure soil temperature and the like.

Table 1: Recommended CU_c and DU_{lq} for various system types.

Irrigation system type	CU_c (%)	DU_{lq} (fraction)
Linear move	90-95	0.82-0.86
Centre-pivot	85-90	0.76-0.82
Side roll	80-85	0.68-0.76
Hand shift	80-85	0.68-0.76
Travelling gun	75-85	0.60-0.76
Fixed boom (low pressure)	90-95	0.82-0.86
Fixed boom (medium pressure)	80-85	0.68-0.76
Rotary boom	80-85	0.68-0.76
Solid set sprinklers	85-90	0.76-0.82
Micro-sprinkler	85-90	0.76-0.82
Drip (point source)	90-95	0.82-0.86
Drip-line	90-95	0.82-0.86
Border-strip	70-80	0.52-0.68

20. Policy 4.69 should read:

"Water used for irrigation is applied using good-practice that achieves an irrigation application efficiency of not less than the potential DU_{lq} for the irrigation type (according to the INZ Design Standard)."

Water Introduced from Outside the Catchment

21. Policy 4.53 states:

"Where water is introduced from outside the catchment, the additional surface flows are not available for abstraction unless a new or revised environmental flow and allocation regime is introduced through a plan change".

22. The policy and the S42a response ignore the importance of water introduced from outside the catchment on the groundwater resource. The S42a response states *"the Policy essentially addresses a separate issue, but as worded, the Policy does not preclude the revision of groundwater allocation limits".* I do not accept the wording will not preclude the revision of groundwater limits.

23. The recent Ashburton-Lyndhurst and Chertsey Groundwater Hearing Decisions concluded the introduction of surface water from outside the catchment (in this case the groundwater zone), made a measurable difference to the water available for allocation. This enabled many of the applications to be granted. As more surface water is used for irrigation (e.g. Central Plains, South Rangitata) it is essential provision is made for groundwater allocation limits to be revised. Such a revision needs to be explicit and not be inferred as possible under a Policy that does not address the issue.

Lapse Period

24. The S42a report has recommended revision of Policy 4.75 to read:

> *"Resource consents to abstract water shall be given effect to within two years unless a longer lapse period is justified to give effect to the consent due to the scale or complexity of the activity. For the purposes of this policy, "given effect to" requires the installation of infrastructure, water meter or flow measuring device and use of the water as proposed."*

25. While the amendment recommended is an improvement on the original Policy statement, I am not convinced the S42a Officers have any idea how long it takes from installation of a bore to putting water through an irrigator. Depending on grant date, even a relatively straight-forward system requiring minimal land clearance, building relocation or removal, fencing, mainline installation, irrigator delivery and assembly, commissioning and rectifying faults so that the *"use of the water as proposed"* would likely not be completed in two years.

26. While a *"longer lapse period is justified .....due to the scale or complexity of the activity"* is possible; this caveat is open to interpretation by ECan Officers. Such interpretation, in my experience, is usually fraught with difficulty and protracted discussion. A more explicit definition of scale and complexity would be appropriate.

27. While I agree five years (as was previously the case) was too long (although I submitted it has been reasonable), in our experience a more realistic and practical lapse period would be three (3) years.

Transfer of Water Permits

28. In my submission I opposed the intent of Rule 5.107 and 5.108 (in particular 5.107 (5) and therefore parts of Policies 4.71, 4,72 and 4.73. I support and adopt in full the submission and evidence of HydroTrader Ltd.

Take and use – ground water

29. In my submission I requested amendment and/or clarification of discretionary activity status of matter 3 of Rule 5.101; i.e.

> *"Unless the proposed take is the replacement of a lawfully established take affected by the provisions of Section 124 of the RMA, the seasonal or annual volume of the groundwater take, in addition to all existing resource consented takes, does not exceed the limits for the relevant Groundwater Allocation in Sections 6-15; and"*

be amended to ensure it is not open to interpretation. The S42a Officers agreed that the matter *"lacks clarity as it only refers to 'any irrigation' system…"*.

30. I consider the S42a Officers have ñmissed the pointò and their recommended revision is no clearer to me than the original rule. In my submission I asked the question:

> ñIf varying a consent that currently does not have an annual volume as a condition, results in an annual volume greater than that recorded on the ECan GIS; does this

constitute exceedance of the allocation limit for the zone? And if so does this result in the status of variation becoming non-compliant or prohibited?ò

31. The majority of resource consents to take and use (except in the Rakaia-Selwyn Groundwater Zone) do not have annual volumes as a condition. However, a Schedule WQN9v2 annual volume is recorded on the ECan GIS data base for purpose of determining the allocation status; fully allocated, 80% allocated or less than 80% allocated. When a consent is varied, for example to change land use or rate of take, an annual volume condition is added and an annual volume is calculated. The volume is calculated using either Irricalc or Schedule WQN9v4, both of which result in significantly greater annual volume than WQNv2 ï because all allocations are now for intensive pasture, better soil information and the like.

32. Invariably the additional annual volume is over and above the allocation limit (there are so few zones not fully allocated). The reworded 5.101 matter 3 still does not clarify this issue and how the application to vary a consent will be handled.

Schedule 10

33. I am pleased the S42a Officers have considered my submission and have recognised and removed what were inappropriate interpretations of the work carried out to derive an annual volume using the methodology set out in Table 10.1.

34. There are two matters that I consider have not been adequately addressed:

    a) Correcting or adjusting annual volumes calculated from past records; and

    b) The requirement to demonstrate a model can ñreliably predict annual irrigation volume with an accuracy of 15%ò.

35. The most precise annual volume will likely be derived from analysis of past records of water meter flows, rainfall and irrigation events, soil moisture content measurements and irrigator performance evaluation. Unless these records are of sufficient length it will not be possible to adequately identify the 9/10 year or 90-percentile demand season. The annual volumes will need to be adjusted to reflect the 9/10 demand season. In my opinion the only way the annual volumes can be adjusted (and I prefer adjusted to moderated as used in the Rule in Section 1) is to determine the percentile demand of each of the seasons for which records exist using a daily water balance model (such as Irricalc, SPASMO or the like). Confirm or otherwise one or more seasons is the 9/10 or 90-percentile season. If not, then the seasons would be adjusted by a factor derived from the daily water balance seasonal demands. Interpretation of how the adjustment is to be undertaken must be removed ï the process must be transparent from the outset.

36. The S42a Officers consider ñfield validationò is commonly understood. To require a model to *"reliably predict annual irrigation volume within an accuracy of 15%"* is simply not possible. The accuracy of an annual volume estimate requires the degree of closeness of estimate to actual (true) value or annual volume. No-one has any idea of the actual or true annual volume. However, the model must be precise, in that the reproducibility or repeatability of repeated estimates under unchanged conditions shows the same. In other words, if an independent person was to use the model with the same data set they would get the same result. Delete accuracy and replace with precision unless the ECan Officers are absolutely sure of the annual volumes.

37. There is a further implication of the 15% accuracy or precision to be attached to the annual volumes. This implies the estimate is ±7.5% of the true value or actual annual volume required to meet demand in the 9/10 or 90-percentile demand season. That is, so long as the use recorded for the irrigation season (1 July to following 30 June) is within ±7.5% the consent holder is compliant. Currently consent conditions require the water metering device to have an accuracy of ±5%. That is the annual volume would need to be ±7.875% of that recorded in the consent condition defining the annual volume.

38. I have previously discussed the matter of irrigation application efficiency of 80% (specified in Sections 1 and 2) of Schedule 10 ï see my paragraphs 16-20.

Summary

39. HydroServices supports the intent of the plan with regard to objectives, policies and rules, but like all plans there are matters that need to be addressed.

40. It is important to use definitions accepted internationally and in the scientific literature. This is not been the case and even the NEMs standard has not been consulted.

41. There needs to be consistency with nomenclature (with regard to what is commonly measured) and units.

42. Take and Use of Groundwater (matter 3 of Rule 5.101) needs further clarification to be very clear what is meant.

43. Schedule 10 still requires further revision and consideration of the outcomes.

Dr Anthony Davoren

4 February 2013