

**IN THE MATTER OF**

the Resource Management Act  
1991

**AND**

**IN THE MATTER OF**

applications by Central Plains Water  
Trust to:

Canterbury Regional Council for  
resource consents to take and use  
water from the Waimakariri and  
Rakaia Rivers and for all associated  
consents required for the  
construction and operation of the  
Central Plains Water Enhancement  
Scheme

Selwyn District Council for resource  
consents to construct and operate  
the Central Plains Water  
Enhancement Scheme

**AND**

**IN THE MATTER OF**

a notice of requirement by Central  
Plains Water Limited to:

Selwyn District Council for the  
designation of land for works  
associated with the construction and  
operation of the Central Plains  
Water Enhancement Scheme

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**BRIEF OF EVIDENCE OF CLIFFORD JOHN MAXWELL TIPLER**

7 September 2009

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## **Qualifications and experience**

1. My full name is Clifford John Maxwell Tipler.
2. My qualifications and experience have been presented to this Committee in my primary brief of evidence and have not been repeated here.
3. I have read the code of conduct for expert witnesses set out in Environment Court practice note, and confirm that I have complied with the code in the preparation of my evidence.

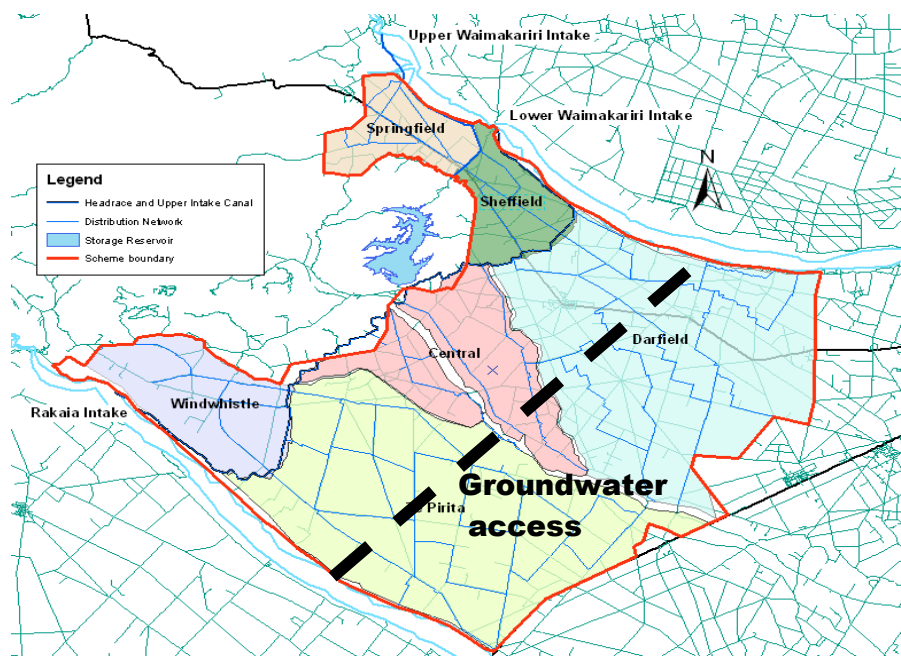
## **Scope of Evidence**

4. I will provide in this section of my evidence, aspects of the revised CPWES that relate to my area of expertise. This will include:
  - A description of the proposed revised Central Plains Water Enhancement Scheme
  - Consideration of the hydrological aspects, and
  - Consideration of nitrate contamination of the groundwater

## **REVISED CPWES DESCRIPTION**

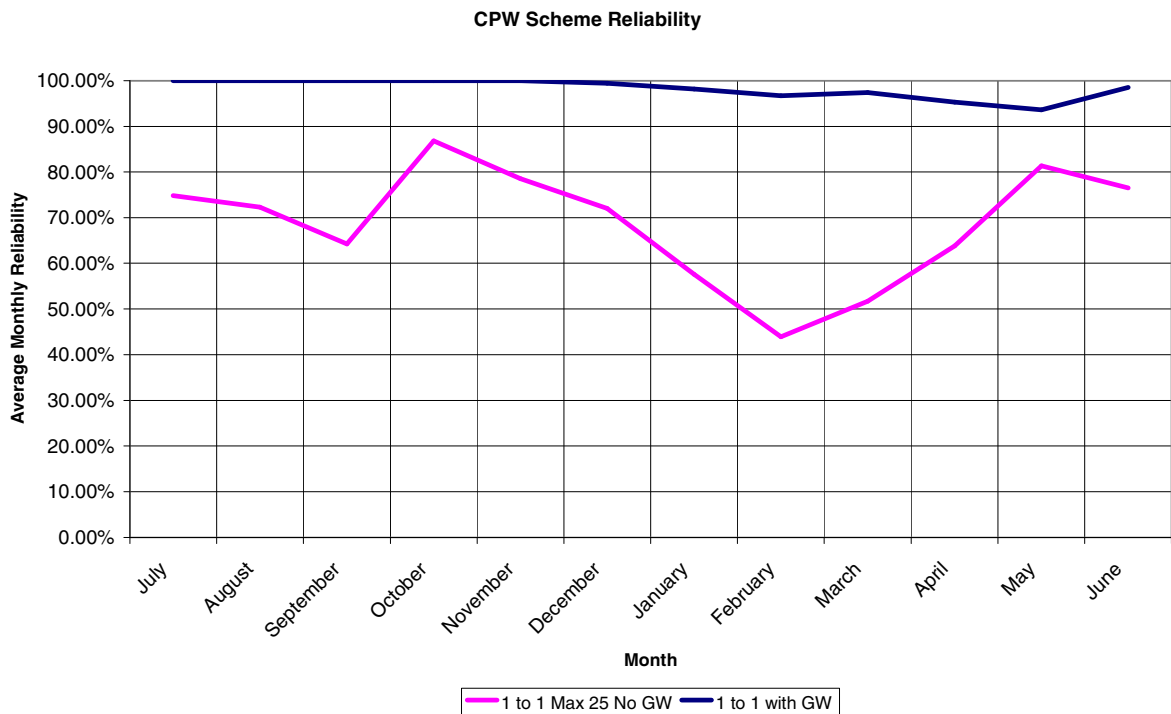
5. In their minute of 1 April 2009, the Commissioners indicated that they would not be recommending the confirmation of that part of the NoR relating to the Waianiwaniwa Reservoir and the Coalgate dam, nor the separate NoR in relation to the upper Waimakariri intake and tunnel. In response to this, CPWL has reconfigured its scheme concept such that these components are no longer part of its applications. In this section of my evidence, I describe the changes to the proposed scheme that are now brought forward for consideration.
6. The Revised Scheme relies upon run-of-river supply from the Rakaia and Waimakariri Rivers, in addition to supplementary groundwater for which resource consents already exist. While there will be no dam nor upper Waimakariri intake and associated structures, all other physical works will remain essentially unchanged, and will be within the scope of the applications lodged. Thus the intakes from each river will be at the same locations as proposed, within the designated areas; the head race canal will follow the same level grade across the plains, and the distribution network will be unchanged for each of the distribution zones as applied for. The command area or scheme boundaries of the scheme remain unchanged and therefore those farmers who will be eligible to join the scheme will be the same as for the original proposal. The area of land within the scheme boundaries that will be irrigated will still be approximately 60,000 ha, however the level of service will be different.

7. It is easiest to conceptualise the revised scheme as having two halves. This is depicted in Figure 1. The first will be serviced by run-of-river water, plus groundwater. The second will be run-of-river supply only. The divider line in Figure 1 separating the command area into an upper and lower half is diagrammatic only, as access to groundwater, while easier in the lower plains, is not restricted to this area. Storage (i.e. a water supply to supplement run of river water when it is not available) is provided for half of the scheme area through the use of groundwater and therefore reliability is very good. The other half with no access to stored water at the present time, will have reasonable reliability during the spring, but poor reliability during summer and autumn. Consequently there will be two very different land management strategies for each half.
  
8. Discussions with ECan officers have included the merits or otherwise of aquifer recharge (i.e. putting surface water onto the ground for the purpose of augmenting groundwater supplies) This would have the benefit of increasing the ground water resource available for supplementary irrigation. However such aquifer recharge is outside the scope of these current applications and therefore not part of the revised scheme concept. CPWL intends to consider aquifer recharge if and when the scheme is consented. That will be the time to consider effects such as mounding, lowland stream flows and water quality.



**Figure 1: Revised Scheme Concept**

9. Figure 2 shows the level of reliability for each half of the scheme by month. I shall return to discussing this figure later in my evidence.



**Figure 2: Revised Scheme Reliability**

10. The 30,000ha of high reliability irrigation supply will be predominantly pasture based, with ~75% of the land area as pasture. The lower reliability supply will be to 30,000ha within a gross farm area of 76,000 ha, where land use will be a mixture of mixed farming (pasture and crop) finishing (pasture) and arable (crop) such that ~66% of the land area will be pasture. This land use forms the basis of the nitrate assessment I present and it is also consistent with the groundwater modelling to be presented by Mr J Weir, the farm economic modelling to be presented by Mr A Macfarlane and the economic modelling to be presented by Mr P Donnelly.
11. The revised scheme can be described as 30-25-1:1, where the maximum rate of take from the Rakaia River is usually limited to 30 m<sup>3</sup>/s, (with the ability to take up to 40 m<sup>3</sup>/s as applied for) the maximum rate of take from the Waimakariri is 25 m<sup>3</sup>/s and the Class B water in the Waimakariri River is shared on a 1:1 basis. The Rakaia take will be from the unallocated water in Bands 2&3 (on average 2 m<sup>3</sup>/s), Barrhill Chertsey (by agreement) water in Band 4 (7 m<sup>3</sup>/s), the Glenroy allocation (2 m<sup>3</sup>/s) and a share of the remaining unallocated water with ACWT. The Waimakariri take will be 1 m<sup>3</sup>/s of Class A water (transferred to CPWL from NTPL) and then Class B water after the existing NTPL allocation of 1.24 m<sup>3</sup>/s, shared on a 1:1 basis.

12. Groundwater already allocated within the scheme area amounts to approximately 145 MCM/yr. It has been assumed that this water will be available for use across 30,000 ha. The mechanisms by which this will occur have not been resolved, it may involve the transfer of unused groundwater to other land or farms to ensure maximum benefit will be attained from the available resources. Over time, I believe this redistribution will enhance the efficient use of the resource.
13. Similarly it has been assumed that the groundwater resource will not increase in size, even though we know that as a consequence of surface water being used for irrigation, supply and leakage from the distribution systems will increase the total volume of groundwater available for abstraction. Therefore while it is reasonable to assume that more groundwater will become available, it has not been assessed as part of these applications. Separate applications would be required for such takes at some future time.

### **Hydrological Aspects**

14. The Commissioners have heard much evidence relating to the hydrology of each river. It is not my intention to represent the full suite of analyses that I presented for other scenarios, rather I will focus my analysis on the matters as outlined in the Commissioner's Minute No. 9 of 7 July 2009, and in particular I will focus on the method of presentation adopted by Mr Duncan, as this found favour with the Commissioners.
15. In relation to the Rakaia River, nothing has changed from my previous evidence, apart from the fact that some water that previously was not available to CPWL has now been made available (7 m<sup>3</sup>/s of BC water by agreement). The net effect is no change to the maximum combined rate of take from the Rakaia River of CPW and ACWT. The effect of gaining access to this water is that the demand on water from the Waimakariri River has been further reduced.
16. An added consideration at this time is the notification of Proposed Plan Change 1 to the Waimakariri River Regional Plan (WRRP) to the effect that there would be a gap of 30 m<sup>3</sup>/s between the present unmodified flow Class A upper limit of 63 m<sup>3</sup>/s and the commencement of the new Class B takes at 93 m<sup>3</sup>/s. While little weight can be placed on the proposed plan change at this time, it is necessary for me to compare the effects of the proposed 30-25-1:1 regime to those resulting with a "30 gap" regime. My evidence will show that the effects on the river are minor with the proposed regime, however there are significant consequence for any scheme that will involve water harvesting from the Waimakariri River if a 30 gap regime was adopted.
17. Plan Change 1 recommends a change to the point of flow measurement for allocation purposes, to Otarama. This is upstream of all take points and therefore simplifies the

consideration of modified and unmodified flow. ECan has analysed the naturalised flow data for the Old Highway Bridge site and the Otarama site, and has shown that “a flow at the Old Highway Bridge of 41 m<sup>3</sup>/s is maintained with a flow at Otarama of 52 m<sup>3</sup>/s”. It has therefore been necessary to change the minimum flows to account for this. This has been achieved by increasing the minimum flows by 11 m<sup>3</sup>/s, thus the 41 m<sup>3</sup>/s minimum flow is now 52 m<sup>3</sup>/s, and the proposed minimum flow for the new “B1 permits” is 104 m<sup>3</sup>/s, equivalent to 93 m<sup>3</sup>/s in the WRRP. To avoid confusion, I have maintained the same conventions as in all previous evidence, assuming that flow measurements relate to the Old Highway Bridge site.

18. Minute 9 has requested analysis of the proposed flow regimes primarily relating to the potential for loss of amenity for kayaking, jet-boating, and salmon angling. Specifically the following information that relates to the frequency and duration of sub-optimal flows and the loss in flow variability has been requested:
- That CPW has a “reasonable need” for the revised rates and volumes it seeks,
  - Change in proposed take time series
  - Length of time the maximum rate of take will occur
  - Reduction in median flow
  - Length of time the river will be at its minimum flow
  - Reduction in the frequency of FRE3 and MIN3 flow events
  - No. days per month that flows are within the ranges 50 – 60, 60 – 70, 70 – 80 m<sup>3</sup>/s,
  - No days per month for average, dry and wet years that flows that flows drop from above 70 to below 70 m<sup>3</sup>/s, and from above 60 to below 60 m<sup>3</sup>/s.
  - The duration of low flow events
  - Analysis of flow durations within the bands as presented by Mr Duncan
  - Comment on changes in turbidity as it might affect fishability, and
  - Mitigation proposed for kayaking, salmon passage, and allowing freshes to occur.

### **Reasonable need**

19. At paragraph 1.1 of Minute 9, the Commissioners have requested information demonstrating the “reasonable need” for the proposed take. The revised scheme can be described as 30-25-1:1. The maximum rate of take required for the scheme is approximately 44.2 m<sup>3</sup>/s, based on a peak application rate of 0.6 L/s/ha, a maximum

irrigated area of 60,000 ha, canal seepage and bywash of 20%, and a 1 m<sup>3</sup>/s loss from the headrace canal. While the nomenclature used would indicate a maximum combined rate of take 55 m<sup>3</sup>/s, this is not what would happen in practice. The actual maximum combined rate of take from both rivers is 43.06 m<sup>3</sup>/s, with an average take of 7.57 m<sup>3</sup>/s. This is a reduction from 51.35 m<sup>3</sup>/s and 11.91 m<sup>3</sup>/s respectively for the previous scheme with storage in the Waianiwaniwa reservoir. This represents a reduction of approximately 36% to the total volume taken compared to the original scheme concept. Individual peak and average rates of take for the Rakaia and Waimakariri Rivers are 26.35 m<sup>3</sup>/s and 5.18 m<sup>3</sup>/s; and 25 m<sup>3</sup>/s and 2.40 m<sup>3</sup>/s respectively.

20. The maximum rate of take requested for the Waimakariri River is 25 m<sup>3</sup>/s. There will be times that a take at this rate is required. CPWL have attempted to minimise the length of time that this maximum rate of take will be required, nevertheless the uncertainties around how much water will be available and when it will be available from the Rakaia River requires that this maximum rate is granted.
21. Without storage, it is important from an irrigation perspective to use as much run of river water as possible, when it is available. This could have been achieved by including a peak rate of take of 40 m<sup>3</sup>/s as applied for. However there is a balancing to be done, between the cost of the infrastructure, the frequency at which its full capacity will be used, and the environmental effects of a large take. CPW have considered this balance, and believe that a peak rate of take of 25 m<sup>3</sup>/s meets the reasonable needs of in river and out of river users.
22. Given that it is an objective of the scheme to maximise the benefit from the use of this smaller volume of water, over the same irrigated area of 60,000 ha, the requirement to take at up to 25 m<sup>3</sup>/s is greater now than before. I believe that this demonstrates that there is a reasonable need for this water at the rates now applied for.

### **Change in proposed take time series**

23. At paragraph 8.8 of Minute 9, the Commissioners have requested information on how the proposed time series of water demand would differ from that proposed previously. The Commissioners have assumed that during the irrigation season, CPW would take from the Waimakariri River up to the maximum permitted under its consents at most times.
24. The “demand” for water has not changed, however the ability of the proposed scheme to meet that demand is severely limited. This has resulted in a change in likely land management practices, with less intensive farming over half of the irrigated area. Rather than focus on the demand time series, it is better to focus on the take time series, as this determines the effects on the rivers rather than the demand series.

25. The assumption that CPW would take “up to the maximum permitted” at most times on the Waimakariri River during the irrigation season is not correct. CPW has agreed to a priority of take regime, where any water required would be taken from the Rakaia River as first priority, with any deficit then being met by the Waimakariri River. Therefore there will be times that there is sufficient water available in either river to meet the demand, however only the Rakaia water would be taken. I have differentiated between what could be taken and what will be taken from the Waimakariri by referring to these as water that is “Available” for take, and water that is “Predicted” to be taken. As is shown below, the predicted take volume may be as little as 34% of the available take volume. Therefore there will be significant periods when water could be taken by the scheme, but will not.
26. The effect of the proposed take on the Rakaia River will be the same as for the original scheme. This is because the NWCO limit of 70 m<sup>3</sup>/s for all takes was the limiting factor previously, along with no water from the Rakaia River being taken for storage purposes. Similarly, priority was always to take available water from the Rakaia River first. All that has happened in terms of the Rakaia River is the allocation of water to the north and south has changed slightly, but the total amount abstracted has not. Effects remain unchanged.
27. The change in the take from the Waimakariri River is significant. The reduction in the total volume to be taken on an annual basis is approximately 73%. This is because more water proportionately is coming from the Rakaia and no water is taken for storage. Table 1 below contains a comparison between the original 20-25-240 scheme and the 30-25-1:1 scheme predicted takes from the Waimakariri River. I have also included in this table, how much water is available to be taken from the Waimakariri River during the summer months, as this represents an upper-bound on the volumes that could be taken for the revised scheme.

**Table 1: Waimakariri Take for Original and Revised Scheme Concepts**

	<b>Original Scheme Predicted 20-25-240</b>	<b>Revised Scheme Predicted 30-25-1:1</b>	<b>Revised Scheme Available 30-25-1:1</b>
Mean take (m <sup>3</sup> /s)	9.29	2.40	7.03
25%ile (m <sup>3</sup> /s)	0.00	0.00	0.00
Median take (m <sup>3</sup> /s)	2.25	0.00	0.00
60%ile	9.10	0.00	0.00
70%ile	18.13	1.00	10.89
80%ile	25.00	2.87	24.00
90%ile	25.00	10.31	24.00
Maximum (m <sup>3</sup> /s)	25	25	25
Annual Average Volume (MCM/yr)	288	77	222

28. When considering the effects of the take, I have included both the available take rates and volumes and the predicted take rates and volumes, as these represent the reasonable limits of the assessment. While my best assessment of the effects is that the “predicted” results will be closer to the actual effects, it is likely that the effect of the CPW take will lie between the “predicted” results and the “available” results.

#### **Maximum rate of take**

29. There are a number of key statistics mentioned in the Commissioner’s Minute 9 at paragraph 8.22. These are discussed in the following sections. There is no change in the maximum rate of take, however the length of time at which this rate of take occurs does change. The original scheme would require the peak rate of take of 25 m<sup>3</sup>/s to be taken for approximately 24% of the time. Under the 1:1 sharing regime, a take of this magnitude would be available for approximately 20% of the time. The predicted maximum rate of take would be for approximately 1 % of the total time.

#### **Reduction in median flow**

30. The median flow pre-CPW is approximately 80.2 m<sup>3</sup>/s. The median flow after CPW is approximately 76.6 m<sup>3</sup>/s. This is a change of 4.5%. If the fully available water was taken, then the median flow would decrease to 70.2 m<sup>3</sup>/s. Changes in the median flow for the critical amenity periods are presented in later sections.

#### **River at minimum flow**

31. The take from the revised scheme would only slightly increase the number of days at minimum flow as a consequence of the predicted take. There would be approximately 1671 days over the full period of record of 34 years (13.46%) at a flow of 41 m<sup>3</sup>/s or less before the scheme and 1781 days (14.34%) after the scheme. If the fully available water was taken, then the number of days at the minimum flow or less would increase to 1793 (14.44%).

#### **Frequency of FRE3 and MIN3 flow events**

32. The FRE3 flow has been used as a statistic that reflects the flushing frequency of the river. The FRE3 flow for the Waimakariri River is 288 m<sup>3</sup>/s. Table 2 following contains the FRE3 data for before and after CPW for both the predicted take and the fully available water for taking.

**Table 2: Change in frequency of FRE3 flows over 34 year period of record**

Scenario	Flow Band	Before CPW	After CPW	Change
FRE3 - Predicted	288 m <sup>3</sup> /s	692	684	1.2%
FRE3 - Available		692	634	8.4%

33. A change of less than 10% in the frequency of the FRE3 flows is in my opinion less than minor.
34. The MIN3 flow has been used as a statistic that reflects the frequency that the flow in the river is low. The MIN3 flow for the Waimakariri is 123 m<sup>3</sup>/s. Table 3 following contains the MIN3 data for before and after CPW for both the predicted take and the fully available water for taking.

**Table 3: Change in frequency of MIN3 flows over 34 year period of record**

Scenario	Flow Band	Before CPW	After CPW	Change
MIN3 – Predicted	123 m <sup>3</sup> /s	3455	3360	2.7%
MIN3 - Available		3455	3056	11.5%

35. As the MIN3 flow is greater than the median flow and is also greater than the flow at which CPW would stop taking water, it is to be expected that the duration of flows less than this figure will increase. The significance of this is discussed later in my evidence in relation to preferred flow bands for recreational uses.

**Flow bands 50 – 60, 60 – 70, 70 – 80 m<sup>3</sup>/s,**

36. The Commissioners at paragraph 9.15 have requested an analysis of flows before and after CPW within the flow bands above. Table 4 contains these data.

**Table 4: Frequency of flows within specified flow bands**

Scenario	Flow Band	Before CPW				After CPW			
		67-01 Full Period	70/71 Dry Year	89/90 Typ. Year	95/96 Wet Year	67-01 Full Period	70/71 Dry Year	89/90 Typ. Year	95/96 Wet Year
Days total		12419	365	365	365	12419	365	365	365
1:1 Sharing 25 Max – Predicted	50 - 60m <sup>3</sup> /s	1165	35	56	13	1244	34	56	14
1:1 Sharing 25 Max – Available		1165	35	56	13	1568	39	72	20
30 Gap 25 max – Available		1165	35	56	13	1165	35	56	13
1:1 Sharing 25 Max - Predicted	60 - 70m <sup>3</sup> /s	1199	18	35	6	1100	16	37	9
1:1 Sharing 25 Max - Available		1199	18	35	6	1226	26	34	14
30 Gap 25 max - Available		1199	18	35	6	1199	18	35	6
1:1 Sharing 25 Max - Predicted	70 - 80m <sup>3</sup> /s	1050	17	28	36	937	15	25	29
1:1 Sharing 25 Max - Available		1050	17	28	36	899	18	24	39
30 Gap 25 max - Available		1050	17	28	36	1807	38	50	64

**Changes from above 70 to below 70 m<sup>3</sup>/s, and from above 60 to below 60 m<sup>3</sup>/s.**

37. The Commissioners have requested at paragraph 9.28, an analysis of the proposed take regime in terms of numbers of days per month in average, dry and wet years, when the take would result in flows dropping from above to below 70 m<sup>3</sup>/s, and from above to below 60 m<sup>3</sup>/s. These data are presented in Tables 5 - 7 below. Data are presented for the actual predicted effect, as well as the effect if all the available water under the conditions of the proposed regime were to be taken.

**Table 5 Average year flow data**

	Average Year (1989/90)					
	Days flow above 70 before CPW	Days flow above 70 after CPW	Days flow above 70 after CPW	Days flow above 60 before CPW	Days flow above 60 after CPW	Days flow above 60 after CPW
		Available	Predicted		Available	Predicted
January	18	8	13	23	12	18
February	0	0	0	0	0	0
March	6	4	4	6	4	5
April	13	13	13	15	15	15
May	31	31	31	31	31	31
June	16	16	16	22	22	22
July	20	20	20	25	25	25
August	6	6	6	11	11	11
September	5	5	5	8	8	8
October	19	11	18	24	16	22
November	14	9	13	16	10	15
December	16	13	13	18	16	17
Total Days	164	136	152	199	170	189

**Table 6 Dry year flow data**

	Dry Year (1970/71)					
	Days flow above 70 before CPW	Days flow above 70 after CPW	Days flow above 70 after CPW	Days flow above 60 before CPW	Days flow above 60 after CPW	Days flow above 60 after CPW
		Available	Predicted		Available	Predicted
January	4	1	1	5	2	2
February	0	0	0	0	0	0
March	0	0	0	0	0	0
April	0	0	0	0	0	0
May	0	0	0	0	0	0
June	18	18	18	21	21	21
July	19	19	19	23	23	23
August	12	12	12	18	18	18
September	30	30	30	30	30	30
October	31	26	31	31	31	31
November	23	15	23	25	21	24
December	10	5	8	12	7	9
Total Days	147	126	142	165	153	158

**Table 7 Wet year flow data**

	Wet year (1995/96)					
	Days flow above 70 before CPW	Days flow above 70 after CPW	Days flow above 70 after CPW	Days flow above 60 before CPW	Days flow above 60 after CPW	Days flow above 60 after CPW
		Available	Predicted		Available	Predicted
January	19	10	11	20	13	15
February	15	9	12	17	12	13
March	11	8	10	12	10	11
April	27	27	27	27	27	27
May	31	31	31	31	31	31
June	30	30	30	30	30	30
July	31	31	31	31	31	31
August	31	31	31	31	31	31
September	30	30	30	30	30	30
October	31	28	31	31	31	31
November	28	22	28	30	26	30
December	31	30	30	31	30	31
Total Days	315	287	302	321	302	311

**The duration of low flow events**

38. The Commissioners have at paragraph 9.88, referred to my Figure 26 from my first brief of evidence in relation to the duration of low flow events. That figure showed how there was a significant increase in the number of short duration low flow events, but there was little change to the frequency of the longer duration events. From that analysis, I developed a mitigation strategy based upon allowing small freshes to pass should these longer term low flow events occur.
39. I have undertaken the same analysis for the proposed regime, and that is presented in Figure 3 below. This shows there is essentially no change in either the frequency or duration of the low flow events, defined as having a flow of equal to or less than 41 m<sup>3</sup>/s. This is a direct result of the 1:1 sharing proposed.

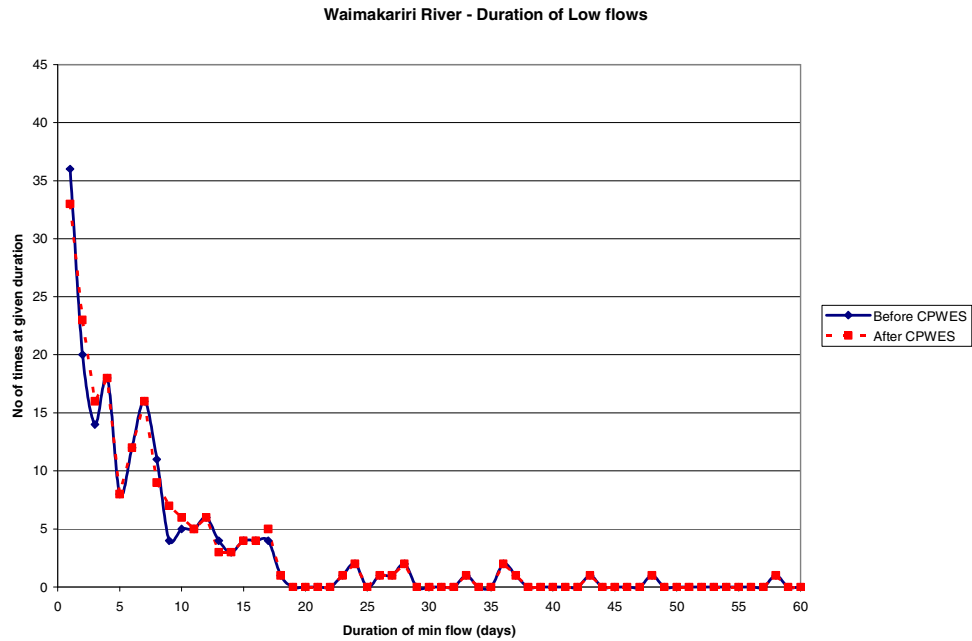


Figure 3: Duration and Frequency of Low Flow Events

Duncan analysis

40. The Commissioners at paragraph 9.138, have referred to the useful presentation of flow requirements for various recreational and instream values produced by Mr M Duncan. Mr Duncan has produced a report (Duncan 2008) for ECan, reviewing allocation mechanisms for B/C Block water from the Waimakariri River. I have reproduced in my Figure 4, his Figure 1 below, and will use the flow regimes as shown in this figure to compare the current pre-CPW situation with the post-CPW situation, both for the predicted takes and the allowable take under the proposed regime.

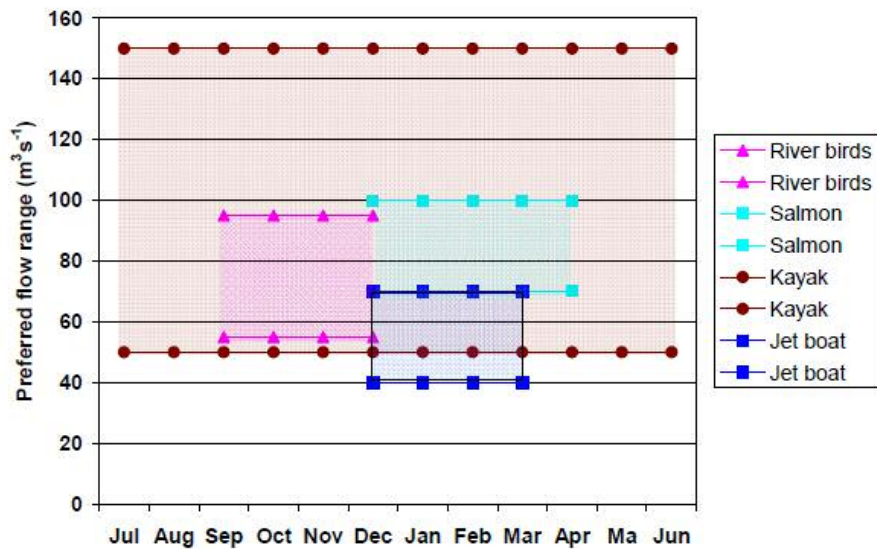


Figure 4: Figure 1 from Duncan 2008

41. The purpose of Mr Duncan’s report, was to assist ECan in evaluating a number of allocation regimes for the purpose of preparing what is now Plan Change 1 for the WRRP. That purpose is different to that of my consideration of take regimes to determine what is acceptable for the CPWES applications. My consideration is not in relation to allocation regimes, however Mr Duncan’s analysis is very helpful in showing how it is not necessary for CPW to adopt on the 30 gap regime proposed in Plan Change 1, to achieve similar outcomes to those assessed as acceptable to ECan during its consideration of that Plan Change. I therefore believe that the Commissioners should place little weight on the regime proposed in Plan Change 1, in relation to the CPW applications.
42. In Figure 5, I have reproduced Table 6 from Duncan 2008, and I have added annotations to assist with the explanation of my considerations. On this table, I have identified what I have called “Betterment”. This means that the state of the river, in relation to the particular criteria referred to, will be in a better or improved state, after a take. Therefore the take has the effect of improving the time spent in the desired flow range beyond that currently permitted by the existing A Block takes. In weighing up the effects the CPWES take has on the in-stream values of the river I consider the positive effects on flows for some values needs to be taken into account against other effects that abstraction of water has.

**Table 6:** The effect of different sized gaps between the A and B Blocks for a B Block allocation of  $40 \text{ m}^3\text{s}^{-1}$  on flow statistics (1967-2007) for critical periods for river dwelling birds and salmon angling.

	Naturalised	A Block summer	A summer $40 \text{ m}^3\text{s}^{-1}$ B 0 gap	A summer $40 \text{ m}^3\text{s}^{-1}$ B 7 $\text{m}^3\text{s}^{-1}$ gap	A summer $40 \text{ m}^3\text{s}^{-1}$ B 17 $\text{m}^3\text{s}^{-1}$ gap	A summer $40 \text{ m}^3\text{s}^{-1}$ B 27 $\text{m}^3\text{s}^{-1}$ gap	A summer $40 \text{ m}^3\text{s}^{-1}$ B 37 $\text{m}^3\text{s}^{-1}$ gap
<b>September - December</b>							
Mean flow	162	145	112	115	118	121	124
Median flow	127	109	69	70	75	81	83
% time at $55\text{-}95 \text{ m}^3\text{s}^{-1}$	26.5	31	36	32	54	53	52
<b>December - April</b>							
Mean flow	109	89.7	69	70	75	81	83
Median flow	83	61	41	41	40	40	61
% time at $70\text{-}100 \text{ m}^3\text{s}^{-1}$	25.9	15.7	25.9	25.9	25.9	25.9	25.9

**Figure 5: Table 6 from Duncan 2008**

43. In Table 6 above, there are two critical assessments, relating to September – December and a flow range of  $55 - 95 \text{ m}^3/\text{s}$ , and December – April and a flow range of  $70 - 100$

m<sup>3</sup>/s. These periods relate to river dwelling birds and salmon angling conditions respectively, and represent the preferred flow regimes. My comparison is between the existing situation represented by the A Block summer takes, and those with the proposed gaps, increasing to 37 m<sup>3</sup>/s. For example the number of days within the first flow regime increases from 31 days to 53 days at a gap with 27 m<sup>3</sup>/s. The second regime increases from 15.7 days to 25.9 days. Both of these are, in my opinion, betterment.

44. It is important to note that Mr Duncan's analysis has assumed that all water within that allocated regime will be taken. In practice this is unlikely to occur, and in terms of the revised CPWES this will not occur, as it would be more than what consent is now sought for.
45. In Figure 6 following, I have reproduced Table 6 with the comparative data for the proposed 30-25-1:1 take regime. This is referred to as CPW 25 m<sup>3</sup>/s B 1:1. This figure shows that the proposed regime is better for both criteria, than would be the case for an allocation as per the existing WRRP and as proposed in the original applications by CPWES.

**Table 6:** The effect of different sized gaps between the A and B Blocks for a B Block allocation of 40 m<sup>3</sup>s<sup>-1</sup> on flow statistics (1967-2007) for critical periods for river dwelling birds and salmon angling.

	Naturalised	A Block summer	A summer 40 m <sup>3</sup> s <sup>-1</sup> B 0 gap	<b>CPW 25 m<sup>3</sup>/s B 1:1</b>	A summer 40 m <sup>3</sup> s <sup>-1</sup> B 27 m <sup>3</sup> s <sup>-1</sup> gap	A summer 40 m <sup>3</sup> s <sup>-1</sup> B 37 m <sup>3</sup> s <sup>-1</sup> gap
<b>September - December</b>						
Mean flow	162	145	112	<b>144</b>	53	52
Median flow	127	109	69	<b>102</b>		
% time at 55-95 m <sup>3</sup> s <sup>-1</sup>	26.5	31	36	<b>39.9</b>		
<b>December - April</b>						
Mean flow	109	89.7	69	<b>88.0</b>	77.2	70.1
Median flow	83	61	41	<b>53.3</b>		
% time at 70-100 m <sup>3</sup> s <sup>-1</sup>	25.9	15.7	6.5	<b>17.0</b>	6.5	25.9

**Figure 6: Table 6 with proposed CPW 25 max 1:1 take regime**

46. In Figure 7 following, I have reproduced Table 6 with the comparative data for the proposed 30-25-1:1 take regime compared to the existing A Block allocations and the proposed 30 m<sup>3</sup>/s gap of the Plan Change 1. This shows that the proposed regime is better for both criteria, than would be the case for an allocation as per the existing A Block allocation. I do acknowledge that a greater percentage of the time would be spent

within the respective flow bands with a 30 gap, however as this is better than the current A Block allocation, I do not believe this is an appropriate standard to assess the CPWES applications against.

**Table 6:** The effect of different sized gaps between the A and B Blocks for a B Block allocation of  $40 \text{ m}^3\text{s}^{-1}$  on flow statistics (1967-2007) for critical periods for river dwelling birds and salmon angling.

	Naturalised	A Block summer	CPW 25 $\text{m}^3/\text{s}$ B 1:1	A summer $40 \text{ m}^3\text{s}^{-1}$ B $17 \text{ m}^3\text{s}^{-1}$ gap	ECan 40 $\text{m}^3/\text{s}$ B 30 gap
<b>September - December</b>					
Mean flow	162	145	<b>144</b>	118	<b>122</b>
Median flow	127	109	<b>102</b>	75	<b>82</b>
% time at $55-95 \text{ m}^3\text{s}^{-1}$	26.5	31	<b>35.0</b>		<b>53</b>
<b>December - April</b>					
Mean flow	109	89.7	<b>88.0</b>	75	<b>78</b>
Median flow	83	61	<b>53.3</b>	57	<b>60</b>
% time at $70-100 \text{ m}^3\text{s}^{-1}$	25.9	15.7	<b>18.4</b>		<b>22</b>

**Figure 7: Table 6 – Predicted CPW Take**

47. I have repeated this assessment using the available water under the 30-25-1:1 regime. These data are presented in Figure 8 following. This shows even if all the water available under the proposed regime was to be taken, the time spent in each flow band would be greater than that for the existing A Block allocations.

**Table 6:** The effect of different sized gaps between the A and B Blocks for a B Block allocation of 40 m<sup>3</sup>s<sup>-1</sup> on flow statistics (1967-2007) for critical periods for river dwelling birds and salmon angling.

	Naturalised	A Block summer	CPW 25 m <sup>3</sup> /s B 1:1	A summer 40 m <sup>3</sup> s <sup>-1</sup> B 17 m <sup>3</sup> s <sup>-1</sup> gap	ECan 40 m <sup>3</sup> /s B 30 gap
<b>September - December</b>					
Mean flow	162	145	<b>133</b>	118	<b>122</b>
Median flow	127	109	<b>90.4</b>	75	<b>82</b>
% time at 55-95 m <sup>3</sup> s <sup>-1</sup>	26.5	31	<b>39.9</b>	← Better	<b>53</b>
<b>December - April</b>					
Mean flow	109	89.7	<b>84.0</b>	75	<b>78</b>
Median flow	83	61	<b>52.7</b>	57	<b>60</b>
% time at 70-100 m <sup>3</sup> s <sup>-1</sup>	25.9	15.7	<b>17.0</b>	← Better	<b>22</b>

**Figure 8: Table 6 – Available CPW Take**

48. The reason that the data presented in the above figures for the CPWES revised take regime are better than those shown for the A Block summer allocation, is that not all the water allocated will be taken, and therefore Mr Duncan’s assessment, while appropriate for his intended use, does not provide justification to require the CPWES to adopt the 30 gap regime. The above analysis demonstrates that the 25 maximum take, along with the 1:1 sharing, will result in an outcome no worse, if not better than that assumed to be provided by the existing A Block allocation.
49. Mr Duncan and I have used different assumptions in our calculations. Nevertheless the differences are small, and in terms of ecological, aesthetic and recreational values, I believe the differences between the two flow regimes in practice will be indistinguishable. The 1:1 sharing regime has positive benefits to CPW in terms of early access to run of river water compared to the 30 gap regime, and these positive effects outweigh any negative effects associated with the different regime.

**Changes in turbidity**

50. At paragraphs 9.45 to 9.61 of Minute 9 the Commissioners address turbidity, suspended sediment, and water clarity, and outline the argument of Dr Hayes relating to water clarity. It will be recalled that clarity, turbidity, and suspended sediment are all different but related parameters. Water with higher suspended sediment concentrations will tend to have lower clarity.

51. Dr Mabin and Mr Duncan have shown that removing water from a river in an irrigation take does not reduce the total suspended solids concentration of the water that remains in the river. For example, if the river upstream of an intake carried 20 ppm suspended sediment, it will still be carrying 20 ppm suspended sediment downstream of the intake. As water clarity is strongly dependent on suspended sediment concentrations, it follows that an irrigation take will not change the clarity of the water that remains in the river downstream of the intake. Therefore the relative differences in water clarity at the Waimakariri Gorge and the State Highway 1 Bridge discussed by Dr Hayes will remain unchanged under the proposed CPW take regime.
52. The Commissioners at paragraph 9.54 have also raised the issue of re-suspension of fine material that has settled. I do not believe this to be a significant issue, as the re-suspension of fine material will be a consequence of the bed shear stress. Bed shear stress is primarily a function of water velocity. Water velocity is primarily a function of water slope. As the slope of the river will not change (from the gorge to the ocean), the velocity will not change significantly, nor will the bed shear stress. What will change is the water depth and wetted perimeter. With a lower wetted perimeter, there will be a smaller surface from which fine material can be re-suspended, however the smaller mass will be carried by a correspondingly smaller volume, and there will be little difference in suspended sediment concentrations. I do not believe this is a factor that affects turbidity or clarity and therefore will not affect fishability.
53. As part of preparing this evidence, I have met with Mr Millichamp from Fish and Game to discuss the proposed CPW take regime, compared to that presented by Fish and Game through Mr de Joux. The discussion was useful, however CPW and Fish and Game differ fundamentally on their preferred regime for the Waimakariri River take. Fish and Game will be seeking a gap, while CPW seeks a 1:1 sharing regime.

### **Salmon Fishing**

54. The Commissioners have raised other issues relating to salmon fishing amenity. These related to fish passage and fishable area.
55. In relation to fish passage, it is the evidence of Dr Glova that fish passage is provided by the existing minimum flow. In addition, Dr Glova saw merit in the proposal to allow freshes to pass down the river after prolonged periods of low flow, to allow salmon that may have been waiting a long time to begin their run up stream, the opportunity to pass the critical reaches such as at Crossbank. For this reason, CPW retains its suggestion to refrain from takes for two days after periods of prolonged low flows. The passing of freshes in this manner, also provide for ecological flushing of the river bed.

56. In relation to fishable area, the reduction in flow will result in a reduction in fishable area. However the assessment undertaken prior to the CPWES being amended will have assumed a much higher take from the river than currently proposed. I therefore believe that assessment will have overstated the effect. While I can accept that there may be a reduction in fishable area, this should not be significant given the actual takes proposed.

### **Mitigation**

57. A number of mitigation measures have been proposed in the past, including:
- Allowing freshes to pass after periods of low flow
  - Not taking during Coast to Coast event
58. The revised scheme can still maintain these mitigations, even though the potential impact on these issues are significantly reduced under these proposals.

### **NITRATE CONTAMINATION**

59. In my previous brief of evidence, I presented my evaluation of the potential effects on groundwater from nitrate contamination. Since that time, I have heard comments from other submitters and the investigating officers, and those comments have been addressed in my evidence in rebuttal. I have also made myself familiar with an assessment of nitrate discharge from agricultural land on the Canterbury Plains (Bidwell et al. 2009) undertaken for ECan. This offered potential for me to up-date my assessment so that I used a similar approach and the same data sources as that used by ECan. Having considered that work, and spoken with Drs Bidwell and Lilburne, I have decided not to follow their approach for this assessment of the modified scheme for the following reasons.
- Input leaching data values are under review
  - Clean water inputs in the current version of the model are not provided for explicitly
  - Calculations are based on single point or average leaching criteria
60. The major advantages in my opinion of the ECan model, are that the predictions retain spatial information, and allow for the physical processes associated with vertical mixing within the aquifers. When the review of the leaching data is completed, clean water input provided for (this can be approximated pers comm. V Bidwell) and the variability and uncertainty aspects can be accounted for, this model has great potential.

**Leaching data from Bidwell et al (2009).**

61. The assessment above links land use, with soil and climate parameters with a particular nitrate leaching loss. Of particular interest are the leaching values with concentrations in excess of 11.3 g/m<sup>3</sup> Nitrate-N. I have selected all the farm types from the ECan study that have concentrations in the leachate greater than 11.3 g/m<sup>3</sup> and these are presented in Table 8:

**Table:8 Nitrate Leaching from Farm Types with Concentrations over 11.3 g/m<sup>3</sup>**

<b>FarmType</b>	<b>Nitrate g/m<sup>3</sup></b>	<b>Drainage mm</b>	<b>losses kgN/ha/yr</b>
Apples	13.1	32.3	4.2
Arable (mixed grazing+dry)	20	168	33.6
Arable (seasonal grazing+dry)	24	136	32.6
Beef (dry)	11.8	125	14.8
<b>Beef (Irrig)</b>	<b>17.8</b>	<b>290</b>	<b>51.6</b>
Berryfruit	18.51	27.7	5.1
<b>Dairy (4 cows/ha+winteron)</b>	<b>11.9</b>	<b>294</b>	<b>35.0</b>
Golf course	20.279	45.1	9.1
Lifestyle pastoral	20.6	75.3	15.5
Pigs (outdoor)	35.2	111.1	39.1
Summerfruit	17.382	16.4	2.9
Vegetables	25.47	60.2	15.3
Viticulture	17.7	50.9	9.0

62. When these land uses are considered, the only land uses that could be representative of the CPWES are Irrigated Beef and Dairy farming. Drainage and Leaching losses for each of these are lower (although within the range) than those I have assumed in my previous assessment (refer Table 6 and Figure 3 of my second brief of evidence). Therefore if I were to use those ECan data, my predictions of increases in nitrate contamination would be less.

63. In Table 9 following, I have included the range of land uses in the ECan model for which leaching concentrations are less than 11.3 g/m<sup>3</sup>. This table shows that for the irrigated versus the non-irrigated land use, the irrigated option has a lower nitrate leaching concentration with a higher drainage volume, than for the non-irrigated land use. In terms of groundwater quality, the impact on groundwater would be less as a consequence of irrigation. This is a result of more water being drained, to offset the increased mass of nitrate leached.

**Table 9: Nitrate Leaching from Farm Types with Concentrations under 11.3 g/m3**

FarmType	Nitrate g/m3	Drainage mm	losses kgN/ha/yr
Apples	10.96	36.5	4.0
Arable (mixed grazing+dry)	11	265	29.2
Arable (seasonal grazing+dry)	10	262	26.2
Beef (dry)	10.9	189	20.6
Beef (Irrig)	11	467	51.4
Berryfruit	10.545	93.1	9.8
Dairy (3 cows/ha+winteroff)	3.85	286	11.0
Dairy (3 cows/ha+winteron)	8.39	286	24.0
Deer (dry)	6	125	7.5
Deer (Irrig)	5.2	290	15.1
Forestry - exotic (Dev)	10	10	1.0
Golf course	11.226	140.8	15.8
Lifestyle pastoral	10.9	98	10.7
Pigs (outdoor)	11.07	51.5	5.7
Sheep (dryland)	4	125	5.0
Sheep (irrig)	3.5	286	10.0
Sheep/Beef (10% beef+dry)	4	125	5.0
Sheep/Beef (10% beef+irrig)	3.5	286	10.0
Sheep/Beef (20% beef+dry)	4	125	5.0
Sheep/Beef (20% beef+irrig)	3.5	286	10.0
Summerfruit	11.077	55.5	6.1
Vegetables	10.05	135.7	13.6
Viticulture	8.85	50.9	4.5

64. I therefore believe that an assessment using these data will conclude that there is little or no risk to groundwater as a source of potable supply. Notwithstanding the above, I have been advised by ECan that the leaching data used in this assessment are under review, and that the new data are not yet available. I have therefore placed little weight on the use of these data.

### **Clean Water Inputs**

65. In the assessment by ECan, the input to the groundwater system is via the contaminated land drainage. There is no “clean” water input from a distribution system such as that which would occur from the headrace and the distribution canals. To put this into perspective, the total land drainage used in my modelling, is an average of 713 MCM/yr. The clean water input is an average of 263 MCM/yr or 37% of the total water. I also note that the drainage rates I have assumed under the post-CPWES scenario are much greater than the corresponding drainage rates that have been used in the ECan assessment.

66. The easiest option available in the ECan model to accommodate this extra clean water is to increase the drainage volumes and consequently decrease the drainage

concentrations so that the mass flux of nitrate remains unchanged. This will dilute the nitrate in the drainage water and will therefore lessen the predicted nitrate concentrations in the groundwater. The ECan model therefore offers no advantages to my approach in regards to this.

### **Single point data calculations**

67. The ECan model selects a representative land use, and applies a representative leaching loss to calculate representative nitrate concentrations. That model undertakes many calculations using a GIS platform that preserves the spatial information associated with the data (soil type, climate, landuse etc). However the calculation for each of these points, still does not include an allowance for, or an assessment of, the uncertainty or variability in the base data. The model uses an averaging technique to calculate an average concentration in the drainage water over an area of land, 1km in radius about any given point. This is an area of ~ 300ha, and in my terminology, becomes the size of the individual buckets used in the assessment. In comparison, I have used larger buckets, being defined by the total land area for a particular land use type within the same soil type and climate zone. Nevertheless, the ECan assessment does assume complete mixing of the drainage water within these 1 km radius buckets, but only produces a single value estimate for that concentration. Again in comparison, my calculation includes the variability in the drainage concentrations and the drainage volumes, to produce a wide range of values of concentrations pertaining to those land uses and locations. I believe there is more value in the approach I have adopted, even though I have lost spatial data.

### **Spatial Representation**

68. As previously mentioned, the ECan model retains spatial data associated with the calculations. Inputs along a stream flow path, contribute to the concentrations along that flow path, and as the groundwater moves down gradient, the concentrations increase due to additions, and decrease due to the mixing and dispersion processes within the groundwater. Thus at the downstream boundary of the scheme area, (approximately SH1 which is the line along which my assessment applies), variations in the predictions of nitrate concentrations along that line are spatially preserved, whereas my assessment has these all mixed in together. However if all the predictions along this boundary from the ECan model were taken together as a single data set, I believe you would start to get a data set similar to that produced from my modelling.
69. The reason for this is that concentrations in the ECan model along this boundary, are a necessary consequence of the land use and drainage activities up gradient from that point. It is highly likely that any combination of land use upstream from any point in the

ECan model is also represented by a combination of land use, soil type and drainage characteristics in my modelling, as I randomly select a full range of land uses above this boundary. Some of my selections will result in high concentrations and some will be low, much as can be seen in the ECan model where higher and lower concentrations are predicted along this line.

70. While there is spatial representation of the predictions in the ECan model, the same problem still exists with defining the depth of the contamination and the concentration that will be found in a pumping well. Pumping can result in water being sampled across a range of depths. As it contributes to vertical mixing at the point of abstraction.
71. For the above reasons, I have retained the methodology used in the earlier hearings to assess the nitrate concentrations from the modified scheme.

### Revised Nitrate Concentration Assessment

72. The land use scenarios used in this assessment are as contained in Tables 10 And 11 following. Table 10 relates to pre-CPW, where the current irrigated land area has been increased to 30,000 ha from my previous modelling (was 24,000ha) as this more accurately reflects the current situation and also represents the area of land that will form part of the fully irrigated part of the scheme. Table 11 contains land areas for the fully irrigated and partially irrigated mixed farming portions of the scheme area.

**Table 10: Land use by sub region before CPWES**

Sub-Region	Region	Soil WHC	Land Use	Title Area	Irrigated	Dryland
12	Darfield	60	Pasture	14752	1250	13502
4	Darfield	90	Crop	4064	1000	3064
14	Darfield	90	Pasture	18389	5000	13389
1	Darfield	120	Pasture	4765	1250	3515
5	Darfield	120	Crop	3500	800	2700
13	Homebush	60	Pasture	8873	1250	7623
2	Homebush	90	Crop	3063	0	3063
8	Homebush	90	Pasture	11610	1250	10360
6	Homebush	120	Crop	7648	2500	5148
15	Homebush	120	Pasture	3950	1000	2950
10	Te Pirita	60	Pasture	9023	4800	4223
7	Te Pirita	90	Pasture	12538	9500	3038
9	Te Pirita	90	Crop	821	0	821
3	Te Pirita	120	Crop	981	400	581
11	Te Pirita	120	Pasture	1372	0	1372
			<b>Total</b>	<b>105349</b>	<b>30000</b>	<b>75349</b>

**Table 11: Land use by sub region after CPWES**

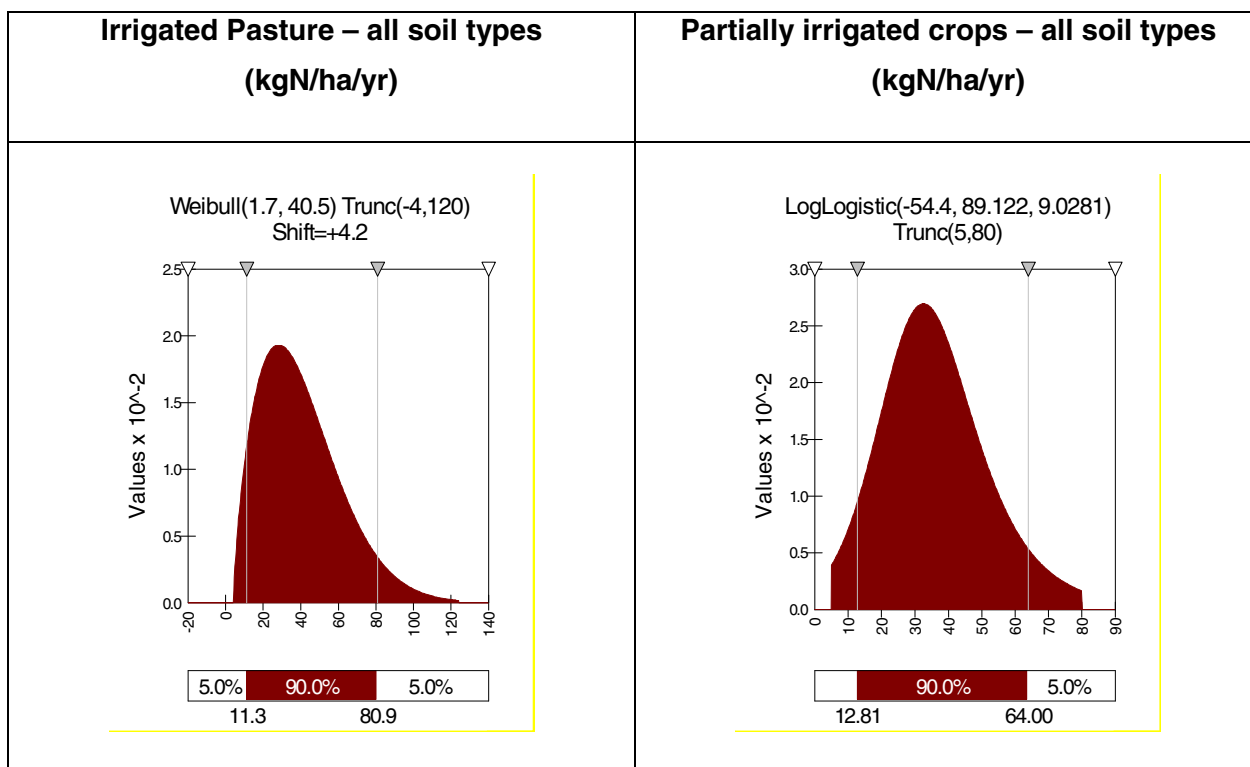
Sub-Region	Region	Soil WHC	Land Use	Title Area	Fully Irrigated	Partially Irrigated	Dryland
12	Darfield	60	Pasture	14752	4500	4500	5752
4	Darfield	90	Crop	4064	2000	2000	64
14	Darfield	90	Pasture	18389	5250	5250	7889
1	Darfield	120	Pasture	4765	1000	1000	2765
5	Darfield	120	Crop	3500	1750	1750	0
13	Homebush	60	Pasture	8873	2000	2000	4873
2	Homebush	90	Crop	3063	1500	1500	63
8	Homebush	90	Pasture	11610	2000	2000	7610
6	Homebush	120	Crop	7648	2250	2250	3148
15	Homebush	120	Pasture	3950	250	250	3450
10	Te Pirita	60	Pasture	9023	3250	3250	2523
7	Te Pirita	90	Pasture	12538	4000	4000	4538
9	Te Pirita	90	Crop	821	0	0	821
3	Te Pirita	120	Crop	981	0	0	981
11	Te Pirita	120	Pasture	1372	250	250	872
			<b>Total</b>	<b>105349</b>	<b>30000</b>	<b>30000</b>	<b>45349</b>

73. The quantities of clean water entering the system have been estimated by Aqualinc Research Ltd in the groundwater modelling described in the evidence of Mr J Weir. These are as contained in the following table, and represent small changes from those values contained in my Table 2 of my second brief of evidence.

**Table 12: Land use by sub region after CPWES**

Water Source	Typical Year	Dry year (1967)	Wet year (1978)
Upper catchment Streams	121 MCM/yr	56.1 MCM/yr	188 MCM/yr
Stock water races	62.8 MCM/yr	62.8 MCM/yr	62.8 MCM/yr
Headrace canal	31.5 MCM/yr	31.5 MCM/yr	31.5 MCM/yr
Distribution canal	23.9 MCM/yr	23.9 MCM/yr	23.9 MCM/yr
Bywash to ground	23.9 MCM/yr	23.9 MCM/yr	23.9 MCM/yr

74. Nitrate loss rates are the same as those in my previous evidence, apart from those used for the existing irrigated areas and mixed arable farming systems on the partially irrigated portion of the scheme area. For these areas I have assumed slightly lower areal leaching rates, commensurate with lower annual drainage volumes. These are as presented in Figure 8.



**Figure 8: Nitrate losses from partially irrigated land.**

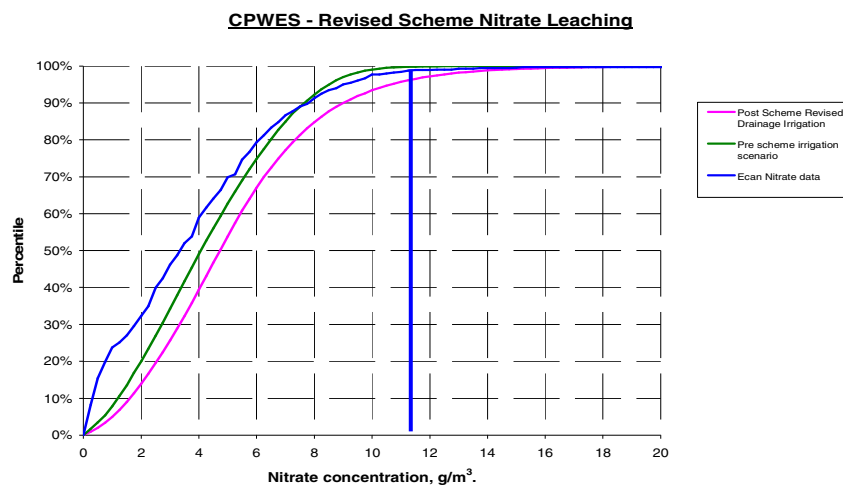
75. Drainage losses have been slightly amended to account for a peak on farm irrigation supply rate of 0.6 L/s/ha and new time series have been generated for the partially irrigated land. The drainage distributions for the partially irrigated land are a combination of dryland and irrigated drainage rates.
76. The modelling methodology I have used is the same as that previously presented. The only difference is that I have added 15 new land use categories representing the mixed arable farming for 30,000ha in the post CPW scenario.

### Modelling Results

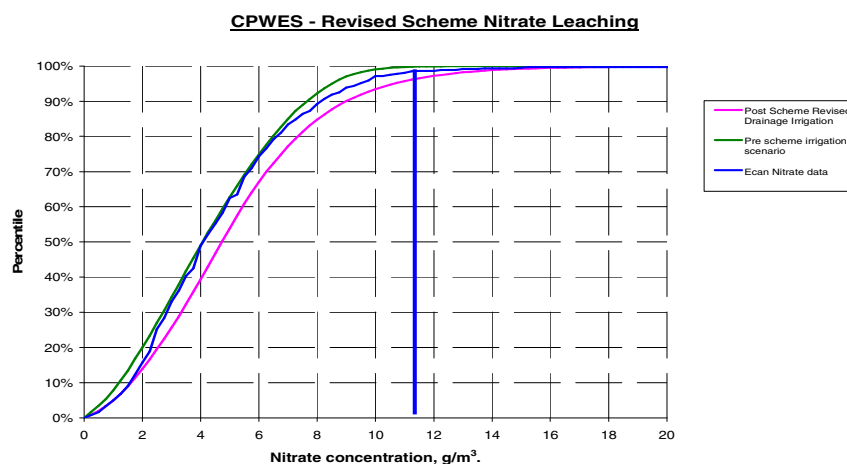
77. The results of the modelling are presented in Figure 9. The green line represents the existing land use scenario as described above. In this case, I have not attempted to calibrate the model at the low (less than 1 g/m<sup>3</sup>) end of the range, as these values are of little consequence. In the raw ECan data, there are a large number of nitrate concentrations less than 0.5 g/m<sup>3</sup>. These samples are likely to be those taken from areas where the influence of inflow from the Waimakariri and Rakaia Rivers is more pronounced. My modelling has ignored that water and its diluting effect, thus these close to zero values have not been replicated in my modelling. An alternate method of demonstrating this aspect, is to remove from the total ECan nitrate data set, those values close to zero. While I do not like manipulating raw data sets, it is interesting to

see how the ECan data set with values of less than 1.0 significantly reduced, more closely resembles the modelling results. This has supported my approach of not trying to replicate these near zero data values. Figure 10 contains my modelling results compared to the ECan data set with near zero values removed..

78. The median concentration is slightly higher than the existing data set and slightly higher than that presented in my previous evidence. This is because I have included a larger area of existing irrigation in my pre-CPW scenario. Of most importance is the shift around the median value and that around the MAV of 11.3 g/m<sup>3</sup>. I consider both of these differences to be small, especially given the assumptions made in the modelling regarding the high mass leaching rates of nitrate used.



**Figure 9: Nitrate concentrations for existing and future land use scenarios**



**Figure 9: Nitrate concentrations for existing and future land use scenarios compared to ECan data over 1.0 g/m<sup>3</sup>**

79. As a reality check of the results, I have calculated the total mass of nitrate that will be leached, and the total inputs of water from drainage and clean water sources. These calculations have been based on median values from the distribution ranges and represents an overall mass balance calculation as outlined below.

***Before CPW***

Existing drainage from scheme area:	431 MCM/yr
Existing inflow from upland streams etc:	192 MCM/yr
Total inflow volume	623 MCM/yr
Total existing mass of nitrate leached	2,590,000 kg/yr
Concentration	4.16 g/m <sup>3</sup>

***After CPW***

Post CPW drainage from scheme area:	450 MCM/yr
Existing inflow from upland streams etc:	263 MCM/yr
Total inflow volume	713 MCM/yr
Total existing mass of nitrate leached	3,350,000kg/yr
Concentration	4.70 g/m <sup>3</sup>

80. This mass balance calculation shows a very small change in nitrate concentrations. A reason for this is that even though there is more nitrate entering the groundwater system, there is more water through drainage and clean water sources to dilute the leached nitrate. The increase in drainage volume is ~90 MCM/yr. This is only a portion of the total water consumed by the scheme, which is ~ 240 MCM/yr. The difference is consumed through evapotranspiration by the plants.
81. Another reason as to why this increase is less than that predicted in my original evidence is that the productivity of the “partially” irrigated mixed farming system will be lower, and therefore from the total 60,000ha, less nitrate will be leached.
82. I conclude that there will be little change in nitrate concentrations in groundwater as a consequence of the scheme, and that this is very similar to the conclusion I drew in my previous evidence.
83. In relation to the down stream effects on water quality and the ecology of Te Waihora, my discussion presented previously about the most likely source of water in the lowland streams being that associated with local drainage (not from the scheme area), still holds. Therefore given my above calculations on nitrate leaching, and my interpretation of the data on lowland stream water quality, I do not believe there will be any significant change to water quality in the low land stream or Te Waihora.

**References:**

Bidwell V., Lilburne L., Thorley M., Scott D., (2009) Nitrate discharge to groundwater from agricultural land use: an initial assessment for the Canterbury Plains.

Duncan M., (2008) Waimakariri River: B/C Block allocation review. Report R08/67, Prepared for Environment Canterbury August 2008.