

OR 14 reconvened hearing

Officer report to the panel

Back ground and update

Reasonable and efficient use of water and Schedule WQN9 – OR14. The NRRP Hearing Panel hearing of these matters was held in October and November 2007. The hearing was adjourned and the hearing panel requested staff to arrange further discussions between Tony Davoren and John Bright to determine similarities in the methodology used to estimate annual volumes and work towards a common approach.

Staff reported back by memo dated 31 March 2008. This included changes summarised below:

These changes did not propose a change to WQN9 version 3. They did include changes to Policy WQN17, Policy WQN18 and Rule WQN25 (now Rule WQN15) to:

- (i) clarify how the use of water on a property that was supplied from more than one source was to be managed.
- (ii) clarify how irrigation schemes were to be managed
- (iii) introduce the terms “principal water supplier” and “component irrigation scheme”.
- (iv) include an investigation method that analyses water use data to better understand and manage irrigation demand.
- (v) include advocacy methods that:
 - monitor and demonstrate best irrigation practices
 - advocate to irrigation schemes fair and equitable sharing of the resource that is available to them, and self monitoring.
- (vi) amend Rule WQN25 to clarify what is a permitted activity and what is a discretionary activity.
- (vii) add a new Rule to provide for the conveyance of water by a “principal water supplier”
- (viii) amend Policy WQN18 to include both temporary and permanent transfers of surface water and groundwater takes, and to provide for the temporary or permanent transfer of the use of water.

Other discussions – WQN9 workshops

Since the hearing in 2007 discussions have also been occurring because of the restorative streams project that involves the review of groundwater consents in the Rakaia Selwyn groundwater zone. This review was initiated because of specific concerns about the amount of water that is being abstracted from this zone and the effect this is having on lowland streams in the area. The review includes assigning of annual volumes to all groundwater takes. ECan staff have been determining these annual volumes by applying the WQN9 version 3 methodology. Irrigation New Zealand and others have been promoting the use of the Irricalc model method. One media report (NZ Dairy Exporter May 2009) records that for one dairy farm the ECan approach “would cut his annual water take in half”.

Two workshops have been held to discuss the two methodologies and which is best to adopt. The main concerns for not accepting the volumes determined by WQN9 are:

- It calculates a volume of water which may not be enough in drier years. (The Irricalc method consistently calculates higher amounts. However making

comparisons has been difficult because the same defining parameters have not been used.)

- The risk of limited water would be accentuated in cases where the irrigation system can not operate according to the 80% application efficiency that is specified in the NRRP and applied in the current WQN9 calculation.
- Many irrigation systems are not as efficient as they were thought to be¹.
- “The WQN9 approach has too many approximations, adjustments and corrections to allow confidence in the values it provides.” (D Painter)

Discussions to resolve the differences have never been satisfactory. It has been difficult to compare “like with like”.

The second Rakaia Selwyn workshop recorded the outcomes as follows:

In general discussion, there appeared to be agreement in relation to a policy position of a base allocation of water to meet a one-in-five-drought with 80% irrigation application efficiency. This would be the allocation for any new applicant if the zone had further water available. There may also be a need for a bridging allocation for existing irrigators where their current equipment did not meet the 80% irrigation application efficiency benchmark. The bridging allocation would only be available for a transition period with shorter transition periods for older technology or larger bridging allocations.

The Davoren method could be used for calculating the base allocation. Irrigation NZ were contemplating the extension of the Irricalc model to cover all of Canterbury for base and bridging allocation calculations.²

There was also a desire for finding incentives to encouraging the use of the least volume of water in any season.

On the basis of the outcome of the workshop, Environment Canterbury will

- *Continue to use the WQN9 v3 as the basis for defining the volume of water that can be allocated for consent applications for a particular land use unless additional site specific information is provided to demonstrate that an alternative allocation is warranted or use a modelled approach with the model and its site application meeting performance criteria relating to calibration, verification and transparency of approach and assumptions.*
- *Explore an approach for consent reviews of existing consent holders using a base allocation derived from WQN9 (or a modelled alternative where the model meets the calibration and verification performance criteria) with a bridging volume for a specified transition period plus a review provision based on metered data.*
- *Commence a data collection programme based on lysimeters that is administered through the new university water centre to enable model verification for representative sites and land uses across Canterbury.*

¹ One thing that has come to light with analysis of lysimeter data from J Donkers property at Bankside is that there is a greater proportion of drainage occurring with irrigation than has been expected. This indicates that roto rainer, turbo-rain, gun and probably centre pivot irrigators greater than 500 metres in length will be unable to meet the 80% application efficiency standard.

² Following the workshop, advice was received from Irrigation NZ that a scope of work had been defined to apply the Irricalc model to pasture across Canterbury using the same input data rainfall as WQN9.

- *Work with Irrigation NZ and others on the development of a modelled approach to determining water allocation requirements.*

In light of these outcomes staff further revised Policy WQN17 to:

- Include a base and a bridging volume approach;
- accommodate the use of models, once they are verified and calibrated for assessing annual volumes

Throughout these discussions staff have pointed out that decisions on the management of the water quality effects of irrigation are likely to affect how the reasonable use of water aspect is managed. (In particular, if the recommendations that the use of water for irrigation is to be a restricted discretionary or discretionary activity for water quality reasons are adopted, then the reasonable use and annual volume considerations will also fall into this category.)

Prehearing meeting 1 May 2009.

The prehearing meeting was convened to allow all submitters on this part of the NRRP to hear and discuss where ECan had got to since the 2007 hearing, including the outcomes of the WQN9 workshops.

Material circulated included the proposed changes that were included in the March 2008 memo (summarised above) and the further changes that had arisen out of the workshops.

In addition, papers by Assoc Prof Hector Malano and David Painter were made available prior to and on the day. Malano provided a review of the Aqualinc model (Irricalc) and Painter provided a comparative review of the WQN9 and the Irricalc methods. These informed the discussion. Conclusions of these reports are attached as Appendix 1.

Ian Whitehouse facilitated the pre-hearing meeting and provided a report of the discussion.

The pre-hearing meeting canvassed the view of the attendees on the use of the current WQN9 approach and the Irricalc approach. There was strong support for the Irricalc method. While there was this support and there was agreement from ECan staff to further consider the use of the Aqualinc model, there was also recognition that documentation of the Aqualinc (Irricalc) model was not complete and there were some outstanding questions to answer. John Bright was to continue on this and complete it for circulation prior to the reconvening of the hearing. (Tony Davoren and John Bright have had a discussion on differences since the prehearing and ECan staff have provided a list of questions / comments for John Bright to consider.)

David Painter was to include consideration of the final Aqualinc documentation in his presentation to the reconvened hearing. At this time of preparing this report it has not become available to ECan.

In the period since the pre-hearing ECan staff have also had email discussion with Brent Clothier and Stephen Greene of Plant and Food Research. They operate the Plant and Food Research SPASMO model for modelling irrigation demand and have applied this for ECan. They have provided seasonal irrigation demand estimates for pasture, for three locations and for six soil types. They include Lincoln as one location. Table 1 below provides a comparison of this data with Irricalc results

provided for Lincoln in their June 2008 report³. These results give further food for thought.

Table 1: Irricalc and SPASMO comparison of irrigation and et results at Lincoln

Soil PAW (Irricalc) (mm)	Soil PAW SPASMO (mm)	Irricalc ¹				SPASMO ²			
		80%ile		90%ile		80%ile	Et (mm)	90%ile	
		Irrig (mm)	ET (mm)	Irrig (mm)	Et (mm)	Irrig (mm)		Irrig (mm)	Et (mm)
60	50	<u>567</u> (850)	813 (805)	<u>620</u> (875)	855 (844)	<u>620</u> (800)	976 (977)	<u>700</u> (850)	989 (990)
80	76	<u>572</u> (715)	817 (814)	<u>624</u> (770)	860 (854)	<u>550</u> (700)	973 (978)	<u>620</u> (750)	986 (989)
120	142	<u>520</u> (720)	817 (818)	<u>572</u> (720)	861 (861)	<u>500</u> (550)	975 (976)	<u>580</u> (600)	988 (989)

¹ The Aqualinc model (Irricalc) results are for a centre pivot and (rotorailer). The irrigation rules vary for the different soil types.

² The SPASMO results are for the irrigation rules - trigger at 60% PAW with a 10mm application and (- trigger at 50% PAW with a 50mm application but no return period limitation; i.e. irrigate whenever the trigger is reached).

The models produce different results. It is difficult to determine if this is an exact comparison of like with like. Different soil PAW are being compared. The irrigation rules used by each model are different and will contribute different annual irrigation results. The first results (underlined) of each model are considered to be for high application efficiency for each model representing centre pivot or linear move irrigation system. They should be adjusted to 80% AE to be more comparable with WQN9.

The SPASMO and Irricalc models calculate different annual volumes: e.g.

- On lighter soils SPASMO calculates a higher irrigation annual volume.
- On heavier soils Irricalc calculates a higher irrigation annual volume.
- The SPASMO model always calculates a higher annual ET.
- The difference in the seasonal irrigation demand between light and heavy soil types in the SPASMO model (80%ile) is large (120 mm – 250 mm).
- The difference between soil types in the Irricalc (80%ile) results is smaller (47 mm – 135 mm).
- The Irricalc model estimates a higher seasonal irrigation demand for the mid-range (80mm PAW soil) than for the lighter 60mm PAW soil under the centre pivot results for both 80%ile and 90%ile examples. It estimates a lower irrigation demand for the mid-range 80mm PAW soil than for the heavier 120mm PAW soil for the rotorailer in the 80%ile case but not the 90%ile case. By comparison the SPASMO model estimates a consistent reduction in seasonal irrigation demand from the light to heavy PAW soils under both irrigation rules in both 80%ile and 90%ile cases.

These results from daily water balance models using the same basic logic raise additional questions; e.g.

- Why the differences?

³ John Bright. Notes prepared for Workshop on Technical methods for estimating seasonal allocations for irrigation. 18 June 2008

- Will the further documentation and the revision of the Aqualinc model change any of the results?
- Are these comparing like with like?
- If model results can differ to this degree what is the best approach to take?
- Which model should be used? (Note that SPASMO has been recommended to be used to determine nitrogen leaching (Refer Rule WQL18)).

A comparison of the Aqualinc (Irricalc model) results and WQN9 version2 was provided in Table 4 of David Painters March 2009 report. An updated comparison is provided in Table 2 below for Lincoln and compares WQN9 v3, Aqualinc (Irricalc model) and SPASMO.

Table 2: Comparison of the Seasonal Irrigation Demand (SID) determined by Schedule WQN9 V3, Irricalc and SPASMO (80% application efficiency, 8 years out 10)

PAW WQN9v3	PAW ¹ Irricalc	SPASMO TAW ²	SID WQN9	SID Irricalc	Irricalc difference to WQN9 mm (%)	SID SPASMO	SPASMO difference to WQN9 mm (%)
<70		50	625			775	63 (24)
<70	60		625	729	104 (17)		
73		73	620			675	55 (9)
76		76	616			688	72 (12)
80	80		610	689	79 (13)		
120	120		550	702 650	152 (28) 100 (18)		
128		128	538			663	125 (23)
142		142	517			625	108 (21)
222		222	445			563	118 (27)

¹ PAW = Profile available water is the difference between field capacity and wilting point and represents the total water available to a depth of 1 metre expressed as millimetres of water.

² TAW = total available water (field capacity (-0.1 bar) to wilting point(-15.0 bar) to a depth of 1m

Note: There are still differences in the length of irrigation season (1 September or 1 October to 30 April) and irrigation strategy.

The SPASMO results from Table 1 have been adjusted by dividing by 0.8 to represent 80% application efficiency. The Irricalc SID numbers are taken from the same June 2008 report as Table 1. These are not exactly an 80% adjustment of the numbers shown in Table 1. When the Table 1 numbers are adjusted to 80% AE the demand becomes 709 mm, 715 mm and 650 mm for 60, 80 and 120 mm PAW soils respectively. Application of WQN9 V3 reduces the differences for the medium PAW soils. The differences range from WQN9 V3 being 13 to 28% less compared to Irricalc and 9 to 27 % less compared to SPASMO. The difference between Schedule WQN9 and SPASMO for the heavy soils (PAW / TAW 108 - 125 mm) is large. The difference in the mid range PAW / TAW soils is smaller (55 – 72 mm). The Irricalc difference is similar in this mid range. The Irricalc model is 104 mm greater on the light soils. The greatest difference between WQN9 V3 and the daily water balance models is for the 120 mm PAW soil demand calculated by Irricalc (i.e. 152 mm). However using the adjusted demand of 650mm (520mm/0.8) the difference between Schedule WQN9 and Irricalc reduces to 100 mm or 18%.

There remains a reasonable difference between the seasonal irrigation demand determined using Schedule WQN9 V3 and the models. Further investigation would

be worthwhile to determine the differences in the parameters that have been used. The additional work done on the Irricalc model may provide some better comparison. Adjustment of the Schedule WQN9 irrigation season length (i.e. from 1 September to 30 April) would assist improving these comparisons.

On the basis of this comparison there remains some uncertainty about the best way to go with Schedule WQN9. Given the recommended changes to Rule WQN15, making the use of water for irrigation a restricted discretionary or a discretionary matter, there is always going to be room for discretion as to which method to use. However it is proposed to use Schedule WQN9 to distinguish between restricted discretionary and discretionary activities. It is recommended later that Schedule WQN9 be amended to accommodate a longer irrigation season. This will increase the annual volume. It is also proposed that water use requirements for other irrigation activities be developed and incorporated into Schedule WQN9 in time.

The comparisons above with Schedule WQN9 indicate that it is calculating below what the models are calculating - between 9 and 27 percent. Some of these differences are difficult to explain. In this sense Schedule WQN9 may be conservative. But it is an important tool for determining the allocation status of zones and for guiding the determination of seasonal volumes. It is important to retain it as guidance while annual volumes are being assigned and as water allocation regimes are being established.

Discussion of parameters.

A number of parameters are applied to determine the annual irrigation demand – i.e:

- nominal irrigation season;
- reliability of supply;
- application efficiency; and
- actual use of the water.

Each of these was discussed at the prehearing and has been subject of earlier discussion during the hearings and the workshops.

Nominal irrigation season for determining total irrigation demand – WQN9 has used 1 October to 30 April. (SPASMO did not apply a season and Aqualinc (Irricalc model) uses 1 September to 30 April). This approach was applied when NRRP Variation1 was notified but specific reference was included in the definition of “total seasonal demand” as part of Variation 2. Submissions on this are directed to Variation 2. (Refer Rec WQN8.187). Many submissions and the pre-hearing meeting requested that the nominal irrigation season be 1 September to 30 April.

It was considered that changing the duration of the season would make only a small difference to the annual volumes and it was recommended that there be no change.

All who attended the Prehearing favoured using the season 1 September – 30 April. If this is adopted and WQN9 is retained the annual volume figures in Table WQN24 and the effective irrigation season rainfall maps would need to be revised. Once revised the application of Schedule WQN9 would likely mean a small increase in the allocated amount for each consent and groundwater zone.

Adopting the nominal irrigation season 1 September - 30 April is recommended. As a consequence Schedule WQN9 and the rainfall maps will need to be amended. Can this be done?

Reliability of supply. This is currently set as 4 years out of 5 (or 8 years out of 10). It has been requested that this be changed to 9 years out of 10 or better. A related request was that, if 8 year out of 10 was retained, there be inclusion of a three year moving average so that if the annual volume is not fully used in 1 year the unused amount can be carried over and taken on top of the allocation volume in the next one or two years. There was general agreement at the pre-hearing meeting that should this provision be applied that the 8 years out of 10 would be adequate. There is one case where Synlait has obtained this opportunity through a reference to the Environment Court. No option was favoured by all parties at the prehearing.

The reliability of supply approach is established in Policy WQN14. The 4 years out of 5 approach was recommended for setting allocation limits for groundwater allocation zones. If this was to be the limiting factor for the overall resource it was considered fair to apply this same approach when determining the reasonable use for each take. This was a defining parameter for the calculation of Total Seasonal Demand. This allowed for Schedule WQN9 to be applied estimating what is reasonably allocated to date.

To change to a higher level of reliability would require recalculation of Schedule WQN9 (if it was to be based on soil moisture data). The annual volume allocated to each water permit will increase that will in turn increase the volume allocated across each groundwater zone. Table 1 shows the differences between the 80 percentile year and the 90 percentile year as determined from the models. Irricalc calculates an increase of 52 mm regardless of soil type. SPASMO calculates an increase of 80 mm for shallow soils and 60 for the deep soils.

The difference was also discussed in Rec WQN8.178 and Rec WQN8.188. The difference estimated by ECan then was 25 mm or about one extra irrigation event. This was derived from an estimate of the difference in demand across the Central Plains area. It was recommended that no change be made. It was considered that this was a small difference and there were other variable factors that would offset this to a degree. (For example the exclusion of all rainfall events of less than 5 mm from the estimate of effective irrigation season rainfall.) The arguments that were presented there still hold if the rest of the Schedule WQN9 approach remains.

The suggestion of applying a three year moving average has merit, but it is considered that it should be incorporated with any approach (including adaptive management) that is developed and incorporated into each Schedule WQN3 groundwater allocation regime that is introduced.

It is recommended that there be no change to the four years out of five reliability.

Application efficiency 80%. There are two key issues to consider. Firstly, 80% application efficiency is difficult to attain and a number of parties have requested that this be lowered.

Secondly, there are a large number of water permit holders with irrigation systems that will not and can not meet this level of efficiency and if an annual volume condition is fixed on their water permit based on this standard, they will not have enough water to meet their annual needs. To meet this standard will require an upgrade of their system. Other factors (shape, slope, requirement for shelter and the like) may prohibit the adoption of more efficient systems. They seek a reasonable time to adapt or modify existing systems.

The 80% application efficiency was considered to be obtainable by centre pivot and other spray systems with good management. The analyses that have been carried out since the 2007 hearing have cast doubt on the 80% application efficiency. Lysimeter data has shown that roto-rainers are achieving on average 60% application efficiency. Based on instantaneous application rates of other irrigation systems, it is considered that few travelling systems (excepting linear move and centre pivots less than 500m long) can achieve an 80% (or better) application efficiency.

The Irricalc model results (Table 1) shows that a centre pivot and a roto-rainer operating under different irrigation rules (achieving different levels of application efficiency) on light soils at Lincoln will require different amounts of water – 567 mm for centre pivot compared with 850 mm for a rotorainer.

It was agreed at the prehearing meeting that there should be a base and bridging approach. New systems should target 80% application efficiency but there should be some grandfathering of old systems.

Provision for base and bridging annual allocation volumes has been included in the modified Policy WQN17 and is incorporated into the rules.

There is a note in the prehearing record that bridging volumes may not be required if reasonable volumes are allocated in the first place. For example if an application efficiency of 70% was used as the efficiency standard.

Ref Recs WQN8.21 WQN8.44 – WQN8.49

It is recommended that the goal of 80 percent application efficiency be retained. It is recommended that a bridging approach be incorporated into the Plan. If this is applied the transfer of any part of a water permit to take or use where there is a bridging volume component should not be permitted. There should be an end date set at which time the bridging volume expires. There may be a need to distinguish between bridging volumes and extra volumes that allow lower application efficiency for other reasons.

Land use. Policy WQN17(1) intends that the amount of water taken should be appropriate for the use intended. That has meant that the use should be identified and annual volumes assigned accordingly. The analysis of water demanded by arable crops (or a mixed cropping operation) compared with pasture indicates that these land use activities have different annual volume demands. Application of the SPASMO model to grapes in Marlborough indicates a seasonal irrigation demand of 185 mm to meet the demand in eight years out of ten (197.5mm for nine years out of ten)⁴.

Allocating water on the basis of the landuse has been opposed. One concern is that this limits flexibility and opportunity to change farming activities to adapt to changing market conditions. While this may be the case, the intention is to allocate the limited water resource to as many activities as possible. This means setting allocation limits for the resource and setting a limit on each water permit. The approach taken to date has been to provide sufficient water to meet the demand for the actual activity in eight years out of ten. It hasn't been intended to allocate water up to the maximum

⁴ Steve Green, Brent Clothier, Carlo van den Dijssel, and Markus Deurer and Pete Davidson: Measuring and Modeling the Stress Response of Grapevines to Soil-Water Deficits

rate that may be required to meet the highest demanding activity that can be carried out on the property. If this were the case there is potential for significant volumes of water to be allocated and not used, denying other people access unless it is transferred to them. It seems unfair that water should be captured in this way and then transferred, particularly if this allows for a profit to arise from the transfer. The allocation of water to meet the reasonable use requirements of the activity that is being carried out or intended to be carried out seems a more fair way to manage the water resource. This is not an issue until a resource is fully allocated. If there is still water available for allocation and a landuse change is proposed then it should not be a problem for an individual to obtain more water. If it is fully allocated it is preferable that it is allocated in a manner that means it is fully utilised.

For these reasons it is recommended that the approach of allocating water to meet the reasonable use requirements of the activity that is being carried out or intended to be carried out is retained. This is consistent with earlier recommendations.

Refer Rec WQN8.178 and WQN8.31.WQN8.170

Application to irrigation schemes.

Irrigation schemes may be small or large and involve one scheme or several schemes. Where there is more than one scheme there may be a principle water supplier. Their function may be to supply the water to the component irrigation schemes. This is the case with the Rangitata Diversion Race Management Ltd. They supply water to three irrigation schemes, stock water and hydro-electricity generation. In recognition of this the terms “component irrigation scheme” and principle water supplier” have been defined. These are being applied in the redrafting of the Rule to assist in clarifying the activity status of the use of water by irrigation schemes.

Schedule WQN9 was not intended to apply to irrigation schemes. Existing irrigation schemes have been developed in earlier times under different circumstances and generally were designed to distribute via open race systems and to irrigate via border dyke methods. Most irrigation schemes are working to improve their efficiencies and this is encouraged. Any proposal for an irrigation scheme to use water is intended to be a discretionary activity.

If an irrigation scheme does not have a water permit to use the water that is taken it will have to obtain one when the plan becomes operative. If they have an existing water permit to use the water then they will be able to continue operating in accordance with any conditions that are attached to the water permit until it expires or is reviewed.

Where an irrigation scheme has a water permit for the use of water then that is intended to apply onto the properties that it supplies. It will be up to the irrigation scheme to ensure that the conditions of their permit to use the water are complied with.

When the NRRP was notified Rule WQN25 provided for the use of water on a property that is supplied entirely from an irrigation scheme to be a permitted activity. On further consideration this provision is not necessary. The right to use water for irrigation on a property will have been covered by the irrigation scheme water permit when it was granted. Each property that is supplied by the scheme will have to

ensure they do what is necessary to comply with the water use permit held by the irrigation scheme.

There will however be cases where a property is supplied by a scheme and has a supplementary supply. This is treated as a dual supply.

Amendments have been proposed to the Rule which clarify how irrigation schemes are to be dealt with.

Dual supply

Dual supply is discussed in the March 2008 memo. There is no change in thinking since that was drafted. It is intended that where a property supplied by an irrigation scheme proposes to supplement its supply then this should be subject to further scrutiny over reasonable use and water quality effects. This is reflected in the Rules. Changes to define “principal water supplier” and “irrigation scheme” are intended to assist in clarifying how a property that is supplied from a private surface or groundwater take and an irrigation scheme are managed. It is intended that they are treated as a Discretionary Activity and address how they will operate in conjunction with the operational rules of the irrigation scheme. It is not intended that the irrigation scheme conditions will be affected every time a dual supply situation occurs.

Water Quality

Water quality matters have been considered at previous hearings. Hearing OR 25 which addressed all the Chapter 5 water quantity rules restructured the Rules and renumbered Rule WQN25 as Rule WQN15. At the same time it was recommended that, except for properties supplied solely by an irrigation scheme, water use for irrigation be a discretionary activity, to enable assessment of water quality effects. This same issue has been addressed in the OR 34 hearing recently. It was proposed there that Rule WQN15 be further amended to accommodate water quality conditions. A second option was included in the officers report which caused some uncertainty. A revised rule is included here aimed at addressing all matters that have come before the hearing panel in relation to this Rule. Refer Recommendations WQN11.296 and WQL13.122.

Recommended Changes

Recommended changes are included as Appendix 2.

Appendix 1.

Malano undertook this work for Irrigation New Zealand. He assessed the information provided to him by Aqualinc. He made five conclusions as follows:

1. On the basis of the documents provided and the structure of the Aqualinc model and the underlying calibration and validation processes, the approach used in the development of the model is adequate to be used as a tool for estimation of seasonal water demand.
2. The validation process used soil-plant-atmosphere model is based on sound principles involving lysimetric and field measurements. As such, the calibrated model provides reliable estimates of near maximum potential rate of crop irrigation demand for the crops concerned.
3. The Aqualinc model appears to be sufficiently robust for its intended end use (irrigated pasture) based on the validation and testing processes used in the model development and the source of model inputs.
4. The approach to determine the 80% percentile (sic) irrigation demand year is appropriate for the typical combinations of crop and irrigation management considered in the simulated modelling scenarios.
5. The reviewer sought and obtained the appropriate documentation, data and information to address the terms of reference set out for this review. These included a model technical report and additional information by email correspondence as necessary.

Painter undertook his review for the Rangitata Diversion Race Management Ltd (RDRML). He assessed WQN9 version 3 and the Irricalc model from reports and evidence that was available at the NRRP hearing and the subsequent workshops. His conclusions were as follows:

7.1 Work Brief Conclusions

1. Both methods are based on forms of 'conservation of volume' equations which are appropriate to the purpose.
2. Both methods make use of appropriate field measurements of water balance components.
3. The two methods differ markedly in the assumptions and approximations incorporated, the computational procedures employed and the seasonal irrigation demands they arrive at.
4. The Aqualinc method has the more robust methodology relative to scientific defensibility and the appropriateness of data and use requirements.
5. The Aqualinc method can be criticised for requiring data for calibration and validation that are not widely or locally available, such as lysimeter data for arable crops.
6. The Schedule WQN9 method more closely matches policy in the pNNRP than does the Aqualinc method.
7. The Schedule WQN9 method has too many approximations, adjustments and corrections to allow confidence in the values it provides.
8. The Aqualinc method is more appropriate for use in relation to the Rangitata Diversion Race schemes.

7.2 Related Conclusions

1. Both Schedule WQN9 and Chapter 5 Variation 2 more generally refer to "Application Efficiency" defined in a manner at variance with more conventional use.

2. The use of 80 %ile reliability of seasonal irrigation demand in connection with the Schedule WQN9 method has not been adequately justified in the relevant parts of Chapter 5 of the pNNRP.
3. Should Chapter 5 of the pNNRP be revised such that Schedule WQN9 takes account of losses of water between the take and the application devices, the RDR schemes could be subjected to scrutiny concerning infiltration losses from main and distribution races.