| | |
|---|---|
| **IN THE MATTER OF** | the Resource Management Act 1991 |
| **A N D** | |
| **IN THE MATTER OF** | an application for a Water Conservation Order pursuant to section 201 of the Act |
| **BY** | **NEW ZEALAND AND NORTH CANTERBURY FISH AND GAME COUNCILS AND NEW ZEALAND RECREATIONAL CANOE ASSOCIATION** |
| | **Applicants** |

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**STATEMENT OF EVIDENCE OF IAN McINDOE**
**FOR AMURI IRRIGATION COMPANY LIMITED**
**DATED 23 MARCH 2009**

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**IAN McINDOE** states:

1 My full name is Ian McIndoe. I am a Soil and Water Engineer and hold the qualifications of BE (Hons) from Canterbury University and Dip Bus Stud (Finance) from Massey University. I am currently employed as Principal Engineer by Aqualinc Research Ltd, of which I am a director.

2 I have over 30 years experience in water resources and irrigation related work. From 1984-90, I was the Ministry of Agriculture's water resources specialist involved in surface and groundwater allocation and management, including preparing the Ministry of Agriculture submissions on several water plans in Canterbury and other areas in New Zealand.

3 I have specialised in water allocation for irrigation and the effect of water restrictions on irrigation reliability and performance.

4 I am also an expert in irrigation design and irrigation efficiency, and have provided information and recommendations to Canterbury Regional Council covering several subjects including seasonal allocations, irrigation efficiency and irrigation reliability to help Council formulate their NRRP policies.

5 I am a board member of Irrigation New Zealand.

6 I acknowledge that I have I have read the Environment Court's Code of Conduct for Expert Witnesses as set out in the Environment Court Consolidated Practice Note 2006, and have complied with it when preparing my written statement of evidence and agree to comply with it when giving oral evidence. I confirm that the issues addressed in this brief of evidence are within my area of expertise. I have not omitted to consider material facts known to me that might alter or detract from the opinions expressed.

7 S207(b) and s212(a) of the RMA describe matters that have to be had regard to, such as economic impacts of the setting of water allocation rules under a Water Conservation Order (WCO).

8 My evidence relates to the assessment of the effects of three different allocation rules from the Hurunui River on reliability of water supply for the Amuri Irrigation Company Limited (AIC) Balmoral Irrigation Scheme (the Scheme). The allocation rules are:

(a) The minimum flows currently applying to the Balmoral Irrigation Scheme;

(b) The minimum flows proposed by Director General of Conservation (DoC) and the Royal Forest & Bird Protection Society of New Zealand (F&B) in their WCO submission; and

(c) An alternative raised by F&B (North Canterbury Branch) in its submission.

9 The evidence considers effects at the hydrological level, in terms of the Hurunui River's ability to provide water for abstraction for irrigation under different scenarios. This information has been provided to Mr Jonathan Davis to assess the economic effects of the different levels of water supply reliability on the Scheme. Information on water remaining in the river after abstraction under the different scenarios has also been supplied to Dr Greg Burrell.

**WATER USE REGIMES**

10 Water diverted from the Hurunui River for irrigation can take place in two ways; these being:

(a) Run-of-river supply, where water diverted on a particular day is used on that day. This includes shallow wells where hydraulic connection with the river is assumed;

(b) Diversion into storage, where water is stored for use at a time in the future.

11 The current diversions for irrigation, including the Balmoral Irrigation Scheme, from the Hurunui River are based on run-of-river supply. An open race is used transfer water from the Hurunui River to the Balmoral Irrigation Scheme.

12 The key feature of run-of-river supply systems is that the flows that can be diverted from a river on a particular day determine the potential use of water for that day. Any restrictions in supply, caused through the application of allocation rules from the river or from natural events, results in a shortfall of water for economic use, if water is required on that day. Allocation rules, therefore, have a direct effect on the reliability of water supply on run-of river schemes.

13 The components of allocation rules that influence water supply reliability for abstractive use are:

(a) Minimum flow – the amount of water that must remain in the river after abstraction has taken place;

(b) Block size – the maximum amount of water that can be diverted at any one time;

(c) Sharing rule – the proportion of the available flow that can be abstracted at flows above the minimum flow;

(d) Priority of use – whether a particular user or group of users have priority over other users of the resource.

14 Different minimum flows, block sizes and sharing rules may be set for different priorities of use. A more reliable block of water may be allocated as an "A" permit for run-of-river uses, while a less reliable block of water may be allocated as a "B" permit, which could be used for diversion to storage, for example.

## ABSTRACTIVE USE OF HURUNUI RIVER WATER

### Current Abstraction by Balmoral Irrigation Scheme

15 For run-of-river supply, the allocation rules could, in theory, range from allowing no diversion at all, leaving a river in its natural state, through to allowing full diversion at any time, assuming water was available from the river.

16 However, in the case of the Hurunui River, the Balmoral Scheme and other users of the water have allocation rules specified by conditions of consent. Because the proposed WCO minimum flows as they would apply to the Balmoral Scheme are not the same as specified in consent conditions, reliability of supply to the Scheme is different under the proposed WCO rules.

17 Currently, up to 5 cubic metres per second (cumecs) of water is diverted, by AIC under consent CRC951326.1, from the Hurunui River into a settling pond. Water is taken from the pond under consent CRC951327 for irrigation of up to 5240 ha of land within the Balmoral Irrigation Scheme.

18 The irrigation system normally runs from 1st September through to the end of April each season.

### Allocation Rule Options

19 The three flow scenarios considered in my evidence in assessing reliability of supply for the Balmoral Irrigation Scheme are:

(a) Current (status quo) Balmoral Irrigation Scheme;

(b) Director General of Conservation (DoC) and the Royal Forest & Bird Protection Sociey of New Zealand (F&B) submission; and

(c) F&B (North Canterbury Branch) submission.

20 The current Balmoral Irrigation Scheme allocation rule has minimum flows as detailed below, is in an allocation block of 5.0 cumecs and has no flow sharing. The allocation block is equal to the Scheme's maximum demand and is consistent with AIC's consent conditions:

| Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sept | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 12 | 12 | 12 | 12 | 12 | 12 | 12 | 13 | 15 | 19 | 18 | 13.5 |

21 The DoC/F&B submission is for a minimum flow of 40 cumecs from September to December, and 20 cumecs in January, February and August, with otherwise current minimum flows for all other months as summarised in the table below.

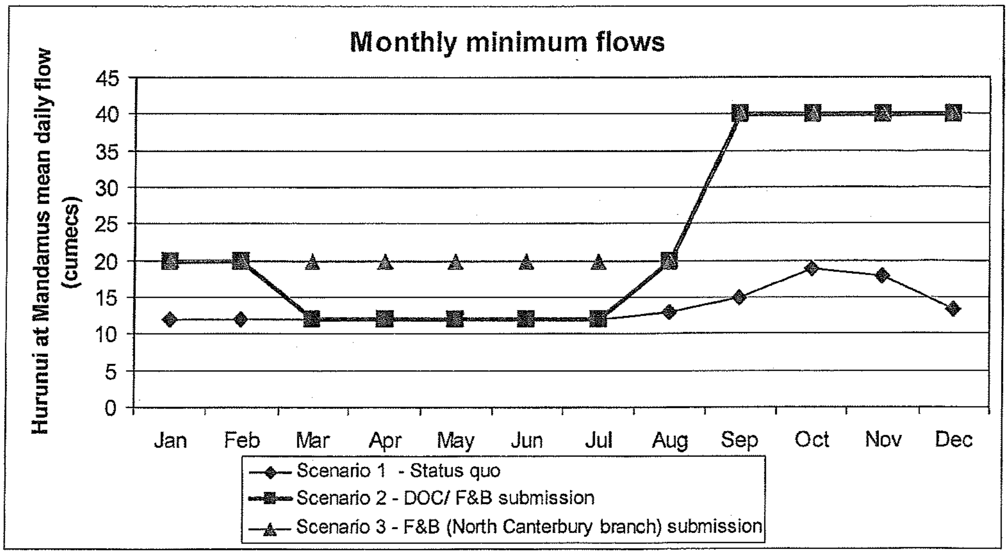
| Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sept | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 20 | 20 | 12 | 12 | 12 | 12 | 12 | 20 | 40 | 40 | 40 | 40 |

22 There is no requirement for flow sharing. I have assumed that equal priority will be given to existing abstractive users of Hurunui water in an 'A' block of 6.7 cumecs, as it is not stated in the submission. This is because if the minimum flows are changed, all abstractors in the block are likely to end up with the same priority. Currently, AICL for example, has slightly different minimum flows to other users. Although a note in a submission has been included asking for a gap between "A" and "B" permits I have not included any specific allowance for "B" permit allocations in my analysis as that will have no impact on the Balmoral Irrigation Scheme.

23 The F&B (North Canterbury Branch) submission seeks a minimum flow of 40 cumecs from September to December, and 20 cumecs in all other months. Again, there is no requirement for flow sharing; equal priority is assumed to be given to all abstractive users specified in the application within an 'A" block of 6.7 cumecs:

| Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sept | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 40 | 40 | 40 | 40 |

24 The minimum flows for the three scenarios are depicted graphically in the following figure.



**DEFINING RELIABILITY OF SUPPLY**

25 Four key factors have to be considered to quantify reliability of supply. They are:

(a) Severity – size or amount of restriction;

(b) Frequency – how often the restrictions occur;

(c) Duration – how long the restrictions last;

(d) Timing – when restrictions occur.

26 A restriction in water supply results in the inability of an irrigation system to fully replenish soil moisture deficits. When that occurs, production and farm profitability is reduced. The four factors determine the magnitude of decreases in production and profit.

27 My evidence quantifies the level of restriction imposed by the different allocation rules at the water supply-demand level to provide a relative level of effect of different allocation rules on supply reliability compared to the current allocation rules. My evidence does not address the effects on production and profitability. That evidence is provided by Mr Jonathan Davies.

28 There are several methods available to quantify reliability of supply of water for irrigation from a hydrological perspective. Each method encompasses some of the four key factors of severity, frequency, duration and timing, but no one method fully addresses all factors. For this reason, my approach is to use three different methods, to give an overall assessment of reliability of supply.

29 Because of the different methods of describing reliability, it is useful to categorise reliability into five bands, as follows:

(a) Very good reliability;

(b) Good reliability;

(c) Marginal reliability;

(d) Poor reliability;

(e) Very poor reliability.

30 With the addition of "Very good reliability", these reliability bands are the same as those used in the information presented to the Rangitata River Special Tribunal Hearing by Christina Robb (ECan, 2001).

31 Very good reliability usually demands unrestricted surface water or groundwater takes, and is required for irrigation of high value horticultural or arable crops, or very intensive irrigated agricultural systems. Intensive dairy farms usually require this level of reliability, for example, to avoid a potential reduction in production.

32 Good reliability demands water supplies that are limited to short infrequent periods of restriction. It is usually required for average or semi-intensive irrigated enterprises, and carries some risk of lost production or profitability.

33 Marginal reliability applies to water supplies subjected to more frequent and severe restrictions. It is not recommended to operate intensive irrigated farms under this reliability, as the risk of production losses are high.

34 Poor reliability applies to situations where restrictions are frequent and irrigation can only be considered as complementary to dryland farming. Storage of water to overcome the shortfalls is highly recommended.

35 Very poor reliability is not recommended unless storage of water is used to overcome shortfalls.

## RELIABILITY OF SUPPLY DEFINITIONS

36 The following three methods have been used to determine the reliability of supply for the five allocation options considered:

(a) Robb reliability bands;

(b) Farming experts reliability thresholds;

(c) Supply/demand ratios.

### Robb Reliability Bands

37 This method was established through informal discussions between Lincoln Environmental staff and farm advisors in Canterbury, and described in Robb & McIndoe (2001). The bands are defined as follows:

(a) Good reliability – Over 36 years of historical river flow, there are no more than three months (November to February) when restrictions greater than 50% are in place for more than 15 days, and never more than 10 days off from 1 November to 31 January.

(b) Marginal reliability – Over 36 years of record, there are no more than three months (November to January) when there is no water available for more than 15 days.

(c) Poor reliability – Over 36 years of record, there are no more than 20 months (November to January) (approximately 25% of months) when there is no water available for more than 15 days.

(d) Very poor reliability – Over the 36 years of record, there are more than 20 months (November to January) (approximately 25% of months) when there is no water available for more than 15 days.

**Farming Experts Criteria**

38 In a project carried out by Lincoln Environmental for CRC (CRC Report U01/1) that investigated reliability of supply, acceptable levels of reliability were discussed formally with key farmers and farm consultants from the Canterbury region. As part of this consultation, water availability thresholds (high and low) were quantified, as follows:

| | |
|---|---|
| To meet the high threshold | No more than three days without water from 1 December to 31 January in any irrigation season.<br>Full water available 50% of the time in September to November and February to April in any season. |
| To meet the low threshold | No more than 15 days without water from 1 December to 31 January.<br>Full water available 50% of the time in September to November, February and March in any season. Full restriction may occur in April. |

**Supply/Demand Ratios (annual, irrigation year, seasons)**

39 On any day during the irrigation season, the supply of water available under an allocation rule can be compared with the demand for irrigation on that day. If available supply equals or exceeds demand, reliability is 100%. If demand exceeds supply, reliability is calculated by dividing supply by demand to give a supply/demand ratio.

40 The daily ratios can be combined into weekly, monthly, seasonal (spring, summer, autumn), irrigation season (September-April) or annual figures. Irrigation season values are often used to indicate the overall reliability of a particular supply.

41 As a general guide, the following average irrigation season reliability assessments apply:

| | |
|---|---|
| 100% | Very good reliability |
| 94-99% | Good reliability |
| 87-94% | Marginal reliability |
| <87% | Poor or very poor reliability |

## DETERMINING RELIABILITY OF SUPPLY

42 The simplest way of assessing reliability of supply would be to consider the amount of time water could be taken from the river under the three scenarios. However, assessing reliability of supply of run-of-river water by considering the water that can be allocated from the Hurunui River in isolation from the irrigation demand of the Balmoral Irrigation Scheme would give an unrealistic evaluation of the reliability for irrigation.

43 The reason is that irrigation demand changes according to climate, soils, crop stage, irrigation method, irrigation management, and the risk that farmers are prepared to take in not always meeting full irrigation demand. Water may be available from the river, but it is not needed, or conversely, water may be needed, but it is not available. The timing and magnitude of supply and demand must therefore be considered.

44 In the case of Balmoral Irrigation Scheme, historical climate records from 1972 to 2008 have been used to establish abstractive use. Daily irrigation demand for the Balmoral Irrigation Scheme was calculated using Aqualinc's irrigation demand model.

45 It is important to compare available supply with required demand on a daily basis to quantify the shortfalls and assess reliability. Using monthly or seasonal averages can obscure important short-term shortfalls.

## RELIABILITY OF SUPPLY UNDER THE THREE SCENARIOS

### Reliability of supply criteria

#### *Robb reliability criteria*

46 The following table summarises the results of the analysis carried out using the Robb reliability criteria:

| Scenario | Reliability |
|---|---|
| ***1. AIC Balmoral Irrigation Scheme status quo*** | Good |
| ***2. DoC/ F&B submission*** | Very poor |
| ***3. F&B (North Canterbury branch) submission)*** | Very poor |

47 One of the key conclusions that can be drawn from this information is that none of scenarios results in "Very good" reliability. The most reliable allocation rule is Scenario 1 status quo, which has good reliability under these criteria. Increasing minimum flows, as proposed by the WCO applications, can only reduce this reliability.

48 Reliability under Scenario 2 and Scenario 3 is very poor and cannot be recommended for irrigation. Large scale storage would be required, and even then, it may not work. The proposed 40 cumec minimum flow from September – December is a primary reason for the very poor reliability, although the 20 cumec minimum flow in January and February also contributes to this poor reliability.

***Farming experts criteria***

49 Using the farming experts criteria, the following results were obtained:

| Percentage of irrigation seasons (Sep – Apr) meeting reliability | | |
|---|---|---|
| High threshold (good or very good) | Between high and low threshold (marginal) | Below low threshold (poor or very poor) |
| ***1. AIC Balmoral Irrigation Scheme status quo*** | | |
| 100 | 0 | 0 |
| ***2. DoC/ F&B submission*** | | |
| 8 | 31 | 61 |
| ***3. F&B (North Canterbury branch) submission)*** | | |
| 8 | 28 | 64 |

50 This method of analysis provides a more detailed indication of reliability over critical periods, because the reliability numbers are concentrated over defined levels of reliability at specific times rather than over the full range of reliability from zero water supply to 100% water supply. To obtain good or very good reliability under these criteria requires a highly reliable supply throughout the peak of the season and good reliability for most of the remainder of the irrigation season.

51 The analysis shows reliability of the Scenario 1 Balmoral Irrigation Scheme under status quo conditions is good or very good, An analysis of the data shows that the Scheme reliability passes the high threshold test in the critical peak months (December and January) in all seasons and in most of the early parts of the irrigation seasons. Some restrictions occur in March in some years, reducing the reliability from very good to good.

52 For the proposed WCO Scenario 2 and Scenario 3, the data shows that for about two-thirds of the time, reliability falls in the below low threshold (poor or very poor). For the remainder of the time reliability is marginal. There is failure to meet the reliability thresholds for a high percentage of time, rather than just in March.

***Supply-demand ratios***

53 Using supply/demand ratios, the following results were obtained. The figures in the table are based on supply-demand ratios calculated from modelled daily values using historical climate over 36 years of record.

| Option | Supply-demand ratios (%) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Sep | Oct | Nov | Dec | Jan | Feb | Mar | Apr | Season |
| **Scenario 1. Status Quo** | 100.0 | 99.7 | 99.1 | 100.0 | 99.7 | 95.4 | 90.9 | 95.9 | **97.6** |
| **Scenario 2. DoC/F&B submission** | 62.4 | 79.0 | 69.0 | 52.3 | 85.1 | 65.8 | 89.2 | 95.1 | **74.7** |
| **Scenario 3. F&B (North Canterbury Branch) submission** | 62.4 | 79.0 | 69.0 | 52.3 | 85.1 | 65.8 | 63.9 | 73.9 | **68.9** |

54 The supply-demand ratios show that Scenario 1, the Balmoral Scheme reliability under the status quo consent conditions is very good in September and December, good approaching very good in October, and November, good in February and April and marginal in March. The overall seasonal reliability is good, but not very good.

55 Under Scenario 2, (F&B/DoC proposal), reliability is very poor or poor through September to February, marginal in March and good in April. The higher reliability in March and April reflects the use of status quo minimum flows for those months.

56 Under Scenario 3 (F&B (North Canterbury Branch) proposal), reliability of supply is very poor throughout the irrigation season. January, at 85%, is the highest reliability, but is in the poor range. Overall seasonal reliability is very poor.

57 The small difference between the results for Scenario 1 and Scenario 3 in March-April reflects the effect of the different 'A' block size (5 cumecs for scenario 1 and 6.7 cumecs for Scenario 3).

**Reliability in dry seasons**

***Annual reliability***

58 I have selected several of the historically least reliable irrigation seasons to give an indication of reliability in a season of low flows. The following table gives the number of days in a particular season that there would have been restrictions. The >0% indicates the number of days when there was some restriction, including full restriction. The 50% indicates the number of days when there was at least a 50% restriction. The 100% indicates the number of days when water would be cut off.

| Restriction | Scenario 1 | | | | Scenario 2 | | | | Scenario 3 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | >0 | 50 | 75 | 100 | >0 | 50 | 75 | 100 | >0 | 50 | 75 | 100 |
| **1972/73** | 74 | 61 | 45 | 9 | 134 | 127 | 122 | 81 | 134 | 127 | 123 | 118 |
| **1977/78** | 38 | 29 | 19 | 14 | 141 | 123 | 108 | 84 | 144 | 126 | 114 | 95 |
| **1984/85** | 27 | 20 | 15 | 11 | 83 | 71 | 64 | 49 | 101 | 93 | 88 | 81 |
| **2000/01** | 38 | 30 | 25 | 21 | 125 | 102 | 96 | 82 | 137 | 121 | 112 | 103 |
| **2005/06** | 23 | 10 | 5 | 2 | 143 | 126 | 121 | 113 | 164 | 151 | 145 | 135 |
| **2007/08** | 44 | 22 | 10 | 8 | 150 | 137 | 114 | 100 | 175 | 161 | 151 | 138 |

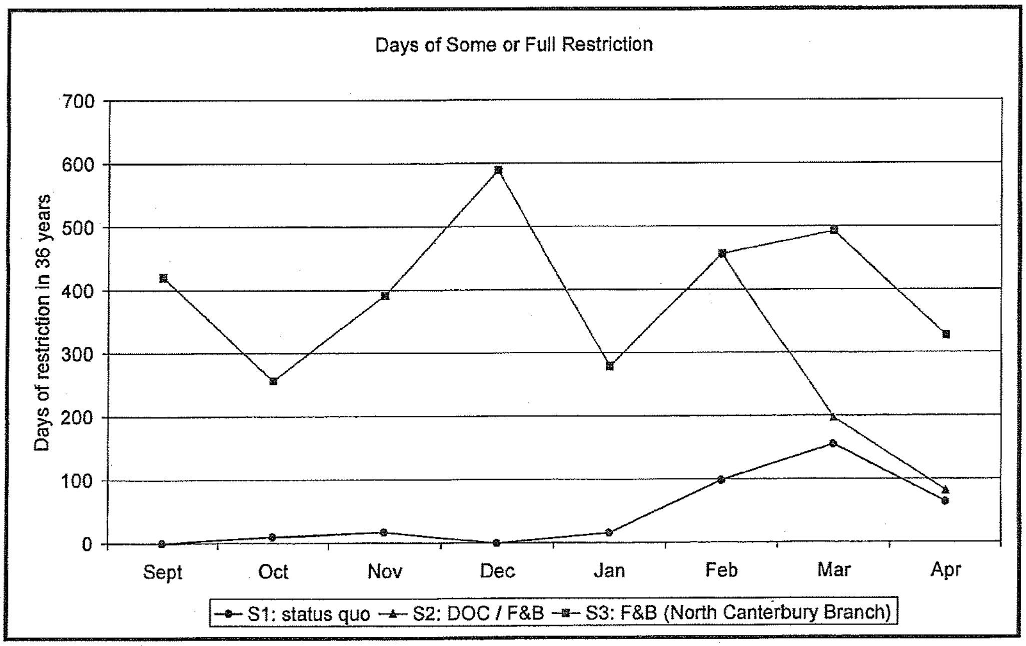
59 This shows that in dry seasons under Scenario 1, the status quo scenario, the Balmoral Irrigation Scheme would be on restrictions for significant periods of time, e.g. 74 days in 1972/73, although total restrictions would only have been applied for 9 days in that season. The fact that there are days of restriction confirms that reliability is not in the very good category in these years.

60 The days of restriction under Scenario 2 and Scenario 3 are very high, e.g. 164 days of restriction in the 2005/06 irrigation season for Scenario 3. Given that the irrigation season is at most 242 days long, and it is likely that irrigation was not required on some of those days, the percentage of time under restriction in dry seasons is very high.

***Monthly reliability***

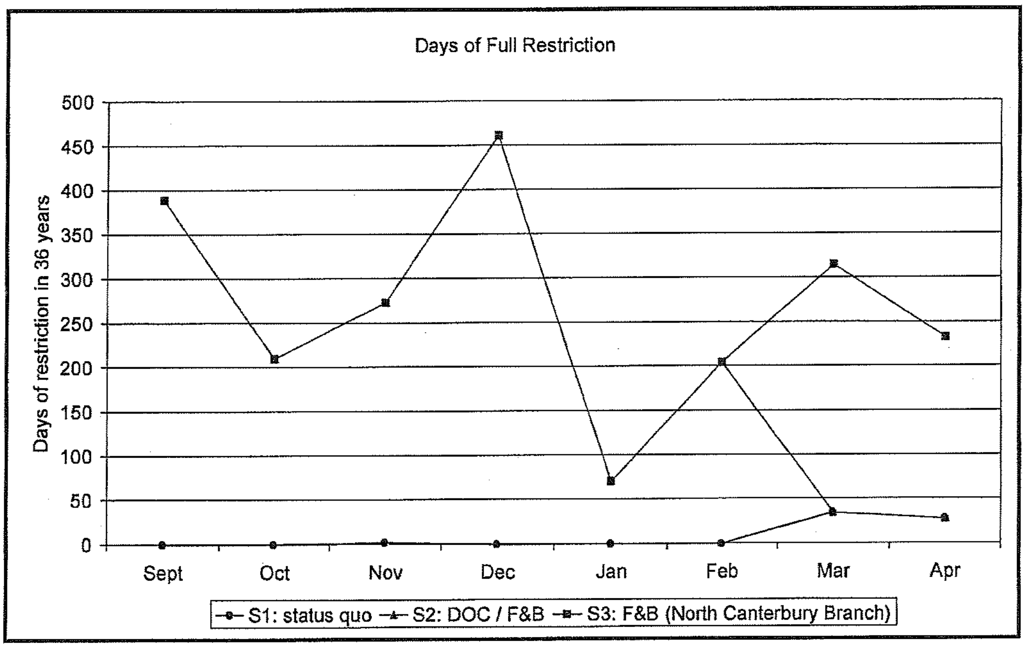
61 Annual figures give an indication of the severity and total number of restrictions in a season, but they don't illustrate the timing and duration of restrictions. Monthly profiles can help in that regard.

62 Graphs illustrating the days of some or full restriction over the 36 years of record (8712 potential irrigation days) are included below.



63 On a monthly basis, there is a marked contrast in reliability between Scenario 1 status quo and the proposed regimes under the WCO. For Scenario 1, the least reliable month is March, consistent with previous analysis and discussion. Reliability of Scenario 1 from September to January is very good.

64 In contrast, restrictions for Scenario 3 are high throughout the irrigation season. This is moderated to some extent for Scenario 2 in March and April, (still slightly worse than for Scenario 1) but those months are the lowest reliability for the status quo situation.




65 Days of full restriction for Scenarios 2 and 3 are much higher than for Scenario 1. It shows that water would be often cut off in September, probably resulting in a late start to the irrigation season. Not irrigating in the early part of the irrigation season can have flow-on effects for the rest of that season due to the difficulty in 'catching up' unless full reliability returns.

66 Total restrictions for Scenario 2 and 3 in December are also very high, which is one of the reasons why those options comprehensively failed the Farm Experts reliability criteria. That is the time when plants most need water – it is the peak growing season for most crops.

## CONCLUSIONS

67 The methods used to determine reliability of supply for irrigation water to the Balmoral Irrigation Scheme provide consistent results.

68 The analysis shows that reliability under the status quo minimum flow rules (Scenario 1) is very good most of the time through to March each irrigation season, but can drop off in March and in dry years (years of low river flows and high irrigation demand). Given that the Balmoral Irrigation Scheme is a run-of-river scheme, a reduction in the current reliability of supply cannot be recommended.

69 The analysis shows that reliability under the proposed WCO minimum flows (Scenarios 2 and 3) is very poor. Increasing the minimum flows as proposed will have an enormous effect on reliability of supply to the Scheme. These minimum flows are totally unacceptable for the Balmoral Irrigation Scheme.

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Robb, C and McIndoe, I (2001): Reliability of supply for irrigation in Canterbury. Report No 4465/1, prepared for Environment Canterbury. Lincoln Environmental, a division of Lincoln Ventures Ltd.

I. McIndoe

Ian McIndoe
23 March 2009