**BEFORE INDEPENDANT HEARING COMMISSIONERS**
**APPOINTED BY THE CANTERBURY REGIONAL COUNCIL**

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| **UNDER:** | the Resource Management Act 1991 |
| **IN THE MATTER OF:** | Proposed Plan Change 7 to the Canterbury Land and Water Regional Plan – Section 14: Orari-Temuka-Opihi-Pareora |

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# UPDATE OF THE EVIDENCE OF DR TIM KERR ON BEHALF OF THE ADAPTIVE MANAGEMENT WORKING GROUP (SUBMITTER NO. PC7-385)

Dated: 27 October 2020

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GRESSON DORMAN & CO
Solicitors
PO Box 244, Timaru 7940
Telephone 03 687 8004
Facsimile 03 684 4584
Solicitor acting: G C Hamilton / N A Hornsey
georgina@gressons.co.nz / nicola@gressons.co.nz

## 1 INTRODUCTION

1.1 My full name is Tim Kerr. My experience and qualifications are set out in my primary statement dated 17 July 2020.

1.2 The purpose of this statement is to provide an update to my earlier evidence following the Hydrology expert caucusing. This includes detailing the remaining outstanding matters not resolved through caucusing, and my opinion in respect of these. I also provide an overview of additional data analysis I have undertaken to further understand matters that arose during caucusing.

## 2 OUTCOME OF THE HYDROLOGY EXPERT CAUCUSING

2.1 Paragraph 39 of the Joint Witness Statement – Hydrology' (JWS) notes agreement that including a seasonally varying lake level trigger has advantages for adapting to periods of water shortage. That is, the lake level trigger threshold should be lower at the end of summer, than at the beginning of summer. This aligns with the underlying management and purpose of the lake storage. This seasonal variability was adopted by the Officer's Recommendations.

2.2 Agreement was not, however, reached on how to set the seasonally-variable lake level thresholds. As shown in my primary evidence (paragraph 10.9 and Figure 6), the method used by the Adaptive Management Working Group (AMWG) aligns with the current lake management, which was derived from 20 years of experience. Over those twenty years, the lake has been managed in different ways, including a period of time when the lake was purposefully kept low. For the Officer's Recommendation regime, the lake level thresholds were derived from the historic lake levels. The resulting thresholds conflict with the current lake level management and would lead to frequent un-needed regime triggers. It is my opinion that setting the lake level thresholds to align with (but below) the known operational management levels is the preferred approach.

2.3 It was agreed in Paragraph 42 of the JWS, that estimating the percentiles of historic data was appropriate for determining the trigger thresholds for snow-storage and lake inflow. The methods of achieving that were not agreed to. There are two aspects to this, the percentiles to be used, and the technique of calculating those percentiles from the data.

2.4 The thresholds affect the likelihood of a restrictive regime being triggered. A very low threshold means a trigger is less likely to occur and the chance is increased of the lake being emptied and the river drying up. Thresholds too high lead to too many unnecessary regime triggers. Ideally there should never be the need for a restrictive regime without a restrictive regime being triggered. The models of Canterbury Regional Council (CRC) and AMWG indicate that the CRC regime thresholds do not always enable a restrictive regime to be triggered when necessary as indicated by the simulated lake emptying on the dry years. The simulations of the AMWG regime did not empty the lake. In my opinion, this evidence demonstrates that the percentiles used by the AMWG are preferable.

2.5 The technique used by CRC of determining the actual threshold value (based on the percentile) from the historic data, led to the unusual situation where some of their lower percentile thresholds (Level 2) had the same value as higher percentiles (Level 1). This should not be possible. My primary evidence (paragraph 5.8 and Figure 1) shows that this was caused by the type of curve they used to fit the historic data. This situation does not arise with the curve selection and fitting technique used to prepare the AMWG threshold values (my evidence, paragraph 5.9 Figure 2). It is my opinion that the AMWG method of determining the threshold is more appropriate.

2.6 It was agreed in Paragraph 43 of the JWS, that premature exiting of a restrictive regime could occur if both the lake level and the inflows (or snow storage) are required to remain below their respective thresholds in order to stay in the regime. The example situation is when lake levels get very low after a long drought and then a rainfall event lifts the lake inflows above the threshold. Under this condition the proposed PC7 and Officer's Recommendation regimes would exit the restrictive regime and the lake would be further drained. The AMWG regime does not require exiting a restrictive regime until the lake level is above its threshold, irrespective of the lake inflows (and snow storage). I consider inclusion of the lake-only exit strategy necessary for correct regime operation.

2.7 It was agreed in Paragraph 44 of the JWS, that the adaptability of the regime is affected by the frequency of assessing the thresholds. More frequent threshold assessment prevents unnecessary lags in regime switching. The monthly threshold assessments in the proposed PC7 and Officer's Recommendations leads to an average 14-day delay. AMWG proposes daily assessments, which enables improved adaptability. I consider daily assessment of thresholds the preferred option.

## 3 POST EXPERT CAUCUSING ANALYSIS

### Maximum Water Take Scenario

3.1 The JWS (Paragraph 38) records agreement that similar assumptions were made in the modelling approaches of CRC and AMWG. A notable difference was in how the demand for water was modelled. The AMWG approach was for water demand to follow a seasonal variation aligned with the general pattern of water use. CRC assumed a worst-case maximum demand without a seasonal cap.

3.2 I have since implemented a “maximum take” scenario in the AMWG model to enable comparison with the CRC model results.

3.3 In the AMWG model, having the demand set to the maximum without seasonal variability and without a seasonal cap, reduced the AMWG regime availability of water for out-of-stream use to 80% (by volume), which is down from 93%, but is similar to the “corrected” CRC spreadsheet model of the AMWG regime availability percentage of 84%. Note that “corrected” refers to inclusion of the corrections for calculation anomalies discussed in paragraph 5.1 below.

3.4 With maximum allocation all year around, the AMWG regime still does not let the Saleyards Bridge flow drop below the ecological minimum of 3 $m^3s^{-1}$. The number of days in restriction increases substantially to 1931 days (from 1136) with 737 of these days during the irrigation season (from 505). During the low flow regimes, the lost abstraction volume was about three times the reduction in river flow volume (an equity ratio of 3:1). This is a change from a 4:3 equity ratio when the demand was limited to the irrigation season. The frequency of full restrictions doubled to 1 in 22 (from 1 in 52).

3.5 This result supports the CRC findings that even under the worst-case full demand scenario the AMWG regime is able to protect the ecological minimum flows at Saleyards Bridge (See Section 42A Report Appendix D.6, paragraph 6.37 and Figure 6), albeit at the cost of reduced abstraction availability and volume and increased periods of restriction.

**Canterbury Regional Council lake model anomalies**

3.6 To replicate the CRC water demand assumptions as closely as possible I reviewed the CRC spreadsheet models used to inform the Section 42A report. The models are referenced in Section 42A Report, Appendix D.6, paragraph 6.1, and were made available by CRC at https://www.ecan.govt.nz/document/download?uri=3858540. A model was not made available for the Officer's Recommendation variant. I found that these models appeared to not correctly account for water takes from the Opihi Mainstem when calculating Lake Storage and Saleyards Bridge flows. When these takes were included, the flow statistics were different to those reported. Most significantly, the low flow statistic (7 day mean annual low flow) for the PC7 and PC7-step 2 variants dropped to 2.3 $m^3s^{-1}$ and 2.2 $m^3s^{-1}$ respectively. The 7 day mean annual low flow values reported in Section 42A Report Appendix D.6, paragraph 6.32 and Table 6 were 5.36 $m^3s^{-1}$ and 5.33 $m^3s^{-1}$. The "corrected" low flow values are below the lowest CRC Saleyards Bridge minimum flow requirement of 3.4 $m^3s^{-1}$ (Section 42A Appendix E Part 1 Table 14(v)). The AMWG 7 day mean annual low flow was found to be 3.6 $m^3s^{-1}$. This change in the modelled low flows after correcting the CRC model spreadsheets is shown in Figure 1.

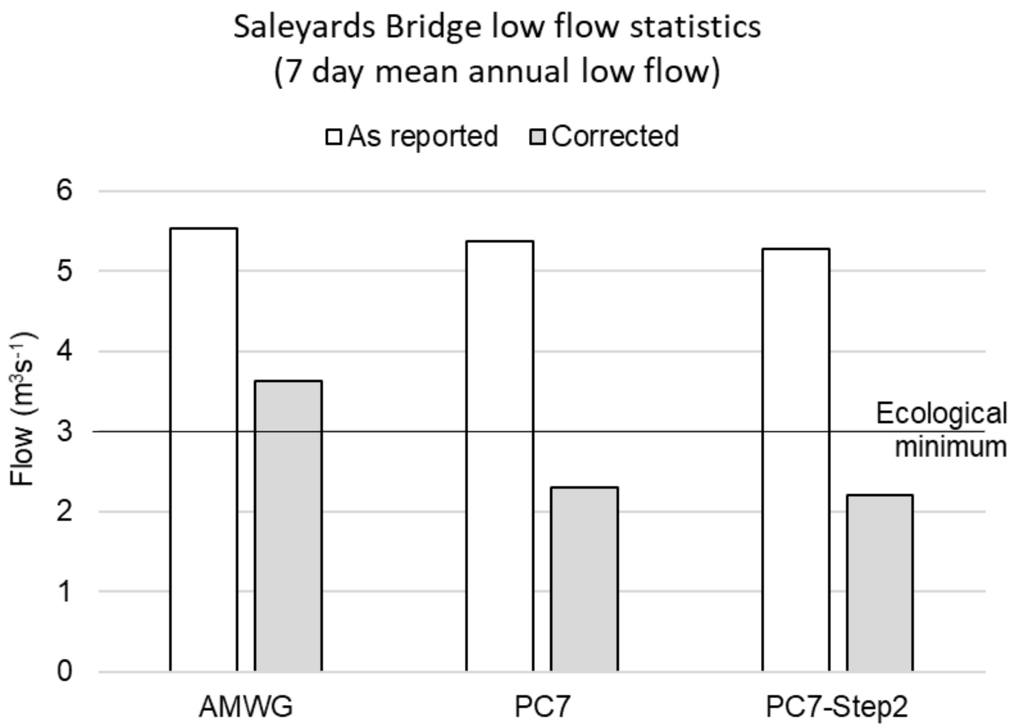


*Figure 1. Saleyards Bridge low flow statistics (7 day mean annual low flow). White bars are as reported in Section42 Appendix D.6 Paragraph 6.32. Shaded bars after correcting the source models to not include abstracted water.*

**Restrictive Regime occurrence frequencies**

3.7 Section 42A paragraph 9.52 states that the AMWG regime "...increases the frequency with which Level 1 and Level 2 flows are triggered…". The Section 42A report Appendix D.6 section 6.41, describes how many years (in the 20 years modelled) that either of the restrictive AMWG regime levels are triggered. The same measure is not reported for PC7 or for PC7-step 2. I have calculated this frequency for each of the regimes using the "corrected" CRC spreadsheet models (see Table 1 below). This indicates that the PC7 regimes trigger a Level 2 (severe) regime on at least 4 more years than the AMWG regime. This finding indicates that, contrary to Section 42A paragraph 4, the AMWG regime does not increase the frequency of restrictive regime triggers. The Officer's Recommendation regime was not included in the CRC models, so the frequency was not calculated. As discussed in my primary evidence (under paragraph 10.25) my independent simulations have shown the Officer's Recommendation Regime to have more days in restriction than the proposed PC7 regimes, so it too is likely to have higher frequency of restriction years compared to the AMWG regime.

*Table 1. Numbers of years out of 20 when a regime trigger occurred. AMWG (reported) values are from Section 42 Report, Appendix D6 Paragraph 6.41. The other values were determined from the corrected Canterbury Regional Council Spreadsheet models.*

| | **AMWG (as reported*)** | **AMWG** | **PC7** | **PC7-Step2** |
|---|---|---|---|---|
| **Level 1 (moderate)** | 15 | 15 | 13 | 14 |
| **Level 2 (severe)** | 4 | 7 | 11 | 12 |

## 4 CONCLUSION

4.1 AMWG and CRC both support the implementation of an Adaptive Management Regime. Their approaches are similar and are derived from the same origin. Both CRC and my own modelling for the AMWG have shown that the CRC variants are inferior for the purpose of maintaining ecological flows in the Opihi at Saleyards Bridge. A primary criticism of the AMWG approach has been the annual frequency of restrictive regime occurrence. The analysis I have completed post-caucusing using the CRC model, indicates that the PC7 regime options lead to worse outcomes of annual frequency of occurrence compared to the AMWG option.

4.2 Based on both my own and CRC's modelling and analysis I remain of the opinion that the AMWG's Adaptive Management Regime provides an appropriate and preferred solution for enabling ecological flows to be maintained during water shortage years.

**Tim Kerr**

27 October 2020