From: Georgina Hamilton
To: Plan Hearings
Cc: Judy Blakemore; mwebb; "Andrew Mockford"; Julia Crossman; Greg Ryder; Richard Measures; Tim Kerr; Tim Ensor
Subject: Plan Change 7: Adaptive Management Working Group (PC7-385) - Evidence in Chief
Date: Friday, 17 July 2020 5:11:43 pm
Attachments: Evidence in Chief of Judy Blakemore (AMWG) 17.7.20.pdf
Evidence in Chief of Mark Webb (AMWG) 17.7.20.pdf
Evidence in Chief of Andrew Mockford (AMWG) 17.7.20.pdf
Evidence in Chief of Julia Crossman (AMWG) 17.7.20.pdf
Evidence in Chief of Dr Gregory Ryder (AMWG & OWL) 17.7.20.pdf
Evidence in Chief of Richard Measures (AMWG) 17.7.20.pdf
Evidence in Chief of Tim Kerr (AMWG) 17.7.20.pdf
Evidence in Chief of Tim Ensor (AMWG) 17.7.20.pdf

Dear Tavisha

We act for the Adaptive Management Working Group (**AMWG**), submitter no. PC7-385.

We **attach** for filing, in relation to the above matter, statements of evidence in chief of the following witnesses on behalf of the AMWG:

1. Judy Blakemore (AMWG representative – Timaru District Council)
2. Mark Webb (AMWG representative – Fish and Game)
3. Andrew Mockford (AMWG representative - Opuha Water Limited)
4. Julia Crossman (AMWG representative - Opuha Water Limited)
5. Greg Ryder (ecology/freshwater quality) – please note that this statement of evidence also addresses matters pertaining to Opuha Water Limited's (OWL's) submission on PC7 and has been filed with the evidence of other OWL witnesses today).
6. Richard Measures (artificial freshes)
7. Tim Kerr (modelling)
8. Tim Ensor (planning)

Kind regards,

Georgina Hamilton
Partner

GRESSON DORMAN & CO
EST 1868

Level 1, 24 The Terrace, TIMARU 7910 | PO Box 244, TIMARU 7940
PHONE: 03 687 8004 | DDI: 03 687 8065 | MOBILE: 027 686 9252 | FAX: 03 684 4584
EMAIL: georgina@gressons.co.nz

BEFORE INDEPENDANT HEARING COMMISSIONERS
APPOINTED BY THE CANTERBURY REGIONAL COUNCIL

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

Dated: 17 July 2020

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

CONTENTS

EVIDENCE IN CHIEF OF DR TIM KERR

1 INTRODUCTION

1.1 My full name is Tim Kerr. I am a water scientist.

1.2 I am the sole director of Rainfall.NZ Ltd., a consulting firm that I set up in February 2020. From 2015 to February 2020 I worked as a scientist for Aqualinc Research Ltd. Prior to that I worked for a year as a hydro-meteorologist in Chile, and 5 years as a hydrologist at the National Institute of Water and Atmospheric Research (**NIWA**) in Christchurch.

Qualifications and experience

1.3 I have a doctorate and a Master of Science degree in Geography from the University of Canterbury. The topics of my Masters and Doctoral theses were related to observing and modelling of surface water resources in mountain areas of New Zealand.

1.4 I am a member of the NZ Hydrological Society, the NZ Meteorological Society, the American Meteorological Society and the International Glaciological Society.

1.5 I have 15 years' experience analysing water resource supply and use. My work over that time has focussed on rainfall, snowfall, and river flows, and has included:

(a) upgrading the rainfall maps of several mountain regions of New Zealand;

(b) assessing climate change impacts on rainfall, and describing the variation in the chemical composition of rain across the Southern Alps;

(c) managing a regional weather and river flow forecasting service in Chile;

(d) providing national daily weather forecasts and daily assessments of snow resources to a range of agencies;

(e) measuring and describing the variability of snow resources from the hill slope to the national scale;

(f) contributing to the improvement of the snow processes within NIWA's river flow modelling software (TopNet);

(g) assessing the impact of regional policy changes on river water quality; and

(h) assessing the potential impact of government policy changes to drinking water source protection policies.

1.6 My work generally involves addressing questions by collating data, processing it through models, mapping, and statistics, and then presenting it through forecasts, reports, presentations or web sites.

Background

1.7 To assist the preparation of Proposed Plan Change 7 to the Canterbury Land and Water Regional Plan (**PC7**), I provided technical assessments to Canterbury Regional Council and Opuha Water Ltd. of climatic influences on the hydrology of the Upper Opihi[1], seasonal forecasting potential for Lake Opuha inflows[2], and projected future snow storage for the Lake Opuha Catchment[3].

1.8 Since 2017 I have provided technical support to the Adaptive Management Working Group (**AMWG**) to help determine the hydrological conditions under which water shortage events in the Opihi catchment are likely. This work was to identify an appropriate set of "rules" for PC7's augmentation/minimum flow regime for the Opihi River at Saleyards Bridge that would avoid regular recourse to Water Shortage Directions (**WSDs**) under section 329 of the Resource Management Act 1991 (**RMA**) during water-short periods.

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[1] Kerr, T., 2017. Climate cycles and trends. Upper Opihi, Opuha and Orari (Client Report for Environment Canterbury No. C17063/1). Aqualinc Research Ltd., Christchurch. https://api.ecan.govt.nz/TrimPublicAPI/documents/download/3358919

[2] Kerr, T., 2017. Lake Opuha Inflow forecast system: Development and skill assessment (Client report No. C17063-2). Aqualinc Research Ltd. for Environment Canterbury and Opuha Water Ltd., Christchurch. https://api.ecan.govt.nz/TrimPublicAPI/documents/download/3472631

[3] Kerr, T., 2017. Projected future snow storage in Lake Opuha (Client Report for Environment Canterbury No. C17063/3). Aqualinc Research Ltd., Christchurch. https://api.ecan.govt.nz/TrimPublicAPI/documents/download/3358915

1.9 I am familiar with the provisions of PC7 to which these proceedings relate. In preparing my evidence, I have reviewed the relevant parts of the section 32 Report and the Section 42A Report. In preparing my evidence, I have also reviewed:

(a) Dodson, J., Steel, K., 2018. Current state of surface water hydrology in the greater Opihi catchment (Technical Report Science Group No. R18/80). Environment Canterbury, Christchurch.

(b) Clark, D., 2019a. Hydrology technical report to support the Orari-Temuka-Opihi-Pareora limit setting process (No. R19/67). Environment Canterbury, Christchurch. https://api.ecan.govt.nz/TrimPublicAPI/documents/download/3625802

(c) Clark, D., 2019b. Setting trigger levels and evaluating a flow regime for the Opihi River (Memorandum to Lyn Carmichael). Environment Canterbury, Christchurch. https://api.ecan.govt.nz/TrimPublicAPI/documents/download/3670910

(d) Talbot, J., McFarlane, H., Ulrich, H., Driver, P., Galbraith, K., Hurst, I., Pearse, J., Sintenie, A., Smith, G., Webb, M., Home, M., Henry, J., Eddington, S., Lyon, R., Munro, A., Anderson, D., 2018. Orari-Temuka-Opihi-Pareora Water Zone Committee Zone Implementation Programme Addendum (ZIPA). Orari-Temuka-Opihi-Pareora Zone Committee. https://www.ecan.govt.nz/document/download?uri=3507116

(e) Draft statements of evidence of other AMWG witnesses, including Judy Blakemore, Mark Webb, Andrew Mockford and Greg Ryder.

Code of Conduct

1.10 I confirm that I have read the Code of Conduct for expert witnesses contained in the Environment Court's Practice Note as updated in 2014. My evidence has been prepared in compliance with that Code. In particular, unless I state otherwise, this evidence is within my area of expertise and I have not omitted to consider material facts known to me that might alter or detract from the opinions I express.

2 SCOPE OF EVIDENCE

2.1 My evidence relates to the technical evaluation of the impacts on the flows in the mainstem of the Opihi River at Saleyards Bridge and availability of water for abstraction under the alternative management regimes proposed in PC7, the amendments sought by the AMWG in its submission on PC7, and in the recommendations made by the reporting officers set out in Appendix E.1 of the Section 42A Report (26 June Version) (**Officer Recommendations**).

2.2 My evidence is structured as follows:

(a) An overview of the Alternative Management Rules under PC7 and the AMWG's submission and how they differ.

(b) A description of the methods used to estimate how the PC7 and AMWG Alternative Management Regimes affect the flows of the Opihi River at Saleyards Bridge, and the availability of water from the Opihi River for abstraction.

(c) An explanation of the measures that have been used to assess the severity of the impacts of the three regimes.

(d) The results of my comparative assessment of the Alternative Management Regimes using the selected measures, showing the shortcomings of the PC7 regime.

(e) Comments on aspects of the Section 42A Report and recommendations made in that Report and Appendix D.6.

3 EXECUTIVE SUMMARY

3.1 Alternative Management Regimes, which are implemented during times of water-shortage, provide a mechanism to prevent ecologically damaging low flows from occurring. Experience has shown that the existing rules in the Opihi River Regional Plan (**ORRP**) do not prevent such low flows in the mainstem of the Opihi River.

3.2 I have modelled five variants of Alternative Management Regimes: PC7 (2025); PC7 (2030); that proposed in the AMWG's submission on PC7 (with and without stakeholder discretion applied); and the Officer Recommendations (2025). I have assessed the impact of these variants on the flows in the Opihi River at Saleyards Bridge. That assessment demonstrates that:

(a) The PC7 rules (2025 and 2030) are insufficient to prevent loss of augmentation flow during recently experienced drought conditions, leading to high risk of flows dropping below the ecological minimum of 3 m^3s^{-1} and an inability to maintain the regime's minimum flows.

(b) All rules simulated enough flow in the Opihi at Saleyards Bridge to maintain connectivity (above 2 m^3s^{-1}) for all the years simulated.

(c) All rules are similar in terms of statistics of water availability and regime implementation frequency.

(d) The Officer Recommendations lead to an improvement on the PC7 rules in terms of augmenting flows. Nevertheless, during climate conditions experienced over the last 20 years, the flows are still likely to drop below the ecological minimum of 3 m^3s^{-1} and the regime's minimum flows.

3.3 In addition, I note that:

(a) The snow storage and lake inflow thresholds for PC7 have been prepared using a methodology that results in values that prevent distinction between a level 1 and level 2 condition. In my opinion, this lack of distinction limits the intended benefit of a stepped approach to regime implementation.

(b) The lake level thresholds for PC7 do not reflect the seasonality of lake level management, which limits the ability to enter into a regime in the middle of the summer season but making it very easy at the end of the summer.

(c) The seasonally variable lake level threshold used in the Officer Recommendations does not align with current lake management strategies and would lead to restrictive regimes[4] most summers.

[4] In my evidence, I have used the term "restrictive regime" to describe a regime where reductions are placed on water availability to abstractors or minimum flow conditions. These are level 1 or level 2 regimes under PC7 and the AMWG's regime, or a level 2 under the Officer Recommendations.

(d) The inflow threshold settings limit the ability of the PC7 and Officer Recommendations regimes to remain in a restrictive regime.

3.4 Of all the regimes tested, the AMWG versions were the least likely to drain Lake Opuha and thereby lose the ability to augment the flows to ensure they do not drop below the ecological minimum of 3 m^3s^{-1}.

4 OVERVIEW OF THE REGIMES

4.1 The rules associated with the Alternative Management Regimes[5] proposed by PC7 and as sought in the AMWG submission are very similar. This is a result of PC7 adapting an early variant proposed by the AMWG, which was informed by the technical assessments I undertook and are referred to above at para 1.7. Further variants are recommended in the Section 42A Report and Appendix D.6 of that Report, which I address separately in Section 9 of my evidence

4.2 All versions determine when their respective Alternative Management Regimes may be applied by considering the state of:

(a) the catchment snow storage;

(b) the lake inflows; and

(c) the level of Lake Opuha.

4.3 For the PC7 and AMWG regimes, two thresholds (level 1 and level 2) are assigned to each of these environmental factors. When two thresholds of the same level (or greater) are crossed, the Alternative Management Rules for that level are implemented. The two levels vary in the severity of the water take restrictions and the minimum flow reductions imposed.

4.4 The main differences between the PC7 and AMWG rules are as follows, which I discuss in the following sections of my evidence:

(a) the environmental factor thresholds;

[5]Alternative Management Regime is defined in PC7 as "…a flow management regime developed to achieve environmental flows in the Opihi River and which takes into account the depth of snow pack, inflows upstream of the Opuha Dam and the level of water in Lake Opuha". However, the Section 42A Report recommends its deletion. In the Section 42A Report, the equivalent concept is described in Appendix E.1 Policy 14.4.37 as "*…a two-tiered minimum flow regime…".*

(b) the water abstraction restrictions;

(c) the minimum flow reductions;

(d) the frequency of assessment of the environmental thresholds for the Level 1 and Level 2 restrictive regimes;

(e) the minimum period of time in a restrictive regime; and

(f) the rules for exiting a restrictive regime.

5 Environmental factors

5.1 There are several differences between the three environmental factors under each regime, which are summarised in Table 1 below and explained in the following paragraphs.

Table 1. Differences between environmental threshold selection for PC7 and AMWG Alternative Management Regimes.

Attribute	PC7	AMWG
Level 1 Snow and Inflow Threshold percentile	20th	25th
Level 2 Snow and Inflow Threshold Percentile	5th	10th
Percentile threshold methodology	Fitting a power curve to the observations	Fitting a Generalised Extreme Value Distribution to the observations
Months when snow is considered	July to December	August to November
Level 1 Lake Level threshold	50 %	15 % below the operating intent[6]
Level 2 Lake Level threshold	25 %	25 % below the operating intent[6]

[6] "Operating intent" refers to the seasonally varying lake level range that Opuha Water Limited aspire to keep the lake within as discussed in section 5.11

5.2 For each regime, the snow storage and lake inflow thresholds have been set to reflect the seasonal hydrological and water use cycles. Consideration of historic (1998 to 2017) inflows into Lake Opuha, and snow storage in the Lake Opuha catchment enabled identification of the relatively low-water conditions for any time of year. Seasonally varying percentile-based thresholds were selected for these environmental factors.

5.3 To avoid the impact of single snowfall or rainfall events, the percentiles were based on an averaging period. For the PC7 regime, the percentiles were the lowest 20th and 5th, calculated over the previous month. For the AMWG regime, the lowest 25th and 10th percentiles were used, averaging over the previous 30 days.

5.4 The threshold percentile affects the frequency of occurrence of the event. The PC7 thresholds were set to keep the likelihood of a restrictive regime at a minimum. The AMWG thresholds were set at a level that is less likely to limit the ability to enter a restrictive regime given the need to do so based on secondary cultural, social, ecological and economic considerations (which I discuss later in my evidence in section7.5).

5.5 For PC7 the thresholds vary from month to month. For AMWG, the thresholds vary every day.

5.6 For PC7 the snow storage thresholds are only applicable from July to December (inclusive). However, for the AMWG regime, they are applicable for the reduced period from August to November (inclusive). As July and December snow storage are poor indicators of subsequent inflows to Lake Opuha[7] they were not included in the AMWG's regime as that would lead to false triggering.

5.7 For each regime, the percentile thresholds were calculated by fitting a curve to the observed recurrence interval of each factor, for each month (PC7) or day (AMWG). The formula of the curve was then used to determine the threshold value at the desired threshold percentile. Use of a curve is helpful when a very long record does not exist. This method relies on the curve being a reasonable fit to the observed data and that the values decrease as the recurrence interval increases.

[7] Kerr, T., 2017. Lake Opuha Inflow forecast system: Development and skill assessment (Client report No. C17063-2). Aqualinc Research Ltd. for Environment Canterbury and Opuha Water Ltd., Christchurch.

5.8 The PC7 percentiles were determined using a power law curve (Clark 2019b), which resulted in some identical thresholds for different percentiles (e.g. May and December Inflows, and July and December snow storage). This should not occur. This means the level 1 threshold is pointless. The power law curve used for the May inflow data is shown in Figure 1 (per Clark 2019b). This indicates that the fit of the curve is not very good, and the thresholds determined from the fit do not reflect the underlying data.

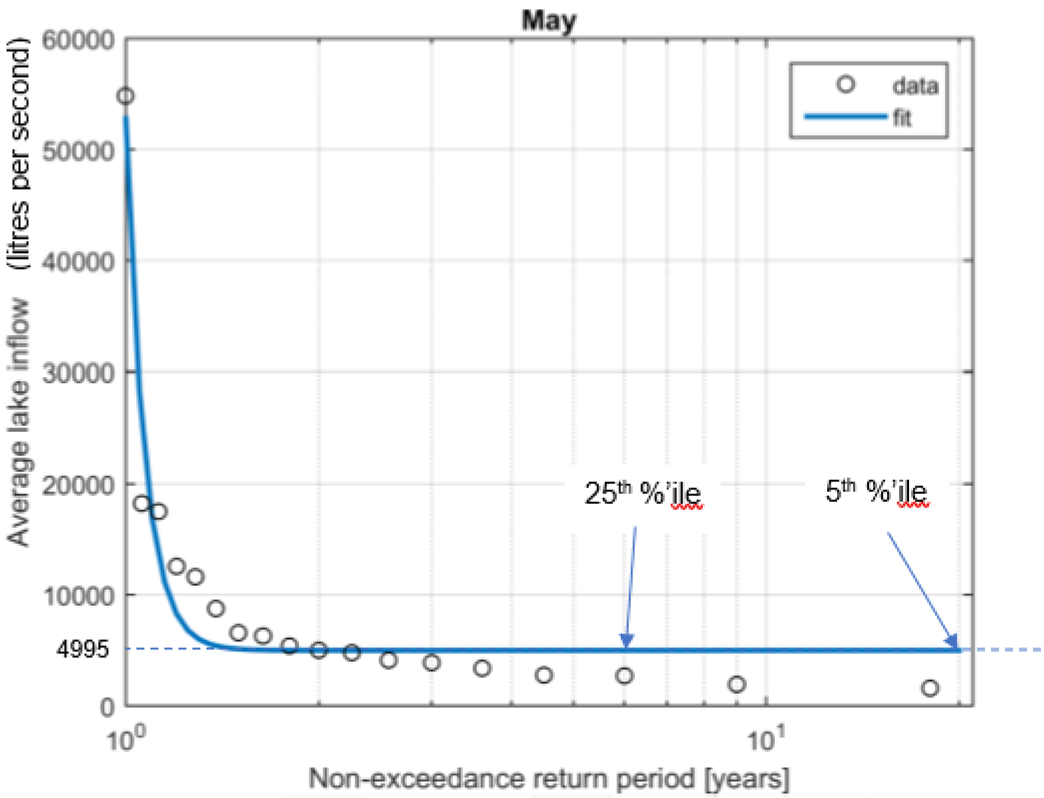

Figure 1. The curve used to fit to the observed May inflow data which resulted in PC7's identical 25th and 5th percentile values of 4995 litres per second. Graph annotated from: Clark 2019b. Note that the original had incorrect units in the graph's y axis labels.

5.9 In developing the AMWG regime, I used the Generalised Extreme Value (GEV) distribution to find a fit to the observations. This family of curves is more commonly used in this kind of application. An equivalent graph of the fit of the May inflows to the Generalised Extreme Value function is shown in Figure 2**.**

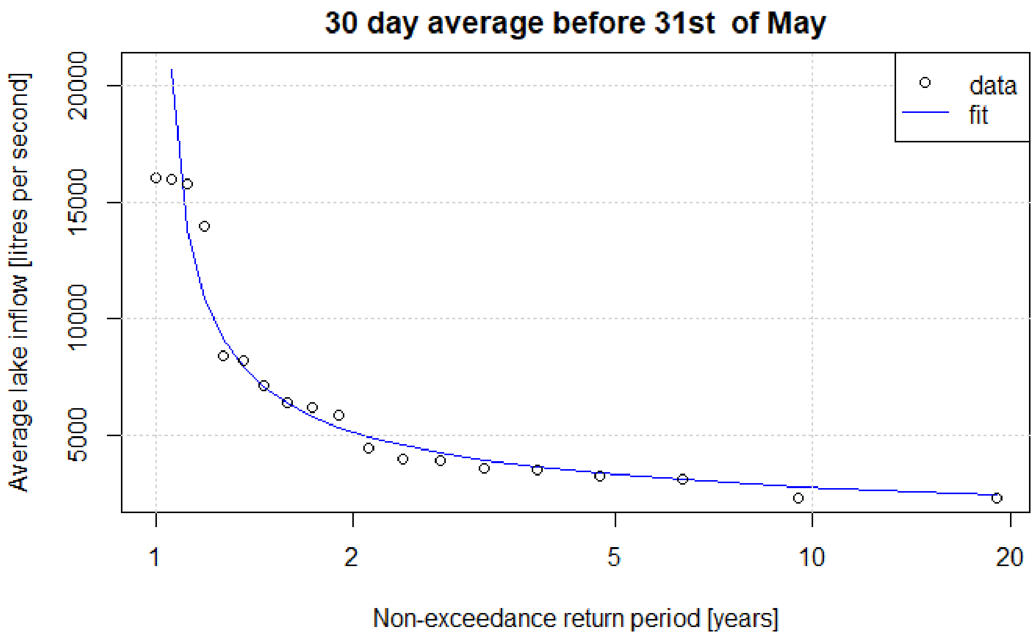

Figure 2. An example of the Generalised Extreme Value curve used to fit to the observed inflows and used to determine thresholds for the AMWG regimes.

Lake level thresholds

5.10 Each regime had a different approach to setting the Lake Level threshold. PC7 implemented a single threshold of 50 % Lake storage for level 1, and 25 % for level 2. The AMWG regime utilises a seasonally varying lake level threshold based on Opuha Water Limited's (**OWL's**) "operating intent".

5.11 The operating intent is the lake storage range that OWL aims to keep the lake within. The range varies throughout the season. Mr Mockford has explained how the operating intent has been developed and has noted that if the lake is within the operating intent range, then OWL is confident of being able to supply the required flows over the remaining season to meet minimum flow requirements and downstream abstraction needs. The operating intent has been developed from experience, as Mr Mockford explains.

5.12 Figure 3 below depicts the seasonally varying operating intent, together with the Level 1 and Level 2 thresholds for the two regimes. AMWG thresholds are set below but follow the operating intent. For PC7 level 1 and 2, the lake level thresholds are fixed and so do not change through the year.

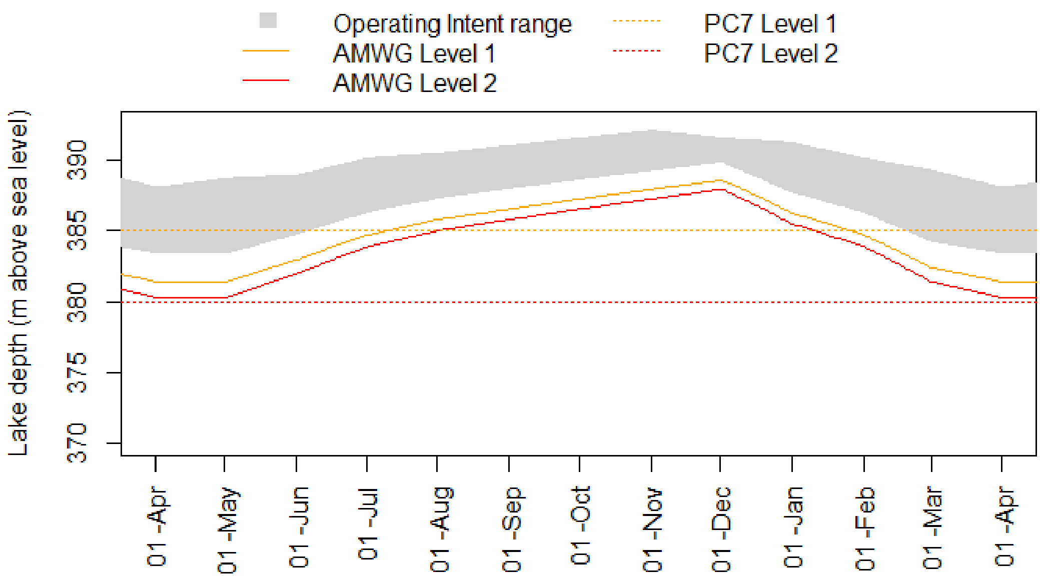

Figure 3. Lake level thresholds and the operating intent.

5.13 From the operating intent perspective, the PC7 Level 1 threshold is very high late in the irrigation season (March to May) and very low in the middle of the season (October to January). The AMWG lake level thresholds were informed by discussions with the OWL lake managers, to reflect their experience of critical lake levels.

Threshold assessment frequency

5.14 Under PC7, the environmental thresholds are assessed once a month, at the commencement of the month. This means that there is up to a month delay to change into a restrictive regime if it is required. The AMWG regime enables daily assessment of the thresholds and immediate implementation. A daily system reduces the likelihood of a delay in implementation of a restrictive regime when it is needed.

Exit strategies

5.15 The regimes vary in the manner under which a restrictive regime is forced to be exited. The PC7 regime requires leaving a restrictive regime if the environmental threshold conditions are not met. This has potential for issues under some conditions. For example, when a restrictive regime is in place and the lake has lowered substantially and then a rain event occurs, which causes the inflow threshold to be crossed but has little effect on filling the lake. Under this condition, the PC7 regime requires the restrictive regime to be exited, leading to accelerated storage loss. Under the AMWG's regime, forced regime exit is based on the lake level only. This arrangement ensures storage recovery to a level appropriate for the time of year prior to restrictions being lifted.

6 HOW THE ALTERNATIVE MANAGEMENT RULES WERE ASSESSED

6.1 I prepared a computer model (**Lake Opuha Model**[8]) that accounts for the daily variation of the flows of the Opihi at Saleyards Bridge. The Lake Opuha Model is a daily time-stepping water balance model. It is implemented in the R scripting language. The model inputs are lake inflows, tributary flows, estimated snow storage, lake management rules and water allocation rules. The lake inflows, tributary inflows (adjusted to account for PC7's proposed Table 14(w) 2030 limits) and snow storage were taken from the historic record (from 1998 to 2017[9]).

6.2 The intent of the model was to test the impact of the different Alternative Management Regimes on the flows of the Opihi River at Saleyards Bridge under the hydrological conditions experienced between 1998 and 2017.

6.3 The assumptions I used in the model were arrived at by balancing pragmatism and reality. The assumptions included:

(a) Water was abstracted when it was available based on a seasonal demand curve created from historic demand variation supplied by OWL

(b) Seasonal allocation limits associated with consents were not considered.

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[8] Available at https://github.com/Aqualinc/LakeOpuha

[9] The 1998 to 2017 period has been used as it was the longest period available when the modelling efforts began. The period has not been extended in an effort to maintain consistency of outputs during proposal, submission and evidence development.

(c) A buffer of 0.1 m^3s^{-1} was added to the required Opuha Dam release flows to ensure natural variation in flows did not breach low flow rules.

(d) The lake was managed to attempt to keep within the seasonally-varying operating intent as advised by OWL and discussed in Mr Mockford's evidence.

(e) Lake area changed with Lake level.

(f) Rainfall into the Lake was not considered.

(g) No account was made of losses to groundwater or soil moisture.

(h) Evaporation was accounted for from the Lake but nowhere else.

(i) There were no Water Shortage Directions issued during the modelling period.

6.4 The model assumptions and structure have been independently reviewed by Dr Vince Bidwell[10].

6.5 Four sets of rules associated with the Alternative Management Regimes were tested:

(a) The proposed PC7 2025 rules – Tables 14(v) and 14(x) as notified;

(b) The proposed PC7 2030 rules – Tables 14(w) and 14(x) as notified;

(c) The following two variants of the rules sought in the AMWG's submission:

(i) AMWG rules assuming the restriction regime applies in all cases (i.e. when the environmental factor thresholds are crossed); and

(ii) AMWG rules with stakeholder group discretion applied (discussed further in Section 6 of my evidence).

[10] Dr Vince Bidwell's letter of review, a brief professional biography, and the email referenced in the review, are provided as Appendix A attached to my evidence.

6.6 The methodology adopted for testing these rules is set out in the following sections of my evidence. As I have explained earlier, these rules vary from each other in several ways. The impact of key variances was tested independently as described later in section 7.11.

6.7 Historic tributary inflows from the upper Opihi and Te Ana Wai Rivers were adjusted to account for the proposed 2025 and 2030 minimum flow limits (proposed by PC7's Tables 14(p) - 14(s)). This was done by clipping the historic tributary low flow limits to the applicable Opihi mainstem minimum flow rule except when the current Saleyards Bridge minimum flow rules (as prescribed by the ORRP) had not been achieved. This assumed that if tributary minimum flows were not achieved in the past, it was the result of climate rather than abstraction, so the flows would remain low irrespective of the rules. For the testing of the AMWG regime the 2030-adjusted minimum flows were used. The AMWG regime was not tested with the 2025-adjusted minimum flows as the difference in impact was considered likely to be minor.

6.8 Availability of water for abstraction was assessed for the mainstem of the system from the Lake Opuha outlet to Saleyards Bridge. Availability was assessed for each month based on modelled river flows, estimated maximum water demand and restriction rules. Maximum water demand for each month of the year was based on OWL's 2015 to 2019 record of shareholder water orders.

7 REGIME EFFECTIVENESS MEASURES

7.1 The likely effect of the different regimes on river flows was measured by calculating six values from the modelled output of the Lake Opuha Model:

(a) How often was river connectivity at risk?

(b) How often were ecological minimum flows at risk?

(c) How frequent did full restrictions occur?

(d) The equity of water reductions i.e. how did the amount of water gained by the river from allocation restrictions compare to the amount of water lost by the river through reduced minimum flows?

(e) How much time was spent in a restrictive regime?

was tested within the AMWG regime through an interactive workshop conducted in December 2019, which Judy Blackmore has noted in her evidence. Representatives of the Central South Island Fish and Game Council, OWL, District Councils and Federated Farmers who are longstanding participants in OEFRAG were present as a proxy for a stake-holder group.

7.8 The Lake Opuha Model (with the AMWG regime) was operated interactively with the group. The model cycled through each day of a range of seasons, with live updating of graphs of river flows, lake levels and snow storage. When the model indicated the occurrence of an opportunity to apply restrictions (i.e. the conditions of a restrictive AMWG regime had been met), the model would pause. The group was consulted on whether, given the simulated conditions, the restrictions should be applied. The model's regime was changed to match the group's selection, and then it was set going again until another restriction-change opportunity arose. The process was repeated until the period being tested was completed.

7.9 The selections of the group were used when testing the AMWG regime in the Lake Opuha Model. For completeness, a non-stakeholder group variation was also tested whereby restrictions were always applied when the regime allowed.

7.10 The impact of the stake-holder group selections on the PC7 regime was not assessed.

7.11 Specific aspects of the different regimes were individually tested. These included:

(a) The effect of PC7 restrictions compared to AMWG restrictions on water availability for abstraction.

(b) The effect of PC7 minimum flows compared to AMWG minimum flows.

(c) Daily assessment of environmental thresholds (AMWG) compared to monthly assessment (PC7).

(d) The effect of extending the AMWG restrictive regime period from 14 days to 30 days (as proposed by PC7).

8 REGIME COMPARISON RESULTS

8.1 The effect of the Alternative Management Regimes on the level of Lake Opuha for the 2014-2016 drought years simulated by the Lake Opuha Model is shown in Figure 4 below.

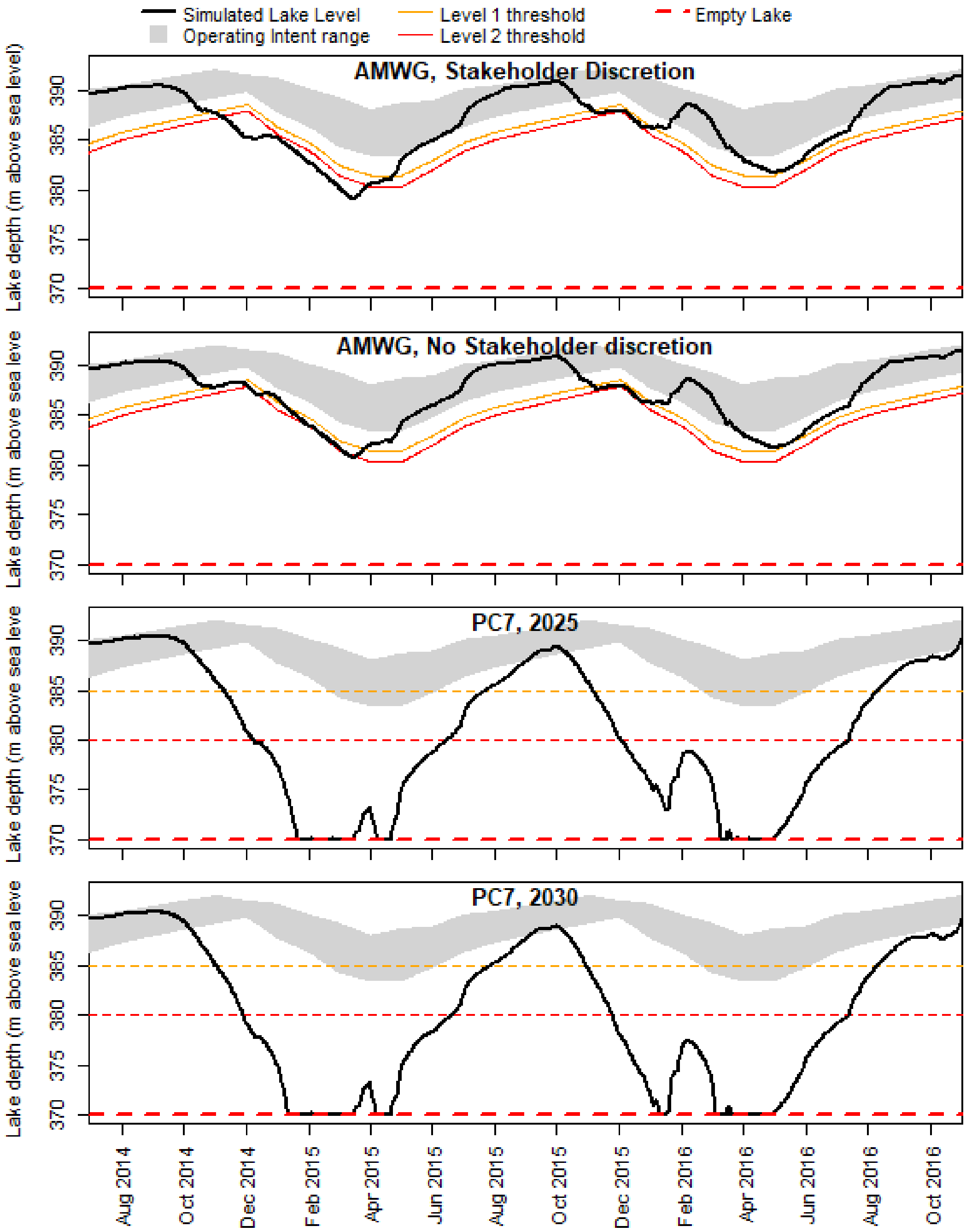

Figure 4. Simulated lake levels under the AMWG and PC7 regimes.

8.2 Figure 4 shows that under the PC7 rules the simulation leads to a drained lake during both summers. The AMWG rules do not lead to a drained lake in either summer. For the AMWG regimes the impact of moving into a restrictive regime results in a flattening of the curve, whereas for PC7 the lake level continues to dive. For AMWG the shift to a restrictive regime can occur soon after the threshold has been crossed (as shown in the graphs by a change in the slope), whereas PC7 has to wait until the start of a month. This is exacerbated in the PC7 regime with the lake level thresholds being lower in early summer with respect the operational intent, and the rarity of both the lake levels and the inflows being below their respective thresholds. For PC7-2030 the level 2 restrictive regime is only ever met on the 1st March 2015, after the lake has run dry. Once the lake is empty, PC7 keeps the lake empty as the inflows are rarely below their threshold levels so the restrictive regime is lifted and the model is forced to use whatever lake storage is available to try to maintain the required minimum flow.

8.3 The two AMWG regime's show that with stakeholder discretion not every opportunity to restrict the regime is implemented. On the 19th October 2014 a level 2 regime was possible, but a level 2 regime was not implemented until the 2nd November. This discretion led to the lake being lower, but still retaining the capability to augment the river flows throughout the irrigation season.

8.4 The effect of the Alternative Management Regimes on Opihi flows at Saleyards Bridge for the 2014-2016 drought years simulated by the Lake Opuha Model is shown in Figure 5 below.

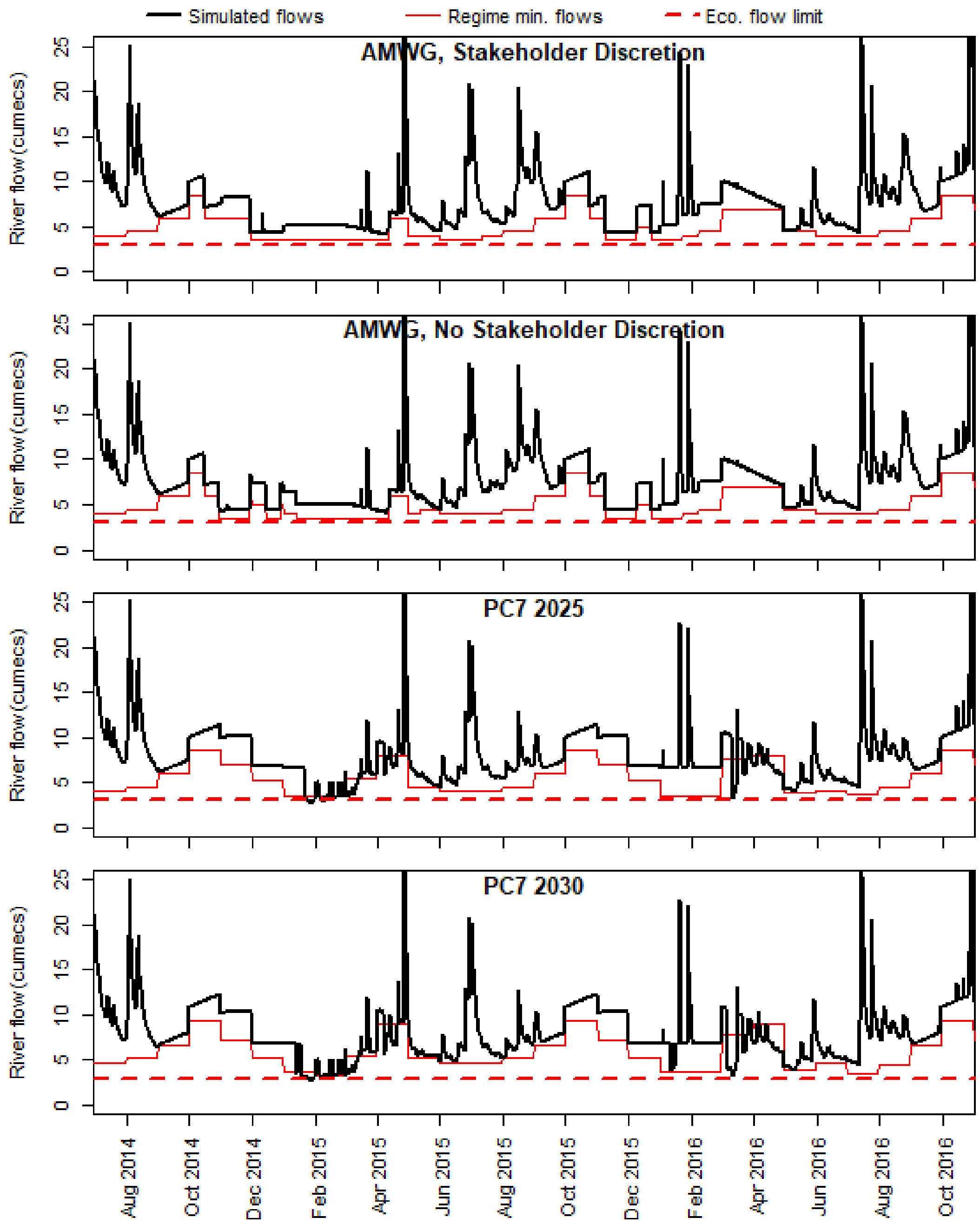

Figure 5. Simulated flows at Saleyards Bridge under the AMWG, PC7 regimes.

8.5 This figure indicates that under the PC7 rules, the simulation for the 2014-2016 drought years is not able to maintain ecological flows of 3 m^3s^{-1} at Saleyards Bridge (in February 2015), or the regime's minimum flows (February to April 2015 and March to April in 2016). This is a direct result of the drained lake and the consequential loss of ability to augment flows. The ability to augment flows to improve the ecological flows and maintain minimum flows in the downstream Opihi catchment is one of the primary benefits of Lake Opuha

8.6 The difference between the PC7 2025 and PC7 2030 regimes are different minimum flow requirements and tributary flows from the Opihi and Te Ana Wai having increased minimum flows. As described in Mr Mockford's evidence, the increased minimum flows required as part of the 2030 regime over-compensate for the increased minimum flows from the tributaries resulting in an estimated 5.2 $x10^6$ m^3/year of additional water having to be released from the Opuha Dam. This leads to the 2030 version running the lake down earlier (by over a week in 2015) and for a longer period (20 extra days over the 2014-2015 period).

8.7 The simulations found that:

(a) For the climate experienced over the last 20 years, ecological flows of 3 m^3s^{-1} would have been maintained under the AMWG regime (with and without stakeholder discretion), but not under the PC7 regimes.

(b) The AMWG regime (with and without stakeholder discretion) has the least amount of time with flows at Saleyards Bridge below the regime's minimum flows.

(c) Under the PC7 2030 rules, the modelled flows of the Opihi at Saleyards Bridge did not meet the required minimum flows for 91 days during the 2014 - 2016 simulation and for 8 of those days did not meet the 3 m^3s^{-1} ecological flows (see

(d) Table 2).

(e) All regimes simulated enough flow in the Opihi at Saleyards Bridge to maintain connectivity (above 2 m^3s^{-1}) for all the years simulated.

(f) The availability of water for abstractors was similar under both the PC7 and AMWG rules.

8.8 The modelling results in relation to the regime effectiveness measures (discussed in Section 7 above) are presented in Table 2 below:

Table 2. Measures of regime effectiveness derived from simulations. Values that are notably different are in bold.

	Drought (2014-2015)				Dry (2005)				All (1999 – 2017)			
	PC7 2025	PC7 2030	AMWG	AMWG No Discretion	PC7 2025	PC7 2030	AMWG	AMWG No Discretion	PC7 2025	PC7 2030	AMWG	AMWG No Discretion
Days with less than 3 m^3s^{-1}	**7**	**8**	0	0	0	0	0	0	**18**	**22**	0	0
Frequency of full restrictions	**1 in 7**	**1 in 6**	Did not occur	Did not occur	Did not occur	Did not occur	Did not occur	1 in 21	1 in 49	1 in 49	1 in 43	1 in 52
Days minimum flows not met	**74**	**91**	0	0	0	0	0	0	**86**	**106**	6	0
Water saved equity ratio[11]	5:1	6:1	7:5	6:5	1:1	1:1	3:1	3:1	7:4	3:2	1:1	4:3
Days in restrictive regimes	152	152	375	375	123	123	**60**	120	767	859	945	1136
Irrigation days in restriction	121	121	273	273	31	31	60	60	214	214	479	505
% Availability (all seasons)	70 %	66 %	68 %	66 %	86 %	86 %	92 %	93 %	94 %	94 %	94 %	93 %

[11] Equity ratio is water volume saved through abstraction restrictions compared to water volume saved through reduced minimum flows

9 ASSESSEMENT OF REGIME DIFFERENCES

9.1 The results of the testing of individual aspects of the Alternative Management Regimes are set out in Table 3 below.

9.2 Each variation affected the outcome to some degree, but no variation on its own resulted in a major change in the outcome that was clearly more beneficial in all aspects. In preparing and analysing the various iterations of regimes considered by AMWG it has become clear that every aspect of the regime has an impact on the outcome, but not always in an obvious way.

Table 3. Summary of impacts of individual aspects of regimes tested for the full 1999 to 2017 period.

Feature	Notable Impact	Comments
Restrictions	AMWG restrictions reduced the days below the ecological minimum flows (3 m^3s^{-1}) and increased the days on full restriction. AMWG applies full restriction in a level 2 regime in June July and August, while PC7 only applies full restriction when the lake is empty.	
Minimum flows	PC7 minimum flows (compared to AMWG minimum flows) increased the number of days when the regime's minimum flows were not met by an average of 69 days.	
Threshold assessment frequency	Monthly assessment (compared to daily) led to 20 extra days when the ecological minimum flows of 3 m^3s^{-1} were not met.	Impact only assessed on AMWG
Minimum days in a restrictive regime	Extending the minimum number of days in a restriction regime from 15 to 30 led to an additional 34 days in a restrictive regime	Impact only assessed on AMWG

10 SECTION 42A REPORT

ECan model

10.1 Appendix D.6 of the Section 42A Report refers to a model developed by ECan that has been used to assess the impacts of the Alternative Management Regimes proposed by PC7 and as sought in the AMWG's submission.

10.2 The assumptions used in the ECan model are set out in para 6.24 of Appendix D.6. Some of the assumptions used in the ECan model are slightly different to the Lake Opuha Model, and are summarised in Table 4 below.

Table 4. Summary of model assumption differences between the ECan model referred to in Appendix D.6 of the Section 42A Report and the Lake Opuha Model.

Assumption	ECan model	Lake Opuha Model
Lake full	105 %	100 %
Abstraction requirements	Maximum possible	Follows a seasonal variation that matches maximum values from the historic record
Lake management	Keep full if possible	Keep within the seasonally-varying operational range

10.3 In my view, for the most part, the different assumptions used in the ECan model are not unreasonable for the level of modelling undertaken. While, the differing assumptions between the two models will impact the exact values generated, they still enable the major differences between the regimes to be identified.

10.4 The availability of water for abstraction reported in Appendix D.6, para 6.27, page 624, is largely similar between the models. The primary difference is the reduced availability through early summer for the AMWG regime. These results are probably affected by the lake management assumptions of keeping the lake full if possible. In-reality the lake is managed lower in early summer to enable harvesting of rain and snow melt, which would lead to more water being available downstream. This means the availability of abstraction water reported in Appendix D.6 is likely to be too low in the August to November period for all regimes, and too high in late summer.

10.5 An important finding reported in Appendix D.6 is that the PC7 regime leads to a drained lake and the loss of flow enhancement capability (at para 6.37 and 6.65, pages 626 and 634). This aligns well with the results of my modelling presented in Section 8.1 of my evidence.

Seasonal lake level threshold

10.6 Appendix D.6 describes an alternative seasonal lake level threshold using the 20th and 5th percentile lake levels from historic lake level data. It is suggested at para 6.67 (page 635) that the seasonally varying lake level threshold maintains flows longer than under the notified PC7 regime and provides *"...increased adaptability, while maintain[ing].. certainty…"*. I agree that a seasonally-varying lake level threshold is an improvement on the notified PC7 regime. I consider the improvement is measured by the reduced time that flow-augmentation from dam storage is lost. The alternative regime still does not avoid draining the lake during drought years as presented in Figure 12 of Appendix D (at page 634). From that perspective, the AMWG regime is still the preferred regime.

10.7 I consider that the approach recommended in Appendix D.6 for lake level thresholds could be improved. Unlike snow storage and lake inflows, the historic lake level is managed, so the historic levels are a mixed signal of hydrological-conditions and lake level operation. For example, in early years of Lake Opuha operation, the lake was specifically managed to be low. This means the historic lake levels are a poor representation of how lake levels would respond to drought conditions. This will bias the threshold levels used in ECan's modelling of PC7 with the seasonal variable lake level threshold, and the Officer Recommendations, which I discuss in the following sections of my evidence. In my opinion, the AMWG method of setting the seasonal lake level thresholds to follow the operational lake level intent, is a more appropriate approach, leverages lake management experience in setting the thresholds and has a better outcome.

Officer Recommendation

10.8 The Section 42A Report recommends a further variant to the PC7 regime, which incorporates the alternative seasonal varying lake level threshold described in Appendix D.6 (**Officer Recommendations**). The variant is described as a "two tier regime", and differs from the PC7 regime in the following additional respects:

(a) The regime is time staged, with the first step taking effect when PC7 becomes operative (Table 14(v)), and the second step at 2025 (Table 14(w));

(b) The time staged regimes each have a single level of minimum flow reductions, and so has a single threshold for each environmental factor based on the 20th percentile;

(c) Entry into the restrictive regime is automatic (i.e. there is no discretion); and

(d) PC7's proposal to retain compensatory flows following artificial flushing flows is deleted.

10.9 The Lake level thresholds under the Officer Recommendations are shown in the following figure. The Officer Recommendations lake level thresholds are the level 1 thresholds from those set out as a potential PC7 alternative in Appendix D.6 of the Section 42A Report. The level 2 thresholds of that alternative are also shown in Figure 6 together with those from the proposed PC7, as well as those proposed for the AMWG regime for comparison purposes. The seasonally varying Opuha Dam operating intent is also shown for context. I note that while the Officer Recommendations use the Section 42A Level 1 thresholds, the Officer Recommendations call it "level 2". The Officer Recommendations are initially a close approximation to the AMWG level 1 threshold, but then steadily increase, with respect to the operating intent, until, by the end of the irrigation season it is in the middle of the operating intent.

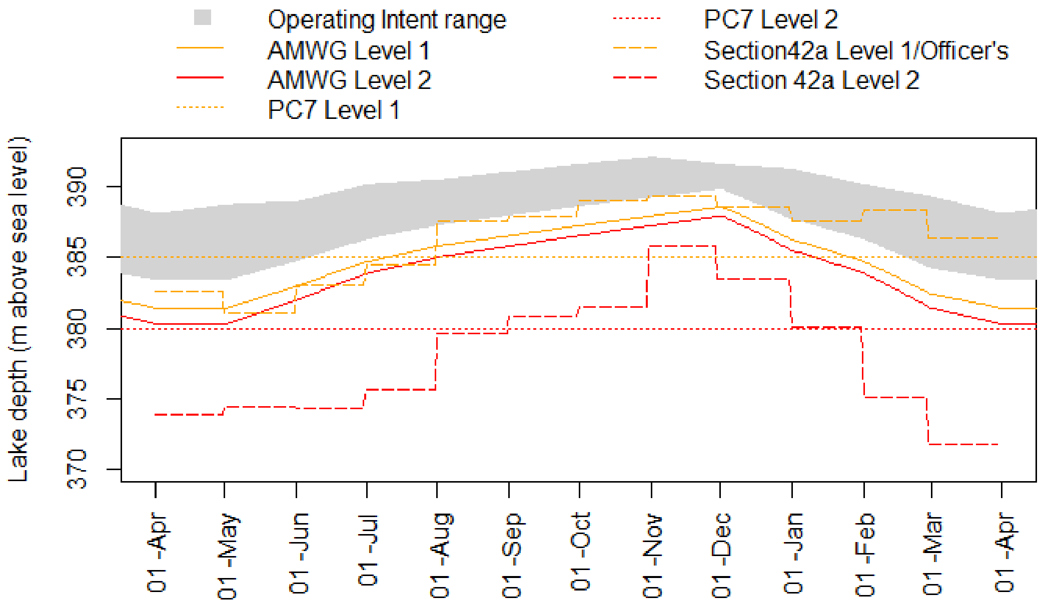

Figure 6. Lake level thresholds and operating intent

10.10 The Officer Recommendations regime is not referred to in Appendix D.6 and does not appear to have been tested by ECan.

10.11 I used the Lake Opuha Model to assess the performance of the 2025 version of the Officer Recommendations. In addition, I assessed:

(a) PC7's 2030 regime with the seasonal variation of lake level thresholds as recommended in Appendix D.6; and

(b) The effect of inclusion/exclusion of flushing flows resulting from the recommended changes to Policy 14.4.35 contained in Appendix E.1 of the Section 42A Report.

10.12 The results of that modelling are set out below from para 10.19 of my evidence.

Flushing flows

10.13 Under PC7, flushing flows were hydrologically neutral in that the water from storage used for flushing flows was able to be recovered through reduced minimum flows (compensatory flows). In addition, the number and size of the flushing flows were prescribed by Policy 14.4.35(e). The compensatory nature of the PC7 approach meant that flushing flows did not affect the water balance of the system and so did not have to be modelled.

10.14 The Officer Recommendations do not enable compensatory adjustment of the minimum flows. This means the flushing flows will affect the water balance and need to be included within the Lake Opuha Model. The Officer Recommendations have no set values for the size or frequency of the flushing flows, but instead specify the outcome to be achieved by flushing flows as being "…*effective at periphyton removal so that it does not reach nuisance levels, 'refreshing' the river and opening the river mouth to enable effective fish passage."*

10.15 To model the flushing flows, reasonable estimates are needed of their size and when they would occur. The focus of this exercise was on the periphyton outcome, as I understand from the evidence of Mr Measures and Mr Mockford that infrastructure constraints preclude flushing flows of a size/duration required to achieve that outcome and it was never the intent for flushing flows released from the Opuha Dam to be effective at *"..opening the river mouth…"*.

10.16 I used the following assumptions in the model, which were based on the advice of Mr Richard Measures and are explained further in his evidence:

(a) To remove nuisance periphyton from the lower Opihi River, the artificial flush flow characteristics recommended are the largest possible flow volume able to be released from the dam (1.5 x 10^6 m^3) over a duration of at least 24 hours with a peak flow of 40-90 m^3s^{-1} maintained for at least 2 hours.

(b) A natural flush event needs to have a peak flow of at least 30 m^3/s.

(c) If nuisance periphyton is needed to be removed from the Opuha River only, then a flush volume of 600,000 m^3 has been recommended as the required amount.

(d) A flushing flow (either natural or artificial) is required every 6 weeks in the November to March period.

10.17 For the purposes of inclusion in the Lake Opuha Model, the flushing flows characteristics need to be simulated from a daily time step point of view. A natural flow event with a peak flow greater than 30 m^3s^{-1} has a longer and higher recession flow than an artificial flushing flow so its overall volume (and daily average flow) will be larger than for an artificial flush. After consideration of historic hydrographs, a daily average flow of 25 m^3s^{-1} was selected as a proxy for a natural event with a peak flow greater than 30 m^3s^{-1}. The average daily flow required to provide the lower Opihi artificial flushing flow volume is 17.4 m^3s^{-1}. For an Opuha-only flush (600,000 m^3) a daily average flow rate of 7 m^3s^{-1}.

10.18 For the flushing flow scenario, the Lake Opuha Model keeps track of how many days in summer (November to March) have elapsed since the last flushing flow (either artificial or natural) occurred at Saleyards Bridge (representing the lower Opihi conditions), and from the dam outlet (representing the Opuha mainstem conditions). A natural flush is considered to have occurred if the daily average flow rate is greater than 25 m^3s^{-1}. If more than 42 days elapses without a natural flushing flow, then an artificial flushing flow is released. If the lower Opihi required a flush, then an artificial flush of 1,500,000 m^3 is released and both the Opuha and lower Opihi are considered to have been flushed. If only the Opuha requires a flush, then an artificial flush of 600,000 m^3 is released and only the Opuha is considered flushed.

Modelling results

Officer Recommendations

10.19 Figure 7 and Figure 8 below show simulated lake levels and Opihi flows at Saleyards Bridge under the Officer Recommendations.

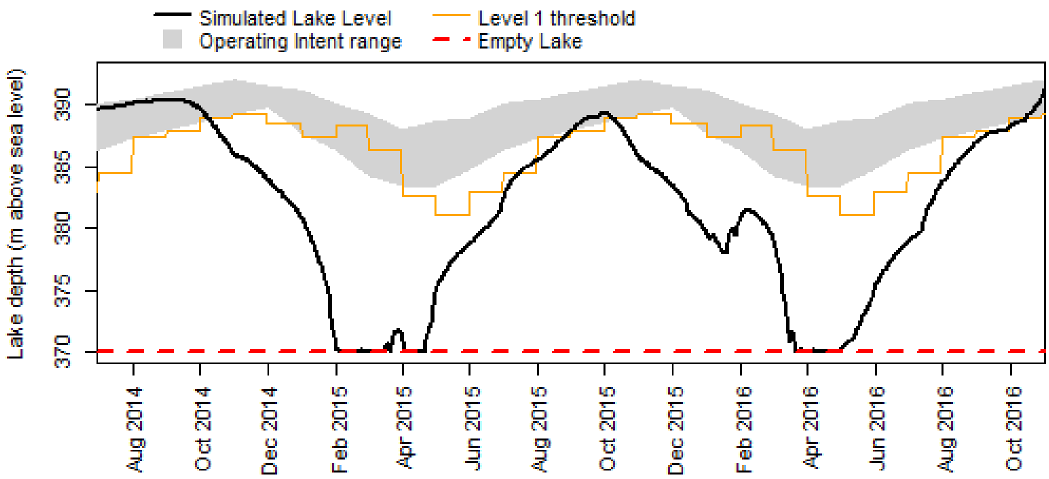

Figure 7. Simulated lake levels under the Officer Recommendations (2025) regime.

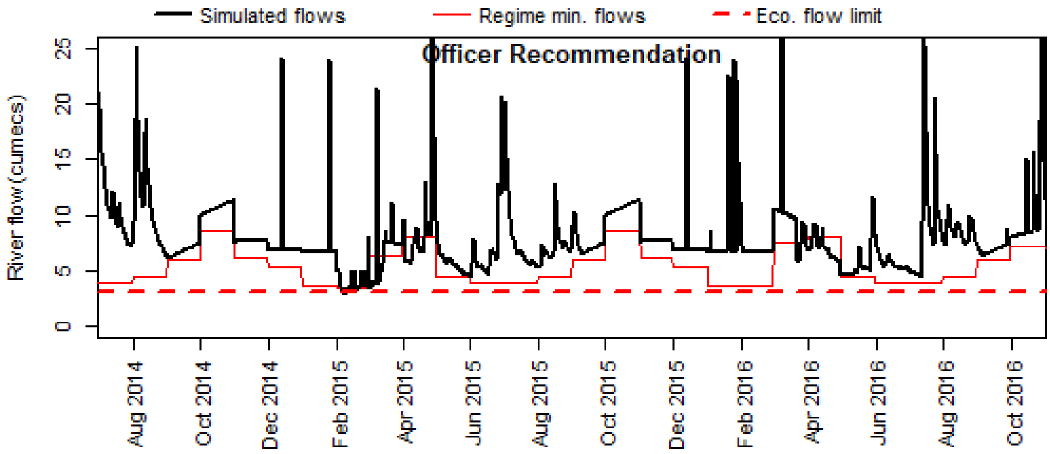

Figure 8. Simulated flows at Saleyards Bridge under the Officer Recommendations (2025) regime.

10.20 These figures show that the Officer Recommendations:

(a) fail to prevent the lake from draining under 2015 climate conditions; and

(b) fail to maintain ecological flows of 3 m^3s^{-1} (in February 2015) or the regime's minimum flows (February and March 2015, and April 2016).

10.21 For the Officer Recommendations regime, a restrictive regime is first triggered on the 1st of November 2014 when both the lake level threshold and the inflow threshold are crossed. This is earlier than for PC7, as the lake level threshold is much lower in PC7. On the 1st of January 2015, even though the lake level is low, the inflows are not below their threshold, so the restrictive regime is exited. This results in a rapid draining of the lake and the reduction of flows at Saleyards Bridge to below the ecological flow threshold of 3 m^3s^{-1}.

10.22 The restrictive regime is implemented again on the 2nd February, but by then the lake is drained and full restrictions are in place anyway. On 1st April 2015, the inflows are again above the threshold level, and so the restrictions are lifted (despite the lake being at 373 m) and so the lake is immediately drained again. The lake manages to fill up through the 2015 winter, despite the lack of restrictions, though by 1st December 2015, the inflows are once again below the regime's threshold and restrictions are put in place, but not enough to prevent the lake from being drained. The restrictions are lifted in January 2015 as the inflows are too high, and so the lake is again drained. Not until the end of April 2015 are both the lake level and inflow thresholds crossed, too late to prevent the emptying of the lake.

10.23 A feature of the Officer Recommendations' regime is the regular flow spikes through the summer months. These are the artificial flushing flows interspersed with natural high flow events. The impact of flushing flows without compensatory adjustment of minimum flows is described in Table 6. This indicates if the flushing flows were compensated for by an adjustment of minimum flows, the number of days in restriction would reduce.

(c)

10.24 Table 5 summarises the modelling results in relation to the regime effectiveness measures discussed in Section 7 of my evidence. In comparison to the PC7 and AMWG regimes reported in Section 7 of my evidence, the Officer Recommendations:

(a) Had less days with flows under the ecological flow rate of 3 m^3s^{-1} and the regime's minimum flows compared to the PC7 regimes, but more than the AMWG regimes.

(b) Had less days in a restrictive regime during the irrigation season compared to the AMWG regimes, but more than the PC7 regimes.

Table 5. Measures of effectiveness for the Officer Recommendations regime derived from simulations.

	Drought (2014-2015)	Dry (2005)	All (1999 – 2017)
	Officer Recommendations	Officer Recommendations	Officer Recommendations
Days with less than 3 m^3s^{-1}	1	0	17
Frequency of full restrictions	1 in 8	Did not occur	1 in 62
Days minimum flows not met	62	0	80
Water saved equity ratio[12]	11:2	3:2	3:1
Days in restrictive regime	212	123	858
Irrigation days in restriction	181	31	304
% Availability (all seasons)	72 %	85 %	94 %

[12] Equity ratio is water volume saved through abstraction restrictions compared to water volume saved through reduced minimum flows

10.25 The Officer Recommendations regime is an improvement on the PC7 regimes with regard maintaining minimum flows and ecological flows of 3 m^3s^{-1}, at the cost of increased days in restrictive regime. The inflow threshold level still limits the ability of the regime to stay in restrictions and so the lake is still not prevented from draining. The improvement over the PC7 regimes will primarily be a result of the changed lake level thresholds. The advantage of having two restrictive levels in PC7, compared to the 1 in the Officer Recommendations is not observed as the PC7 regimes very rarely achieved a level 2 restriction level even during the 2014-15 drought summers.

10.26 The main findings of testing the impacts of the seasonal variation in lake level threshold, and un-compensated flushing flows are listed in Table 6.

Table 6. Summary of impacts of the variable lake level thresholds and flushing flows for the full 1999 to 2017 period.

Feature	Notable Impact	Comments
Seasonal variation in lake level	Inclusion reduced the number of irrigation days on full restriction by 38, and the number of days when the minimum flows were not met by 25	Impact only assessed on PC7
Flushing flows	Inclusion without compensation increased the number of days under a restrictive regime by an average of 98 days.	

PC7's 2030 regime with seasonal variation of lake level thresholds

10.27 These results indicate that a seasonally-varying lake level threshold is an improvement on a fixed threshold. As noted earlier (section 10.9) the threshold used for level 1 (and the Officer Recommendations) crosses the operational-intent, so will lead to restrictive regimes most summers if the inflows are also low. In my opinion, based on the modelling, adjustment of the seasonally varying lake level to always be below the operational intent (in the manner adopted by AMWG) would reduce the number of days in restriction without stressing lake levels or river flows at the end of summer.

11 CONCLUSIONS

11.1 Simulation of the various Alternative Management Regimes indicate the AMWG option is preferred for maintaining the ability of Lake Opuha to augment the Opihi River flows, and to ensure Saleyards Bridge flows do not drop below either the ecological minimum of $3 m^3 s^{-1}$ or the regime's minimum flow.

11.2 Key to this is the inclusion of stakeholder discretion on whether a restrictive regime should be entered, daily assessments of thresholds, seasonally varying lake level thresholds, the assurance that a restrictive regime is able to continue while the lake level is low and compensation for flushing flows.

11.3 The PC7 regime is unlikely to prevent the draining of Lake Opuha during drought years. Alteration of how a restrictive regime is exited and adjustment of the environmental thresholds (particularly for the lake level and inflows) may avoid this.

11.4 The Officer Recommendations are an improvement on the PC7 regimes from a point of view of maintaining ecological ($3 m^3 s^{-1}$) and the regime's minimum flows, at the cost of increased days in restriction. Under this regime the lake is still drained during the simulated 2014-15 seasons.

11.5 It is my expert opinion that the requirement for implementation of an Alternative Management Regime cannot be determined purely from the assessment of physical hydrological parameters. Nevertheless, they do provide a guide for when a restrictive regime might reasonably be considered.

11.6 I agree with Section 42A Report subsection 9.52 *"…there is a fine balance between minimum flows in the river, the amount of water made available for abstraction, climate variability, the level of the lake and the frequency and size of summer freshes…"*. Based on the modelling reported in my evidence, it is my opinion the AMWG regime is the closest to that balance point.

Recoverable Signature

X 

Signed by: 8f0333d8-9c20-47cd-8a26-1d6aa77205b4

Tim Kerr

17 July 2020

Appendix A: Vince Bidwell letter of review and credentials.

Vincent Bidwell Consulting

17 Brookside Rd
Rolleston
Christchurch 7614

Email: Vincent.Bidwell@gmail.com

Phone 027 347 8181

Date: 12/05/2020

To: Opuha Water Ltd
875 Arowhenua Rd
RD4 Timaru 7974

Attn. Julia Crossman

Subject: **Opuha Model Review**

Dear Ms Crossman

I have completed my review of the report on the Lake Opuha Model prepared by Dr Tim Kerr of Aqualinc. The review process comprised: an initial review of the report; a meeting with Dr Kerr to discuss suggested revisions; and a review of the revised report.

In my opinion, the report should meet the requirements of the Plan Change 7 process that you described in your email of 18/07/2019.

In support of my reviewer credentials with respect to mathematical modelling of water resource systems, I have attached a short biography and list of publications.

Yours sincerely

Vincent Bidwell

Dr Vince Bidwell

Vince Bidwell BE(Hons)(civil)PhD is an engineering scientist, retired from Lincoln Ventures Ltd (now Lincoln Agritech Ltd) a subsidiary of Lincoln University. His professional background includes civil engineering, mathematical hydrology, agricultural drainage, irrigation, biomass fuel production, and research management. He is a Chartered Member of Engineering New Zealand, a Member of The Royal Society of NZ and a Member of the NZ Hydrological Society. The latter part of his career has been spent in providing new mathematical applications and associated technology transfer directed at management of groundwater quantity and quality in New Zealand.

Vince is the designer of the “Eigenmodel” method for determining the dynamic response of groundwater to recharge stresses imposed by climate and pumped abstractions. The first major application of this technology was to the original water resource analysis for the Canterbury Strategic Water Study in 2002.

He is also the designer of the groundwater model component for “AquiferSim”, which was the regional-scale model of the response of groundwater quality to land use, developed under the multi-agency IRAP (Integrated Research for Aquifer Protection) programme. This model has been applied to regional groundwater nitrate assessment within the Canterbury Water Management Strategy, including the pilot Hurunui Catchment Study. During this latter study, Vince served on the Governance Group and the Technical Committee of the Land Use and Water Quality Project.

Since retirement from full-time employment, Vince has been a consultant to: Hawkes Bay Regional Council as a member of the Technical Advisory Group for the Heretaunga Plains Groundwater Model Project; and to Environment Southland as a member of the Technical Advisory Group for the NPSFM Southland Science Programme. Recent review work has been done for Environment Canterbury and Greater Wellington Regional Council.

From: Julia Crossman
Sent: Thursday, 18 July 2019 12:03 PM
To: Vincent.bidwell@gmail.com
Subject: Model peer review

Hi Vince

I hope all is well with you. I am writing to gauge you interest in undertaking a peer review for us.

We (Opuha Water Ltd) are currently in the middle of the sub-regional planning process for the OTOP (Orari-Temuka-Opihi-Pareora) zone, with Plan Change 7 being notified this Saturday. We have been engaged in this process for the last couple of years through the community collaboration phase. As part of this we have been part of a stakeholder group who came up with some recommendations regarding the flow regime for the mainstem of the Opihi River and how the storage of Lake Opuha should be managed.

This has been informed by a hydrological model that has been developed by Tim Kerr from Aqualinc. This model accounts for snow storage, lake inflows and lake level as the key determinants of how much storage we have in the system, and it will largely drive/inform how we respond to the notified PC7 in our submissions/hearing.

We (and Tim) are keen to get his model peer reviewed so we can be confident it and the assumptions underlying it are robust, particularly going into the hearing.

Do you have capacity at the moment to undertake such a peer review? If you think you may have, I will link you and Tim up (though I am sure you already know each other) and he can run you through what he has developed.

It would be great if you could let me know. Happy to chat if that would be valuable (as I am sure Tim would be too)

Regards

Julia Crossman | **Environmental Manager** | **Opuha Water Ltd** | 875 Arowhenua Rd | RD4 | TIMARU 7974 | Phone 03 614 7801 | Mobile 021 535 174 | **www.opuhawater.co.nz**