**BEFORE THE CANTERBURY REGIONAL COUNCIL**

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| **UNDER** | the Environment Canterbury (Temporary Commissioners and Improved Water Management) Act 2010 |
| **IN THE MATTER** | of the proposed Hurunui and Waiau River Regional Plan |

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# STATEMENT OF EVIDENCE OF RICHARD NEILSEN MONTGOMERIE ON BEHALF OF THE NORTH CANTERBURY FISH AND GAME COUNCIL

**12 October 2012**

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## 1. INTRODUCTION

### Qualifications and experience

1.1 My name is Richard Neilsen Montgomerie. I am a freshwater ecologist and owner of Freshwater Solutions Ltd, a specialist freshwater environmental consultancy. I hold a BSc and MSc in Zoology from the University of Otago. I am a member of the New Zealand Freshwater Sciences Society.

1.2 My areas of expertise include freshwater fish and fisheries, in-stream flow requirements, river health assessment, water quality, and assessment of environmental effects.

1.3 Over the last 14 years I have undertaken freshwater ecological work throughout New Zealand and in Europe for a wide range of organisations including Central Plains Water Enhancement Scheme, Fonterra Co-operative Group Ltd, Alliance Group Ltd, power companies, regional councils, Ministry for the Environment, Hungarian Government, Scottish Environmental Protection Agency and the European Union.

1.4 I have been an Eastern Region Fish and Game Councillor for the last 2 years.

1.5 I have previously undertaken in-stream ecological assessments of the Hurunui River and Waiau River for the Canterbury Water Executive and Hurunui Water Project Ltd. I have fished extensively throughout both river systems over the last 10 years.

1.6 In preparing my evidence I have drawn on information from the following reports and evidence:

a. Review of minimum flow requirements for aquatic ecological values in the Hurunui catchment (ECan 2011 unpub. draft report).

b. Reports on Hurunui Water quality (Aquanet 2010, NIWA 2010).

c. In-stream values of the Waiau River catchment – D. Armstrong (2006).

d. Various briefs of evidence prepared by experts for the Hurunui River Water Conservation Order Hearing – March 2009.

e. Various briefs of evidence prepared by experts for this hearing – October 2012.

f. Hurunui River Habitat 2-D Modelling – ECan (2004).

g. Hurunui River Habitat 2-D Modelling: Habitat for periphyton – NIWA (2007).

h. Waiau River in stream habitat based on 2-D hydrodynamic modelling – NIWA (2009).

i. Current nutrient loads and options for nutrient load limits for a case study catchment – ECan (2010).

j. Waiau River – In-stream values and flow regime – Mosley (2004).

k. Hurunui River – In-stream values and flow regime – Mosley (2002).

l. Intrinsic natural values of the Hurunui River catchment – DoC (2006).

m. A fisheries overview of the Hurunui Waiau Zone – North Canterbury Fish and Game (September 2011).

n. Proposed Hurunui and Waiau River Regional Plan – ECan (2011).

o. Planning Report Hurunui River and tributaries: environmental flow and water allocation – ECan (2007).

p. Hurunui River: B Block allocation review – NIWA (2009).

q. Waiau River mid range flows evaluation - NIWA (2011).

1.7 I confirm that I have read and agree to comply with the Code of Conduct for Expert Witnesses (November 2011). This evidence is within my area of expertise, except where I state that I am relying on what I have been told by another person. I have not omitted to consider material facts known to me that might alter or detract from the opinions that I express.

**Scope of evidence**

1.8 I have been asked by the North Canterbury Fish and Game Council to provide evidence to this hearing on the following for both the Hurunui and Waiau Rivers:

a. The effects of flow regimes on salmon passage.
b. The effects of flow regimes on fish habitat.
c. The effects of flow regimes on food producing habitat.
d. The effects of flow regimes on water quality and periphyton growths.

1.9.1 The proposed A block abstraction, A+B block abstractions and A+B+C block abstractions all influence the natural flow regimes of the Hurunui and Waiau Rivers as described by Mr Dave Stewart in his evidence. In making my assessment of the proposed flow regimes I have drawn extensively on the evidence of Mr Dave Stewart.

1.9.2 The focus of my evidence is the assessment of the A+B+C abstraction regime as this regime has the greatest potential to alter the ecology of the Hurunui and Waiau Rivers.

## 2. EXECUTIVE SUMMARY

2.1 Instream habitat quantity and quality, minimum flow, flow variability and water quality can all exert strong influences on the ecology of rivers. The proposed A+B+C block allocation regime for the Hurunui and Waiau Rivers has the potential to adversely affect salmon passage, habitat quantity and quality, water quality and periphyton growths, benthic invertebrate communities and trout and salmon condition and numbers

2.2 The proposed minimum flow for the Hurunui River during the months when salmon migrate upstream is 12 $m^3/s$ and this would remain the minimum flow under the A block and A+B block abstraction regimes. The results of the NIWA (2004 and 2008) work, the assessment of

Mosley (2004) and the review by ECan (2011) suggests that the proposed minimum flow of 12 $m^3$/s is very likely to restrict upstream salmon passage and in my opinion the minimum flow at Mandamus during the months when salmon migrate (January – May) should be set at 15 $m^3$/s.

2.3 The results of the 1-D modelling on the Waiau River at Mouse Point and the evidence presented by Mr Stewart on the Waiau River hydrology at Marble Point indicates that the A+B+C Block allocation could reduce river water depth to critical levels and adversely affect salmon passage.

2.4 The number of freshes that trigger salmon to move upstream and provide the water depth and clarity preferred by salmon are significantly reduced in the Hurunui and Waiau Rivers under the A+B+C block allocation regime in dry years. In my opinion the A+B+C block allocation regime could adversely affect salmon in the Hurunui and Waiau Rivers in dry years by reducing the number of freshes that trigger upstream passage.

2.5 In my opinion the proposed A+B+C block allocation regime has the potential to benefit adult trout by increasing the amount of habitat and adversely affect salmon by decreasing the amount of adult salmon holding.

2.6 In my opinion the proposed A+B+C block allocation regime for the Waiau River has the potential to benefit juvenile salmon greater than 55 mm by increasing the amount of habitat and adversely affect smaller juvenile salmon and juvenile trout by decreasing the amount of habitat.

2.7 The number of days when the Waiau and Hurunui Rivers would be below 7 day MALF increases significantly under the A+B+C block allocation regime and would be likely to adversely affect trout and salmon for long periods.

2.8 The proposed A+B+C abstraction regime significantly increases accrual period length and decreases the frequency of freshes in the Waiau and Hurunui Rivers. Nutrient concentrations are currently capable of supporting nuisance algal growths in the lower Waiau and Hurunui Rivers. The proposed A+B+C block abstraction regime is likely to significantly increase the risk of nuisance algal growths occurring which would adversely affect the food producing capacity of the river and could result in a decline in trout and salmon condition and numbers.

2.9 After considering all the available information I conclude that the A+B+C block abstraction regime proposed for the Hurunui and Waiau Rivers has the potential to have the following effects:

a. Result in some positive and negative effects on the amount of available habitat for trout and salmon.

b. Adversely affect salmon passage through restricted water depths, changes in water quality and reduced frequency of migration trigger flows.

c. Significantly increase the risk of nuisance algal growths occurring on a more frequent basis, reducing the food producing capacity of the rivers and increase the risk of a decline in trout and salmon condition and numbers.

2.10 Based on these findings I conclude overall that the proposed A+B+C block allocation regime significantly increases the risk of adverse effects on trout and salmon in the Hurunui and Waiau Rivers.

## 3. IN-STREAM ECOLOGICAL EFFECTS ARISING FROM THE PROPOSED FLOW REGIME

### Salmon Passage

*Hurunui River*

3.1 Chinook salmon are diadromous and must have access from the ocean to rivers to spawn. Minimum flow, flow variability and water clarity all play a role in salmon passage. The proposed Hurunui River flow regime has the potential to affect salmon passage by:

a. Reducing the water depth to critical levels (< 0.25 m from Mosley 2004).
b. Altering the frequency and size of freshes that trigger migration and aid passage through the rivers.
c. Altering the frequency of river mouth closure.
d. Altering water quality.

3.2 NIWA (2004) described the results of a 2-D modelling assessment of a representative 1.2 km reach of the Hurunui River, 1 km downstream of the SH7 Bridge. The study did not assess the habitat conditions in the shallowest riffles. I consider this is an important aspect when using the modelling results to assess the effect of minimum flows on salmon passage.

3.3 I note that ECan (2011 unpub. report) in reviewing the NIWA (2004) report raised concerns about the representativeness of the study reach used stating that the mean number of braids in the study reach was 4.7 compared to >7.5 in other sections of the 25 km reach downstream of the SH7 Bridge. I share the concerns described in the review by ECan.

3.4 I note also that Dr John Hayes of the Cawthron Institute, in a letter to the North Canterbury Fish and Game Council in 2006, raised concerns about the apparently low flow that the model predicted would provide optimum habitat for invertebrate food production and the potential bias associated with In-stream Flow Incremental Methodology (IFIM) modelling based on a single study reach. I share the concerns of Dr John Hayes regarding the model results for the optimum habitat for invertebrate food production and potential bias associated with surveying a single study reach for the 2-D IFIM modelling.

3.5 Another concern raised in the ECan (2011) review was the assessment of critical riffles which was undertaken on the 17 km reach upstream of SH7 Bridge and may not provide an indication of the habitat limitation downstream of the SH7 Bridge or in the braided section downstream of SH1. I share the concerns described in the review by ECan.

3.6 ECan (2011) also raised concerns about the recommendation of Familton (2007) that the same minimum flow be applied at the Mandamus and SH1 flow recorder sites despite a 7 day MALF at the Mandamus flow recorder of 16.9 $m^3/s$ and a 7 day MALF at the SH1 site of 21.4 $m^3/s$.

3.7 NIWA (2004) concluded that there was sufficient depth (> 0.2 m) to allow adult salmon passage through the studied reach at flows of 5 $m^3/s$ and that at 10 $m^3/s$ the minimum water depth was 0.24 m. The minimum water depth at 10 $m^3/s$ reported by NIWA (2004) is below the critical depth (> 0.25 m) reported by Mosley (2004).

3.8 NIWA (2008) amended the conclusion of the NIWA (2004) report and concluded that flows greater than 15 $m^3/s$ during January – May should provide sufficient water depth for unimpeded passage to the spawning grounds. I note that prior to the IFIM work of NIWA (2004) that Mosley (2002) reported that a flow of > 20 $m^3/s$ is required to provide unhindered upstream passage through the braided section.

3.9 ECan (2011) identified that the assessment of the critical riffles undertaken by NIWA (2004) recorded a minimum depth of 0.25 m at a river flow of 13.5 $m^3/s$ and suggested that there were differences between the modelled 1.7 km reach downstream of the SH7 Bridge and the 17 km reach assessed for critical riffles upstream of the SH7 Bridge. In my opinion this creates a question over the validity of using the NIWA (2004) modelling results to assess minimum flows for salmon passage.

3.10 ECan (2011) cited work by Docherty (1979) that a flow of 12.4 $m^3/s$ at Mandamus reduced riffle depth to < 0.15 m and work by Davis (1980) who reported poor salmon recruitment in 1976 after a prolonged period of flows below 13.6 $m^3/s$.

3.11 Dr Murray Hicks in his evidence (paragraph 38) described the effect of abstraction on the river bed profile upstream and downstream of the abstraction point and stated that the river bed rises upstream of the abstraction point. In my opinion this could further reduce the ability of adult salmon to traverse the section of the river upstream from the point of take. This is not an aspect I have seen identified or discussed by others that have assessed the minimum flow requirements for ensuring salmon passage.

3.12 The proposed minimum flow for the Hurunui River during the months when salmon migrate upstream is 12 $m^3/s$ under the A block and A+B block abstraction regimes. The results of the NIWA (2004 and 2008) work, the assessment of Mosley (2004) and the review by ECan (2011) suggests that the proposed minimum flow of 12 $m^3/s$ is very likely to restrict upstream salmon passage and in my opinion the minimum flow at Mandamus during the months when salmon migrate (January – May) should be set at 15 $m^3/s$.

3.13 NIWA (2009) provides an assessment of the A block, A+B block and A+B+C block allocation regimes proposed at that time. Although the report did not consider the river water quality in any detail the author did comment that water quality was 'reasonably high' but that high river water temperatures may delay adult salmon migration from time to time.

3.14 Mosley (2002) reporting on water quality data collected prior to 2002 concluded that river water temperatures reach levels that are stressful to salmonids in summer. The A+B+C block allocation regime is likely to increase river water temperature in periods of summertime low flow and is likely to further increase the periods when river water temperatures are stressful for salmonids.

3.15 Mr Dave Stewart, in his evidence, presented flow hydrographs based on the Mandamus flow record for a wet year, an average year and a dry year. The number of freshes that trigger salmon to move upstream and provide the water depth and clarity preferred by salmon are significantly reduced under the A+B+C block allocation regime in wet, average and in dry years. I note that Dr Don Jellyman in his evidence (paragraph 24) identifies the adverse effects of prolonged periods without flow variation on water quality and salmon health and spawning success. In my opinion the A+B+C block allocation regime could adversely affect salmon in the Hurunui River by reducing the number of freshes that trigger upstream passage.

*Waiau River*

3.16 NIWA (2009) described the results of a 2-D modelling assessment of a representative 3 km reach of the Waiau River, 1 km downstream of Mouse point. The study did not assess the habitat conditions in the shallowest riffles. I consider this is an important aspect when using the modelling results to assess the effect of minimum flows on salmon passage.

3.17 Jowett Consulting Ltd (2012) described the results of a 1-D modelling assessment of a representative reach between Sandersons Road and Mouse Point. The report identified a number of key concerns with the 2-D modelling presented in NIWA (2009) for flows below 60 $m^3/s$ and presented a range of results and conclusions that differ from those presented in NIWA (2009).

3.18 NIWA (2009) concluded that there was sufficient depth (> 0.26 m) to allow adult salmon passage through the studied reach at flows of 18 $m^3/s$. The authors commented that salmon can traverse water shallower than 0.26 m but that it may come at a cost of energy and wear and tear on the body that can affect fecundity. Mosley (2004) quoted from Mr Ian Jowett's 1997 evidence to the Canterbury Regional Council hearing for the Amuri Irrigation Scheme abstraction stating that 0.25 m was the minimum depth to allow salmon passage. Jowett Consulting Ltd (2012) state that the minimum depth for salmon passage is 0.24 m and that the minimum depth was below 0.24 m in the shallowest riffle surveyed at flows below 16 $m^3/s$.

3.19 NIWA (2009) stresses that the assessment of flows were for the reach at Mouse Point and not the long term flow recorder site at Marble Point. NIWA (2009) states that, at the time of their study, there was an estimated loss of 4.59 $m^3/s$ from the river to groundwater between Marble Point and the study reach at Mouse Point.

3.20 Jowett Consulting Ltd (2012) reported finding no good evidence for a significant loss of flow to groundwater reported in NIWA (2009) and estimated a loss of 1 – 2 $m^3/s$ between Marble Point and the Waiau Township Bridge. I have relied on the assessment of water loss calculated by Jowett Consulting Ltd (2012) to assess the likely effect of abstractions on salmon passage in the Waiau River.

3.21 Jowett Consulting Ltd (2012) reported that at a flow of 20 $m^3/s$ within the shallowest riffle that there was 3 m of suitable water to allow for adult salmon passage but at 16 $m^3/s$ there was no passage width through the shallowest riffle.

3.22 Mr Stewart presented hydrographs for a dry, an average and a wet year for the flow record at Marble Point that showed that the A+B+C block allocation regime reduced the river flow at Marble Point, in dry, average and wet years, to 22.0 $m^3/s$ for extended periods in each of the years with the longest periods at 22 $m^3/s$ occurring in dry years. If one uses Jowett Consulting Ltd's (2012) estimated loss of 1-2 $m^3/s$ of river water to groundwater between Marble Point and Waiau Township the flow in the shallowest riffles upstream of Waiau Township could be 18-19 $m^3/s$ and at that flow water depth could become critical for adult salmon passage.

3.23 The hydrographs for a dry, an average and a wet year for the flow record at Marble Point presented by Mr Stewart showed that Row 1 of the A+B block allocation regime reduced the river flow at Marble Point, in the dry, and average year to approximately 15.0 $m^3/s$, albeit for less extended periods of time. Again if one uses Jowett Consulting Ltd's (2012) estimated loss of 1-2 $m^3/s$ of river water to groundwater between Marble Point and Waiau Township the flow in the shallowest riffles upstream of Waiau Township could be 15-16 $m^3/s$ and at that flow water depth would almost definitely prevent or delay adult salmon passage.

3.24 As I outlined earlier in my evidence Dr Murray Hicks in his evidence described the effect of abstraction on the river bed aggradation upstream of the abstraction point. In my opinion the river bed aggradation described by Dr Hicks could further reduce the ability of adult salmon to traverse the section of the river upstream from the point of take.

3.25 The results of the 1-D modelling results presented in Jowett Consulting (2012) and the evidence presented by Mr Stewart on the Waiau River hydrology at Marble Point and the evidence of Dr Hicks shows that the A+B Block and A+B+C block allocation regimes could reduce river water depth to critical levels and adversely affect salmon passage in particularly dry years.

3.26 NIWA (2011) and Dr Don Jellyman in his evidence (paragraph 24) reported that persistent low flows could have a serious effect on adult salmon upstream migration because achieving maturity is largely a function of time spent in fresh water.

3.27 The flow hydrographs based on the Marble Point flow record for a wet year, an average year and a dry year presented in the evidence of Mr Stewart show that the number of freshes that trigger salmon to move upstream and provide the water depth and clarity preferred by salmon are significantly reduced and the frequency and duration of low flows is significantly increased under the A+B+C block allocation regime in dry years. In my opinion the A+B+C block allocation regime could adversely affect salmon in the Waiau River in dry years by reducing the number of freshes that trigger upstream passage.

3.28 Mosley (2004), reporting on water quality data collected prior to 2004, concluded that river water temperatures reach levels that are stressful to salmonids in summer. Mosley (2004) reported that water temperature increased downstream of Marble Point and that temperatures of 25 °C have been recorded at the river mouth. The A+B+C block allocation regime is likely to increase river water temperature in periods of summertime low flow and is likely to further increase the periods when river water temperatures are stressful for salmonids.

**Trout and salmon habitat quantity and quality**

3.29 The quantity (physical area of stream bed) and quality of habitat (physical habitat quality including water quality, substrate composition, periphyton cover) can affect trout and salmon.

3.30 The minimum flow (7 day MALF) in a river exerts a strong influence on the amount of habitat available for trout and salmon. Accrual period length (time between fresh events), frequency of flushing flows, flow variability and water quality can all play an important role in determining the quality of the habitat and ultimately the productivity of trout and salmon populations.

3.31 The proposed A+B+C abstraction regime has the potential to affect the amount of physical habitat available for trout and salmon and also the quality of the habitat by altering accrual period lengths, the frequency of flushing flows and water quality.

3.32 In this section of my evidence I will discuss the effect of the proposed A+B+C abstraction regime on the amount of physical habitat available for the various life stages of trout and salmon. I will then discuss the affect the proposed A+B+C abstraction regime will have on accrual period length, frequency of flushing flows and flow variability and water quality and the likely effect of these combined influences on the trout and salmon populations of the Hurunui and Waiau Rivers.

*Hurunui River*

3.33 The potential effects of minimum flow on the amount of physical trout and salmon habitat within the Hurunui River has been thoroughly described in ECan (2004) and NIWA (2009). I draw on this work and the hydrological assessment undertaken by Mr Dave Stewart in this section of my evidence.

3.34 ECan (2004) assessed that the Weighted Useable Area (WUA) for adult salmon holding habitat increases from 5 $m^3$/s and peaks at approximately 30 $m^3$/s. The proposed A+B+C block allocation regime would result in the river flow declining to below the optimum adult salmon holding flow of 30 $m^3$/s for significant periods of wet, average and dry years and would make the river less suitable for resting adult salmon as they migrate upstream compared to the proposed A+B block allocation.

3.35 The WUA for juvenile salmon habitat (salmon < 55mm and salmon 52-102 mm) increases as flow decreases from 20 $m^3$/s to 5 $m^3$/s. The WUA for juvenile salmon habitat (salmon < 55mm and salmon 52 - 102 mm) increases between 20 $m^3$/s and 50 $m^3$/s. The WUA for salmon 52 – 102 mm in length peaks at 80 $m^3$/s. The WUA for salmon < 55 mm in length peaks at 5 $m^3$/s. The proposed A+B+C block allocation regime would result in the river flow remaining in the preferred range (5 $m^3$/s to 20 $m^3$/s) of juvenile salmon habitat for longer and assuming habitat is the limiting factor would potentially increase the amount of habitat for these life stages

3.36 The WUA for yearling brown trout which prefer riffle habitat increases as flow decreases from 20 $m^3$/s to 5 $m^3$/s and increases slowly between 20 $m^3$/s and 80 $m^3$/s because of the effect of flow on the amount of riffle habitat across multiple braids. The proposed A+B+C block allocation regime would result in the river flow remaining in the preferred yearling brown trout flow range (5 $m^3$/s to 20 $m^3$/s) for longer and assuming yearling brown trout habitat is limiting, would potentially increase the amount of yearling brown trout habitat and increase the level of recruitment of yearling brown trout into the adult population.

3.37 The WUA for adult brown trout which prefer pools and deep run habitat increases between 5 $m^3$/s and 10 $m^3$/s and decreases between 10 $m^3$/s and 30 $m^3$/s. The proposed A+B+C block allocation regime would result in long periods at the minimum flow of 12 $m^3/s$ or 15 $m^3/s$ depending on the month. The A+B+C block allocation regime has the potential to increase the amount of preferred habitat (pools and deep runs) available to adult brown trout.

3.38 In summary the proposed A+B+C block allocation could potentially increase the amount of habitat available to juvenile salmon and juvenile and adult brown trout and decrease the available habitat for adult salmon. Any positive effect for juvenile salmon and juvenile and adult brown trout would be dependent on whether habitat is limiting the populations.

3.39 Given the relatively small size of the salmon run described by Mr Ross Millichamp in his evidence it is unlikely that juvenile salmon habitat is a limiting factor in the Hurunui River and therefore I would not expect the proposed A+B+C allocation regime to benefit juvenile salmon. Similarly the large amount of riffle habitat that is available across a range of flows indicates that the amount of juvenile trout habitat is unlikely to be limiting in the Hurunui River so I would not expect there to be a benefit to juvenile trout.

3.40 In my opinion the proposed A+B+C block allocation regime has the potential to benefit adult trout by increasing the amount of habitat and adversely affect salmon by decreasing the amount of adult salmon holding water. This conclusion hinges on the assumption that adult trout and salmon habitat is more likely to be a limiting factor rather than other potential limiting factors such as flood disturbance, habitat quality, temperature and food availability which I will discuss later in my evidence.

3.41 The 7 day MALF is a good general measure of the habitat available for fish. Significant increases in the amount of time spent at 7 day MALF can adversely affect biological communities (Jowett 2005).

3.42 The number of days when the Hurunui River would be below 7 day MALF under the natural flow regime is 902 days or approximately 5% of the total number of daily records (20,044) between 1956 and early

2012. The number of days at or below 7 day MALF increases under the Natural+ A block allocation to 2,932 days or 15% of the records. The number of days at or below 7 day MALF increases further under the A+B block allocation regime to 4,651 days or 23% of the records. The number of days at or below 7 day MALF increases even more significantly under the A+B+C block allocation regime to 7,661 days or 35% of the record.

3.43 This analysis of the number of days when river flow is at or below 7 day MALF shows that A+B+C block allocation regime would restrict access to habitat for trout and salmon for long periods and in my opinion could result in a reduction in trout and possibly salmon numbers in the river.

3.44 I will describe the effect of the proposed abstraction regimes on food producing habitat, water quality and periphyton and accrual periods and freshes and what the overall potential effects on trout and salmon in the Hurunui River are likely to be later in my evidence.

*Waiau River*

3.45 The potential effects of minimum flow on the amount of physical trout and salmon habitat within the Waiau River has been thoroughly described in NIWA (2009) and Jowett Consulting Ltd (2012). The 2-D hydrodynamic modelling was undertaken by NIWA (2009) in a 3 km reach at Mouse Point. Mouse Point was chosen for its representativeness and not because it contained critical reaches, for example for salmon passage. As I outlined earlier in my evidence there are issues associated with the 2-D modelling and for these reasons I have relied upon the 1-D modelling presented in Jowett Consulting (2012) in this part of my evidence.

3.46 The WUA graph presented in Jowett Consulting (2012) shows juvenile salmon (<55 mm) and salmon fry habitat is predicted to decrease as flows decrease from approximately 30 to 10 $m^3/s$ due to a decrease in the amount of the preferred riffle habitat for these life stages. The maximum WUA for these life stages is at approximately

30 $m^3/s$. The proposed A+B and A+B+C block allocation regimes would result in the river flow remaining in the less preferred range (< 30 $m^3/s$) for longer and would potentially decrease the amount of juvenile salmon and salmon fry habitat.

3.47 The WUA graph presented in Jowett Consulting (2012) shows that for juvenile salmon >55 mm that habitat is predicted to decrease as river flow decreases from 15 $m^3/s$ to 10 $m^3/s$ as the amount of pool habitat decreases. The WUA for juvenile salmon> 55 mm remains static between approximately 15$m^3/s$ and 25 $m^3/s$ and then decreases between 20 – 60 $m^3/s$ as pool habitat decreases. The proposed A+B and A+B+C block allocation regimes would result in the river flow remaining in the preferred range of 15 $m^3/s$ – 25 $m^3/s$ for longer and would potentially increase the amount of preferred pool habitat for juvenile salmon greater than 55 mm in length.

3.48 The WUA for juvenile brown trout preferred riffle habitat is predicted to decrease sharply as flow decreases from 30 $m^3/s$ to 5$m^3/s$. The WUA for juvenile brown trout then increases at flows above 30 $m^3/s$ to peak at 50 $m^3/s$. The proposed A+B+C block allocation regime would result in the river flow remaining in the less preferred juvenile brown trout flow range for longer and would potentially decrease the amount of juvenile brown trout habitat (riffles).

3.49 The WUA for adult brown trout habitat (pools and deep runs) is predicted to remain static between 5 $m^3/s$ and 40$m^3/s$ and then decline slowly between 40 and 60 $m^3/s$. The proposed A+B+C block allocation regime is therefore not expected to have a significant effect on the potential amount of habitat available to adult brown trout.

3.50 In summary the proposed A+B and A+B+C block allocation regimes would result in the river flow remaining in the less preferred range for juvenile salmon < 55mm, salmon fry and juvenile brown trout for longer and would potentially decrease the amount of habitat for these species and life stages. The proposed A+B and A+B+C block allocation regimes would result in the river flow remaining in the preferred range for juvenile salmon greater than 55 mm for longer and would potentially increase the amount of available habitat for this life stage of this species. The proposed A+B+C block allocation regime is not expected to have a significant effect on the potential amount of habitat available to adult brown trout.

3.51 If it is assumed that habitat is limiting, the proposed A+B+C block allocation regime therefore has the potential to benefit juvenile salmon greater than 55 mm by increasing the amount of habitat and adversely affect smaller juvenile salmon and juvenile trout by decreasing the amount of habitat.

3.52 Given the relatively small size of the salmon run described by Mr Ross Millichamp in his evidence, however, it is unlikely that juvenile salmon habitat is a limiting factor in the Waiau River and therefore I would not expect the proposed A+B+C allocation regime to benefit juvenile salmon. The Waiau River provides a large amount of juvenile trout habitat across a range of flows so the amount of juvenile trout habitat is also unlikely to be limiting in the Waiau River and I would not expect the proposed A+B and A+B+C block allocation regimes to be a benefit to juvenile trout.

3.53 I will discuss other potential limiting factors such as flood disturbance, habitat quality, temperature and food availability later in my evidence.

3.54 The number of days when the Waiau River would be below 7 day MALF under the natural flow regime is 792 days or approximately 5% of the total number of daily records (16,157). The number of days at or below 7 day MALF increases sharply under the Natural A block allocation to 3,782 days or 23% of the records. The number of days at or below 7 day MALF increases further under the A+B block allocation regime to 5,918 days or 37% of the records. The number of days at or below 7 day MALF increases significantly under the A+B+C block allocation regime to 11,315 days or 70% of the record.

3.55 This analysis of the number of days when river flow is at or below 7 day MALF shows that A+B+C block allocation regime would restrict the use of the available habitat for trout and salmon for long periods and in my opinion this has the potential to result in a reduction in trout and possibly salmon numbers in the river.

3.56 As I have outlined earlier in my evidence the amount of in-stream habitat, described here as WUA is only one factor that can influence trout and salmon. I describe the effect of the proposed abstraction regimes on food producing habitat, water quality, periphyton habitat, accrual periods and freshes on trout and salmon in the Waiau River below.

**Water quality and periphyton habitat**

3.57 A river's flow regime can affect didymo and periphyton communities by altering the amount of WUA, deposited sediment and water quality (particularly nutrient concentrations, temperature, suspended solids and clarity). The productivity of periphyton communities in South Island braided rivers is typically more strongly influenced by water quality and flow stability than the amount of physical habitat (WUA).

*Hurunui River*

3.58 Didymo was first confirmed in the Hurunui River in 2007. Observations to date indicate that didymo is most extensive in the North Branch where the more stable flow conditions are suitable for its proliferation. North Canterbury Fish and Game (2011) reported that didymo is at times not visually apparent downstream of the South Branch confluence and even after extended periods of low flow didymo is patchy. Didymo prefers rivers with stable flow and low suspended solids loads. The flow variation and higher suspended sediment loads introduced by the South Branch is likely to help limit didymo downstream of the South Branch.

3.59 Didymo can grow to cover entire channels under low temperature and nutrient conditions within 6 – 8 weeks. Didymo is thought to be resistant to freshes and floods unless bed material moves to assist with scouring. Some recent work on the Waitaki River on the size of flushing flows required to remove didymo suggests that flows well in excess of FRE3 and possible closer to 6x the annual median flow are required to remove didymo.

3.60 It is difficult to assess what the effect of the proposed A+B+C abstraction regime would be on didymo growths. Based on current knowledge it appears likely that the A+B+C abstraction regime, because it significantly increases the frequency and duration of low flows and significantly decreases the frequency of freshes, will increase the risk of didymo reaching nuisance levels between the South Branch confluence and the river mouth.

3.61 The potential effects of minimum flow on periphyton habitat within the Hurunui River is described in NIWA (2007), NIWA (2009) and in the evidence of Dr Ton Snelder presented to this hearing.

3.62 The WUA for diatoms, the algae community generally preferred by the more highly valued benthic invertebrate taxa such as *Deleatidium* decreases steadily between 80 – 5 $m^3$/s. The WUA for short filamentous algae, the less preferred algal community increases between 30 – 10 $m^3$/s. The WUA for long filamentous algae, the least preferred algal community increases between 20 – 5 $m^3$/s

3.63 The proposed A+B+C block allocation regime would result in the river flow remaining in the flow range that is less suited to a preferred algal community (thin diatoms) and more suited to a less preferred algal community (short and long filamentous algae) for longer. This increases the risk of nuisance algal growths developing that can adversely affect recreational use and decrease invertebrate community productivity.

3.64 The MfE (2000) New Zealand Periphyton Guidelines outline recommended nutrient concentration limits for accrual period lengths of 20+ days, 30+ days, 40+ days, 50+ days, 75+ days and 100+ days. Accrual periods are a very important factor determining the extent and type of algal communities that develop in rivers. In general terms the longer the accrual period the less nutrients are required to support algal growths and the greater the risk of nuisance algal growths developing.

3.65 The total number of days within the 20+ day, 30+ day, 40+ day, 50+ day, 75+ day and 100+ day accrual period categories for the natural, A block, A+B block, A+B+C block abstraction regimes for the complete flow record at Mandamus is presented in Table 1.

Table 1

| Flow | Accrual days | | | | | |
|---|---|---|---|---|---|---|
| | 20+ days | 30+ days | 40+ days | 50+ days | 75+ days | 100+ days |
| Natural | 24 | 34 | 43 | 62 | 87 | 177 |
| A Block | 24 | 34 | 43 | 62 | 87 | 179 |
| A+ B Block | 23 | 34 | 44 | 62 | 88 | 194 |
| A+B+C Block | 23 | 36 | 45 | 62 | 84 | 233 |

3.66 The data in Table 1 shows that as the number of days within accrual periods ranging from 20+ to 75+ days generally decreases the number of days in the 100+ day accrual period increases. The mean 100+ day accrual period length increases from 177 days under natural flows to 179 days under the A block allocation, 194 days under the A+B block allocation and 233 under the A+B+C block allocation. The increased length of accrual periods can be seen in the hydrographs presented by Mr Dave Stewart in his evidence and appear as sections of flat lining.

3.67 The shift to longer accrual periods significantly increases the risk of nuisance algal communities developing that can adversely affect water quality, benthic invertebrate communities and fish, a conclusion that was also made by Dr Ton Snelder in his evidence (paragraphs 48 and 54).

3.68 Flow variability and the frequency of freshes that remove algal growths and larger floods that rework the riverbed and ‘reset’ the biological communities are very important to the overall health of rivers. I note that Dr Ton Snelder in his evidence (e.g. paragraphs 48 and 54) also describes the importance of mid range flows. Flows 3 times greater than the annual median flow, known as FRE3 flows, are generally regarded as being capable of removing algal growths.

3.69 NIWA (2009) and Dr Ton Snelder in his evidence draw on the results of a study of the Waimakariri River of bed movement for resetting ecological communities to assess the size of the flow that is likely to be required to remove periphyton from the Hurunui River. NIWA (2009) concluded that FRE2 (flows 2x the annual median flow) flows of approximately 80 $m^3/s$ were likely to be capable of surface flushing periphyton and fine sediment in the Hurunui River and that FRE3 flows are likely to result in deep flushing and significant bed movement.

3.70 ECan (2011) reviewed the limited amount of periphyton cover data that is available and related this to natural high flow events and concluded that a FRE3 size flow event is required to cause significant removal of nuisance periphyton. I share the view of Mosley (2002) and ECan (2011) that a FRE3 size flushing event is likely to be required for effective flushing of nuisance algal growths.

3.71 The effect of the A block, A+B block and A+B+C block abstraction regimes on FRE2 and FRE3 frequency are presented in Table 2.

Table 2

| Abstraction Regime | FRE2 events/year | FRE3 events/year |
|---|---|---|
| Natural | 8.3 | 5.4 |
| A Block | 7.6 | 4.7 |
| A+B Block | 6.6 | 4.3 |
| A+B+C Block | 4.6 | 3.2 |

3.72 The data shows that the number of FRE2 events decreases from 8.3/year under natural flow to 4.6/year (45% decrease) under the A+B+C block abstraction regime. A total of 8.3 FRE2 events/year translates to an average accrual period length of 42 days. A total of 4.6 FRE2 events/year translates to an average accrual period length of 76 days.

3.73 Mosley (2002) reported an average FRE3 frequency of 6/year which translates to an average accrual period of 61 days. NIWA (2007) calculated a FRE3 for the Hurunui River based on instantaneous flows at an interval of 5 days of 8.8/year giving a mean accrual period of 40 days. NIWA (2009) concluded that 41 days was long enough for nuisance algal growths to occur in summer provided there were sufficient nutrients. This conclusion is supported by Mosley (2002) that reported that nuisance growths are possible every couple of years during summer low flows and have led to complaints in the past.

3.74 The data presented in Table 2 shows that the number of FRE3 events under natural flows is 5.4/year similar to the frequency of FRE3 events reported in Mosley (2002).

3.75 The data presented in Table 2 shows the number of FRE3 events decreases from 5.4/year under natural flow to 3.2/year (41% decrease) under the A+B+C block abstraction regime. A total of 5.4 FRE3 events/year translates to an average accrual period length of 65 days. A total of 3.2 FRE3 events/year translates to an average accrual period length of 110 days. The reduced frequency of freshes can be seen in the hydrographs presented by Mr Dave Stewart in his evidence.

3.76 Aquanet (2010) analysed the available water quality data for the Hurunui River and reported median dissolved reactive phosphorus (DRP) concentrations of 0.002 $g/m^3$ at the SH 7 Bridge and of 0.004 $g/m^3$, in the mid and lower reaches of the Hurunui River.

3.77 Aquanet (2010) reported that the median DRP concentration at the SH7 Bridge site exceeded the recommended DRP concentration in the MfE (2000) periphyton guidelines for accrual periods greater than 50 days. The median DRP concentration in the mid and lower reaches exceeded the recommended DRP concentration in the MfE (2000) periphyton guidelines for accrual periods greater than 40 days.

3.78 The MfE (2000) recommended median dissolved inorganic nitrogen (DIN) concentration for controlling nuisance growths was exceeded at the SH7 for accrual periods exceeding 40 days. The MfE (2000) recommended median DIN concentration was exceeded at the mid and lower Hurunui River sites for all accrual period lengths.

3.79 The current nutrient concentrations in the river would appear to be high enough to support nuisance algal growths if the accrual period length is sufficiently long. Dr Roger Young, in his evidence reported that nutrient concentrations in the lower Hurunui are elevated and are sometimes above guidelines and that nuisance periphyton growths can occur in the lower reaches of the river. Aquanet (2010), drawing on limited data for the SH7 site, reported that the MfE (2000) filamentous algal cover guideline of 30% has not been exceeded at the SH7 site.

3.80 The effect of the A+B+C block abstraction regime on FRE2 and FRE3 frequency reduces the ability of the river to remove periphyton growths and increases the risk of nuisance algal growths and negative adverse effects on recreational users and the invertebrate community occurring.

3.81 The results of the NIWA (2009) study of periphyton habitat showed that the A+B+C block abstraction regime will result in flows that are more suited to a less desirable periphyton community more often. The A+B+C block abstraction also increases the length of long (100+ day) accrual periods and reduces the frequency of FRE2 and FRE3 events. Nutrient concentrations are already suitable for supporting nuisance algal growths at accrual periods in excess of 40 days at the SH7 Bridge.

3.82 Based on my assessment of all of the relevant information I conclude that the A+B+C abstraction regime is likely to significantly increase the risk of nuisance algal growths occurring. If this did occur then, in my opinion it is likely that the food producing capacity of the river would be adversely affected, increasing the risk of a decline in trout and salmon condition and numbers.

*Waiau River*

3.83 The potential effects of minimum flow on the amount of food producing habitat within the Waiau River is described in Jowett Consulting (2012).

3.84 The WUA for diatoms, the algae community generally preferred by the more highly valued benthic invertebrate taxa such as *Deleatidium* decreases between 80 – 10 $m^3$/s. The WUA for short filamentous algae, the less preferred algal community increases between 15 –30 $m^3$/s. The WUA for long filamentous algae, the least preferred algal community increases sharply between 40 – 10 $m^3$/s.

3.85 The proposed A+B+C block allocation regime would result in the river flow remaining in the flow range that is more suited to long filamentous algae for longer. This increases the risk of nuisance algal growths developing that can adversely affect water quality by altering dissolved oxygen levels and pH, recreational users and the invertebrate community.

3.86 The total number of 20+ days, 30+ days, 40+ days, 50+ days, 75+ days and 100+ days accrual periods for the complete flow record at Marble Point is presented in Table 3.

Table 3

| Flow | Accrual days | | | | | |
|---|---|---|---|---|---|---|
| | 20+ days | 30+ days | 40+ days | 50+ days | 75+ days | 100+ days |
| Natural | 23 | 35 | 45 | 64 | 85 | 145 |
| A Block | 23 | 34 | 44 | 61 | 89 | 154 |
| A+ B Block | 23 | 34 | 44 | 62 | 88 | 157 |
| A+B+C Block | 23 | 35 | 43 | 59 | 88 | 161 |

3.87 The data in Table 3 shows that as the number of days of accrual periods ranging from 20+ to 50+ days decreases, there is a shift towards greater number of days in the 75+ day and 100+ day accrual period categories. The mean 100+ day accrual period length increases from 145 days under natural flows to 154 days under the A block allocation, 157 days under the A+B block allocation and 161 days under the A+B+C block allocation. The increased length of accrual periods can be seen in the hydrographs presented by Mr Dave Stewart in his evidence and appear as sections of flat lining.

3.88 The shift to longer accrual periods increases the risk of nuisance algal communities developing that could lead to negative effects on water quality, recreational users and benthic invertebrate communities of the Waiau River.

3.89 Mosely (2004) reported that the Waiau River has very good water quality and low nutrient concentrations and frequent freshes prevent nuisance algal growths occurring although nuisance algal growths have been recorded in some tributaries in the eastern half of the Waiau River catchment.

3.90 Dr Adrian Meredith, senior water quality scientist at ECan reported in 2011 that water quality in the Waiau River is generally good but that nutrient concentrations increase downstream and that exceedances of the MfE (2000) cover guidelines do occur in the middle and lower reaches. Dr Meredith states that algal growths tend to be dominated by black and brown mat types rather than filamentous algae that typically occurs in the Hurunui River.

3.91 NIWA (2011) reported on the risk of nuisance algal communities occurring in the reach between Marble Point and the lower Waiau River and concluded that flows of between FRE2 and FRE3 were required to remove periphyton.

3.92 The effect of the A block, A+B block and A+B+C block abstraction regimes on FRE2 and FRE3 frequency are presented in Table 4. The data shows that the number of FRE2 events decreases from 11.3 under natural flow to 7.5 (34% decrease) under the A+B+C block abstraction regime. The number of FRE3 events decrease from 7.7 under natural flow to 5.3 (31% decrease) under the A+B+C block abstraction regime. The reduced frequency of freshes can be seen in the hydrographs presented by Mr Dave Stewart in his evidence.

Table 4

| Abstraction Regime | FRE2 events/year | FRE3 events/year |
|---|---|---|
| Natural | 11.3 | 7.7 |
| A Block | 10.5 | 6.8 |
| A+B Block | 9.6 | 6.5 |
| A+B+C Block | 7.5 | 5.3 |

3.93 The effect of the A+B+C block abstractions on FRE2 and FRE3 frequency reduces the ability of the river to remove periphyton growths and increases the risk of nuisance algal growths and negative adverse effects on recreational users and the invertebrate community occurring.

3.94 The results of the NIWA (2011) study of periphyton habitat and the evidence presented by Dr Ton Snelder at this hearing show that the A+B+C block abstraction will result in flows that are more suited to a less desirable periphtyon community more often. The A+B+C block abstraction also increases the length of long (100+ day) accrual periods and reduces the frequency of FRE2 and FRE3 events.

3.95 The results of NIWA (2011) and the evidence presented by Dr Ton Snelder at this hearing confirm the importance of mid range flows (FRE2 and FRE3 events). NIWA (2011) and Dr Ton Snelder and Mr Ned Norton in their evidence concluded that reducing the number of FRE2 and FRE3 events increases the risk of nuisance algal growths.

3.96 After considering the available information I conclude that the A+B+C abstraction regime is likely to significantly increase the risk of nuisance algal growths occurring in the middle and lower river on a more frequent basis than is currently the case. If this did occur then, in my opinion it is likely that the food producing capacity of the river would be adversely affected and would lead to an increased risk of a decline in trout and salmon condition and numbers.

**Benthic macroinvertebrates**

3.97 A river's flow regime can affect invertebrate communities by altering the amount of WUA, deposited sediment, water quality (particularly temperature and suspended solids), algal community composition and cover. The flow regime can also influence fine sediment transport and deposition. Longer accrual periods and reduced frequency of flushing flows can lead to fine sediment being deposited on periphyton reducing its palatability to invertebrates. I note that Dr Murray Hicks in his evidence (paragraph 36) concluded that the A+B Block and A+B+C block abstraction regimes will reduce the frequency of fine sediment flushing in the Hurunui River.

3.98 The productivity of invertebrate communities in South Island braided rivers is typically more strongly influenced by flow stability than the amount of physical habitat (WUA). The importance of the WUA for invertebrates is therefore lower when weighing the range of factors such as habitat, water quality, periphyton cover compared to when making this assessment for fish.

*Hurunui River*

3.99 The WUA invertebrate production, using the habitat preference curves of Waters (1976)and reported by Jowett Consulting Ltd (2012) decreases sharply below 30 $m^3$/s. The WUA for *Deleatidium*, a key invertebrate food source also decreases sharply below 30 $m^3$/s. The proposed A+B+C block allocation regime would result in the river flow remaining in the flow range that is less suited for food production and *Deleatidium* for longer and would decrease the amount of food producing habitat.

3.100 A decrease in *Deleatidium* could lead to a decrease in algal grazing pressure and an increase in algal (periphyton) cover and biomass further exacerbating the negative effect of low flows in promoting nuisance algal growths as I outlined previously .

3.101 As I outlined in the previous section of my evidence, accrual period length and frequency of freshes are very important in determining the extent and type of periphyton and invertebrate communities that develop in a river. South Island braided river invertebrate communities are typically dominated by taxa such as the mayfly *Deleatidium* that prefer high – moderately high water quality and a periphyton community dominated by thin diatom films. The invertebrate communities are adapted to moderate to high suspended sediment loads and regular freshes.

3.102 Juvenile and adult trout and juvenile salmon depend on aquatic invertebrates as their main food source. Trout and juvenile salmon prefer 'clean water' invertebrates such as *Deleatidium* that typically dominate in clean braided rivers with thin diatom dominated periphyton communities.

3.103 A shift from a thin diatom dominated periphyton community to a community dominated by extensive growths of thick mats or filamentous algae shifts the invertebrate community from one dominated by 'clean water' taxa preferred by trout and salmon, to one dominated by water quality tolerant taxa such as chironomids and snails. An invertebrate community tolerant of thick algal mats and filamentous algae do not provide the same source of energy to fish as clean water taxa.

*Waiau River*

3.104 The WUA for invertebrate and *Deleatidium* production decreases sharply below 25 $m^3$/s. The proposed A+B+C block allocation regime would result in the river flow remaining in the flow range that is less suited for invertebrate and *Deleatidium* production (below 25 $m^3$/s) for longer and would potentially decrease the amount of food producing habitat.

3.105 As I outlined earlier, a shift from a thin diatom dominated periphyton community to a community dominated by extensive growths of thick mats or filamentous algae alters the composition of the invertebrate community. This shift can reduce the capacity of the invertebrate community to support a healthy fish population.

**R Montgomerie**
**12 October 2012**

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