

**IN THE MATTER** of the Resource Management Act 1991

**AND**

**IN THE MATTER** of an application pursuant to Section 201 for a Water Conservation Order on the Hurunui River.

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**STATEMENT OF REBUTTAL EVIDENCE OF ROGER YOUNG ON BEHALF OF NORTH CANTERBURY FISH AND GAME COUNCIL**  
**Dated 17<sup>th</sup> day of April 2009**

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1. I prepared a first statement of evidence dated 6 March 2009, in respect of Fish and Game's application for a Water Conservation Order on the Hurunui. I confirm the detail of my experience and qualifications set out therein.
2. In this statement of evidence I address some supplementary points that have been raised by the tribunal members during the hearing.
3. I also set out my comments in rebuttal in respect of the evidence of Dr Vaughan Keesing and Mr Bruce Norrie on behalf of the Hurunui Water Project, Dr Ruth Goldsmith on behalf of Trustpower, Drs Richard Allibone and Greg Burrell on behalf of the Amuri Irrigation Scheme, and Dr Phillip Mitchell on behalf of Meridian Energy Ltd.

**What have been the effects of didymo on fisheries and angling around the world?**

4. Until recently, didymo was described as a relatively rare diatom that was only found in cold-water rivers in the northern parts of Europe, North America and Asia. Didymo blooms have been apparent in British and Scandanavian rivers for many years, however, for some reason didymo has expanded its range into new geographic areas and habitat types over the last decade. The sudden appearance of didymo blooms has been noted throughout Canada (British Columbia, Alberta, Quebec, Yukon), U.S.A. (South Dakota, Colorado, Montana, Missouri, Arkansas, New Hampshire, Pennsylvania, Vermont, New York), Iceland, and New Zealand.
5. Concerns about the potential effects of didymo on trout and salmon fisheries and angling have almost certainly been raised in all the areas where didymo has appeared, but there have been few studies that have addressed direct impacts on fisheries. One study noted that a decline in the density of adult brown trout in Rapid Creek, South Dakota coincided with the appearance of didymo. However, severe droughts occurred at the same time and the decline in the brown trout population could also be attributed to reduced stream flow (Larsen & Carreiro 2008).
6. An analysis of long-term records of coho salmon, chum salmon and steelhead trout populations on Vancouver Island has indicated that didymo did not diminish the natural fish production capacity of rivers during a period of extensive blooms in the 1990's. In fact there was some evidence suggesting possible stimulation of coho salmon production associated with didymo, although this was not consistent across all didymo affected rivers (Bothwell et al. 2008).

7. In Norway, didymo blooms have been a naturally occurring phenomena since at least the 1800's and still occur in rivers that are considered to be their best Atlantic salmon fisheries (Lindstrøm and Skulberg 2008).
8. In summary, the situation overseas seems similar to New Zealand with concerns about potential effects of didymo on fisheries. However, limited studies to date suggest that the effects of didymo are not as serious as initially feared.

**What is the likely explanation for differences between scientists' conclusions on fish migration to the sea/estuary compared to anglers' theories on sea-run trout?**

9. Anglers often distinguish brown trout as either sea-run or resident fish based on fish colour, shape, size, presence of loose scales, and observations of shoaling behaviour. I've caught several of these large silver trout and it's hard to believe that they aren't something special. However, it is possible that these morphological and behavioural differences are merely part of the natural variation that is characteristic of brown trout populations. The fish that anglers consider to be sea-run trout may be riverine fish migrating from one part of the river to another. Scientists have looked for techniques that provide an objective indication of whether fish are sea-run or not – otolith microchemistry and growth modelling are useful techniques in this regard.
10. As part of a study on the effects of land use on the Pomahaka River fishery I conducted some strontium analyses of the scales from trout collected by anglers (Young & Hayes 1999). The otolith microchemistry technique that I described in my original evidence was in its infancy then. I found no relationship between Sr levels in the scales and whether the anglers thought they were searun fish or not. Some silver fish had low Sr levels suggesting that they were residents (not sea-runners), while some brown spotted trout had high Sr levels suggesting that they may have been to sea (but were considered resident fish by anglers). I did, however, find that fast growing trout generally had high strontium levels indicating they had been to the sea/estuary, while the old slow growing fish had lower strontium levels indicating freshwater residency. Given this result, I am sceptical about the ability of anglers to accurately distinguish between resident and sea-run trout.
11. Despite this scepticism I am not ruling out the possibility that some trout in the Hurunui River do spend a considerable proportion of their time in the lower reaches/estuary of the Hurunui River and/or at sea. Our growth modelling indicated that approximately 5% of the angler caught fish in our sample would have required a period of growth in the ocean, or would have needed to have fed significantly on fish, to have attained the size-at-age observed.
12. The otolith microchemistry analysis indicated that none of the adult trout collected from the Hurunui River had elevated Sr:Ca ratios and a simultaneous drop in Ba:Ca levels that are indicative of time spent in an estuarine/marine environment (Bickell & Olley 2009). It is possible that we would have detected some sea-run fish if a larger sample of trout had been analysed. However, the 5 kg trout that was caught at the river mouth did not display Sr:Ca levels that were sufficiently elevated to indicate time spent in an estuarine/marine environment, which seems counterintuitive. Perhaps this fish was able to take advantage of abundant forage fish resources near the river mouth without actually spending much time in Sr-rich salt water. Other fish may have followed a similar strategy and spent time at or near the river mouth without incorporating elevated Sr:Ca levels in their otoliths. Regardless of this, the otolith

microchemistry study clearly showed that migration throughout the freshwater part of the catchment is a common life-history strategy for Hurunui trout.

**Is there overseas evidence of brown trout using fish passes? What heights and styles are successful?**

13. The majority of overseas fish passes have been designed to enable passage for salmon and sea trout (Clay 1995). Sea trout are the sea-run form of brown trout and have the same scientific name (*Salmo trutta*). Passage of brown trout through a range of fish pass types has been reported in North America and Europe (Clay 1995).
14. Fish passes can be classified into three main types – pool and weir fish passes, fish locks, and fish elevators.
15. Pool and weir fish passes consist of a series of pools in steps leading from the river below the dam to the reservoir upstream. Water flows from pool to pool, either over the weir, through a vertical slot in the weir, or through submerged holes/orifices in the weir. Fish are able to burst swim through the slot/hole, or jump, from pool to pool. Each pool provides a resting opportunity. A slight variation on this theme is the Denil fish pass where baffles are installed on the sides and bottom of a relatively steep channel to help dissipate the energy and velocity of the flowing water, allowing fish to migrate upstream. Fish don't have the opportunity to rest in Denil fish passes, so resting pools are typically required in association with these passes. Pool and weir fish passes, especially those with vertical slots in the weirs, are considered to be effective for a wide variety of fish species, but require a considerable amount of space for their construction. This design is not considered appropriate for dams greater than 30-35 m in height (Jowett 1987).
16. Fish locks are a device that raises fish over dams by attracting fish into a chamber at the bottom of the dam, closing the entrance to the chamber and filling it with water until the water level reaches the reservoir level enabling fish to swim into the reservoir above the dam. After a certain period the chamber is emptied and the process is repeated. Fish locks have been built on dams of up to 60 m in height and are considered to operate successfully maintaining runs of salmon and trout (Clay 1995). Fish locks are not considered suitable for large runs of fish, which has deterred their use in western North America. There have also been problems reported with clearing the fish from the chamber once it is full, resulting in fish being washed back downstream and injured when the chamber is emptied.
17. Fish elevators take a variety of forms but all involve the collection of fish at the bottom of a dam, followed by mechanical transport of the fish upstream of the dam. This can be conducted via cable and bucket systems associated with the dam, or more independent trap and transfer systems involving trucking fish upstream. Fish elevators are used extensively on rivers in North America, France and Russia and can cope with large numbers of fish (Clay 1995). However, fish can be stressed/injured during capture, transport and release and ongoing costs associated with this method are very high.
18. Fish pass design has traditionally concentrated on facilitating upstream passage past dams. However, facilitating downstream passage of juvenile trout and salmon (and adult eels) is at least as big a problem. Downstream movement of juvenile salmonids is delayed due to the lack of current in reservoirs and significant mortality can occur if fish pass through turbines or over spillways. Downstream passage of juvenile trout and salmon has been reported with some fish locks (Clay 1995), while trap and

transfer systems are used to transport juvenile salmon downstream past dams on several North American rivers.

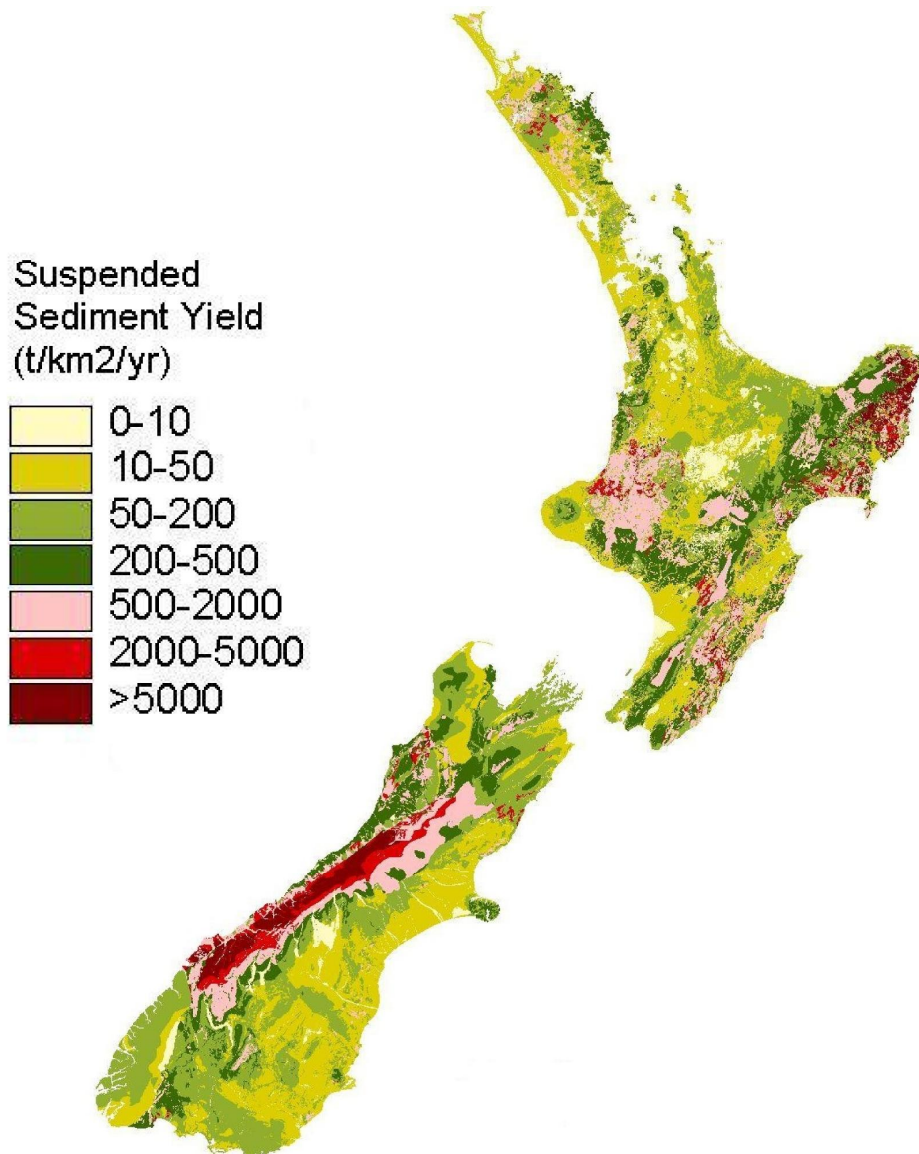
19. In summary, brown trout are known to use a variety of fish passes overseas. Pool and weir fish passes are expected to be most effective and economical for relatively low dams (<30 m), while fish locks or a trap and transfer regime appears more suited to high dams. Although the style of the fish pass is an important element of its success, the most important consideration relates to the location of the fishpass entrance. The entrance needs to be located immediately off the main path used by migrating fish and a sufficient flow from the entrance is required to attract fish to the pass. A successful pass needs to consider both upstream and downstream movement of fish.

### **What is the height, style and success rate of the Mararoa fish pass?**

20. The fish pass on the Manapouri Lake Control structure (otherwise known as the Mararoa Weir) was retro-fitted to the structure in 1998 after the previous fish pass was considered a failure. The fish pass is a vertical slot pool and weir fish pass with three entrance gates at the bottom of the weir. The height of the Mararoa Weir is dependent on the level of Lake Manapouri and can range from 4.3 m under normal lake levels up to 6.2 m (Zane Moss, Fish & Game NZ – Southland Region, personal communication).
21. In 1999/2000 Fish & Game NZ, Southland region undertook a trapping and tagging programme to assess the effectiveness of the pass. From April 1999 to June 2000 1645 trout (889 brown and 756 rainbow) were caught in a trap at the upper end of the fish pass. Movement was most pronounced during May for brown trout and December for rainbow trout. There were also indications that increased flows stimulated fish movement, and movement was greatest during periods when the moon was close to New Moon phase, rather than a full moon phase (Maurice Rodway, Fish & Game NZ – Southland Region, personal communication).
22. Fish & Game also conducted a radiotagging study from March to November 2001 to determine the behaviour of trout as they approached the Weir, success of passage, and their subsequent movements upstream. Fifty seven brown trout were implanted with radiotransmitters as part of that study. Fifty five of these trout were initially caught in a trap within the fish pass before being tagged and therefore had some knowledge of how to locate and ascend the pass. Forty four trout were released downstream of the weir and 14 of these subsequently passed through the fish pass and were located in the Mararoa and Whitestone rivers upstream. Some of these fish spent a considerable amount of time (up to 46 days) below the weir before ascending the fish pass. Thirteen trout were recorded immediately downstream of the Weir but did not ascend the pass, suggesting that they had difficulty locating the pass, were not seeking passage at the time, or the trapping/handling/tagging procedure stressed the fish and impaired their migratory behaviour. These trout spent 1 to 25 days downstream of the Weir (Maurice Rodway, Fish & Game NZ – Southland Region, personal communication). This study provides some information, but it does not provide a definitive estimate of the proportion of the trout population negotiating the pass.
23. There are also reports of lamprey and elvers using the fish pass (Zane Moss, Fish & Game NZ – Southland Region, personal communication).

## What is the sediment supply from the South Branch of the Hurunui River?

24. As far as I'm aware there have been no studies that have investigated the sediment load of the South Branch of the Hurunui River. However, Murray Hicks from NIWA has produced a map of predicted sediment delivery rates for all the New Zealand using information on climate, geology and topography (Figure 1, available at <http://www.niwa.co.nz/ncwr/tools#SSY>).



**Figure 1.** Map of New Zealand showing predicted sediment yield.

25. Using this map and a geographic information system (GIS) it is possible to predict the sediment load for any river system in New Zealand. Using this approach the South Branch of the Hurunui River is predicted to have a sediment load of 237 kt/y, which is 46% of the total load from the Hurunui River to the ocean (Table 1). The North Branch of the Hurunui River above Lake Sumner, and other tributaries to Lake Sumner export 512 kt/y, but this material is assumed to be trapped within Lake Sumner. Other tributaries to the mainstem of the river provide a relatively small load to the river (Table 1). So in summary, the South Branch makes the largest single contribution to the Hurunui River's sediment load to the sea and any reduction in this

sediment load may reduce the ability of the river to flush periphyton and didymo, and results in changes to the braided morphology of the river.

**Table 1.** Sediment load from parts of the Hurunui Catchment. Note that sediment load from the tributaries of Lake Sumner is assumed to be trapped within Lake Sumner and thus does not contribute to the sediment load to the ocean.

<b>Sub Catchment</b>	<b>Sediment Load (kT/y)</b>
Mandamus	25
North Branch	67
South Branch	237
Dry Stream	5
Pahau	27
Waitohi	24
Waikari	11
<b>Entire Catchment</b>	<b>515</b>
Lake Sumner tributaries	512

**Dr Vaughan Keesing, evidence dated 19 March 2009**

26. At paragraph 14 Dr Keesing states that he relies on data that he has collected from field work in the South Branch and North Branch of the Hurunui River, including a 10 km electric fishing survey, a spawning gravel survey, a general survey of aquatic physical habitat, a 10 km drift dive survey, temperature monitoring, IFIM transect survey, and a macroinvertebrate survey of 18 sites.
27. Unfortunately the details and results from these studies have not been provided with Dr Keesing's evidence therefore it is difficult to know how the results of these studies relate to other work, or if the techniques used were appropriate. For example, I have serious concerns with the suggestion that an entire 10 km reach of the South Branch could be surveyed using electric fishing techniques.
28. Electric fishing can be conducted using a battery powered 'back pack' machine with one fishing anode, or a generator powered system with several fishing anodes. Electric fishing is most effective in small shallow streams, but inefficient in rivers and even in the deeper parts (> knee deep) of small streams. Generator systems are generally more powerful and effective than back pack systems.
29. Quantitative electric fishing involves putting a stop net at the top and bottom of a 50-100 m study reach to stop fish entering or leaving the study reach. The reach is intensively fished several times and ideally the number of fish caught each time will decline. A fish population estimate is made based on the rate of decline in numbers of fish caught on each pass of the study reach. A team of researchers would be expected to complete 2-5 reaches per day using quantitative methods, depending on river width, the distance between study reaches, and the amount of data collected from the fish. Therefore, it would take at least 20 days to electric fish a 10 km reach of a small stream, and considerably more if attempted in a relatively large system like the South Branch of the Hurunui River.
30. Qualitative 'single pass' surveys can also be conducted if the researcher is primarily interested in relative abundance or the presence/absence of particular species. These surveys are considerably quicker, with perhaps 10 reaches covered in a day,

but still a large effort would be required to cover a 10 km stretch of river (probably at least 10 days).

31. Some species are more susceptible than others to electric fishing – some species will burrow down into the riverbed substrate and not be detected, while others will flee as a result of disturbance by the electric fishing team, and before the electric current is sufficient to hold/stun them. Yearling and adult trout are particularly difficult to catch, especially in a relatively large river like the South Branch of the Hurunui River where they can easily move to deeper water where the electric fishing machine is ineffective.
32. Based on these concerns, I have strong reservations about any information and conclusions generated from Dr Keesing's electric fishing study.
33. Similarly, Dr Keesing has supplied no information on the water clarity or number of divers used for his drift dive survey of a 10 km reach of the lower South Branch. Both of these factors will affect the number of fish that he observed. A 10 km reach is a very long reach for effective drift diving. Most drift diving is conducted in reaches of around 1 km in length, and big surveys routinely undertaken by Fish and Game include up to ten 0.5 - 1 km reaches per river, with 3 to 10 divers depending on river width.
34. At paragraph 18 Dr Keesing states that the evidence from the applicants addresses fishability and not fish habitat in part or water quality in part.
35. I'm not sure what Dr Keesing is referring to by 'in part', but my first statement of evidence covered substantial detail on fish habitat and water quality of the upper Hurunui River.
36. At paragraphs 25-27 Dr Keesing comments on what is meant by outstanding and attempts to quantify it in terms of a national ranking where the top 5% is outstanding.
37. Although I see merit in the need to compare the Hurunui River and its values with other river systems throughout New Zealand, I believe it is overly simplistic to define a single criteria for one indicator when the many characteristics of a river should be considered together to determine if outstanding status is appropriate. For example, in the Hurunui River, the high trout densities, large average size, abundant habitat, good water quality, popular fishery, presence of an unmodified lake outlet, unimpeded passage to and from the sea, and impressive scenery combine to create something that in my opinion is truly outstanding.
38. Dr Keesing does not identify what values and states he is referring to in Paragraph 27, or what information he has obtained on each of the rivers referred to in his Table 1, or how he has concluded that many of these rivers do not have top 5% rankings. It should also be noted that several of the rivers listed in Dr Keesing's Table 1 were not given Water Conservation Order status based on their trout fishery values (e.g. Rakaia, Rangitata, Grey and Lakes Ellesmere and Wairarapa). I also note that trout data for the Oreti and Rangitikei rivers was included in my first statement of evidence (Figures 8, 13, 14 & 15), despite Dr Keesing's indication to the contrary in his Table 1.
39. At paragraph 48 Dr Keesing describes some aspects of his sampling of water quality in the South Branch in February 2009, refers to low levels of suspended phytoplankton, and refers to a study by Bayly and Williams (1973).
40. Water quality results are typically variable over time, therefore I would be cautious about inferring anything from one-off samples such as the ones mentioned by Dr

Keesing, although they apparently do confirm the high water quality in the South Branch. The reference to suspended phytoplankton is rather unusual since phytoplankton are only found in lakes or the ocean and almost never in rivers (only lake outlets and very slow flowing, low gradient systems). The study by Bayly & Williams (1973), along with at least 19 other studies cited in Dr Keesing's evidence, is not listed in the reference section of his evidence.

41. At paragraph 49 Dr Keesing states that fish passage is largely a function of channel depth, flow and contaminant loading.
42. An important feature affecting fish passage that was not mentioned by Dr Keesing is the presence of barriers, such as dams.
43. At paragraph 51 Dr Keesing refers to productivity as an important factor affecting carrying capacity of a river and indicates that it is expressed as a dry weight per area.
44. I agree that productivity of a river system is an important aspect affecting carrying capacity. The '100 Rivers' study indicated that invertebrate density, along with the percentage of adult trout drift feeding habitat at the mean annual low flow, the percentage of food producing habitat at the median flow, cover of fine sediment on the riverbed, availability of instream cover, and the percentage of the catchment upstream in improved pasture were important factors affecting trout population densities (Jowett 1992). However, I should point out that there is a big difference between productivity (which is the rate of production of dry mass over time) and standing stock (which is just a measure of dry mass), which Dr Keesing is really referring to. As an example, two lawns may have the same standing stock of grass, but the one that is fertilised and irrigated has higher productivity and thus needs to be mown much more regularly.
45. At paragraph 52 Dr Keesing refers to phytoplankton sample results.
46. As mentioned above, phytoplankton are typically not found in rivers and therefore this reference is rather unusual.
47. At Tables 2, 3, 4 and 5 Dr Keesing reports the results from his studies of macroinvertebrate communities in the South Branch of the Hurunui.
48. As mentioned earlier, the details of these studies have not been provided with Dr Keesing's evidence therefore it is difficult to know if the method of sample collection or number of samples collected is sufficient to comment on the macroinvertebrate community of the South Branch. In addition there appears to be some contradictions among the tables that Dr Keesing has presented in his evidence. In Table 2 he shows that *Aoteapsyche* caddisflies are not present in the South Branch, but in Table 4 he reports that there are 38.9 *Aoteapsyche* per square metre in the Hurunui South Branch.
49. Dr Keesing makes comparisons of taxa richness and invertebrate density in the South Branch with several other rivers around New Zealand. However, it appears that these comparisons are all based on the single sampling occasion in the South Branch. Invertebrate densities are known to vary widely over time (Scarsbrook et al. 2000), therefore there are strong limitations on what can be inferred from these comparisons. Nevertheless, the information provided by Dr Keesing appears to support the general conclusion I made in my first statement of evidence (based on annual measurements of invertebrate communities at Mandamus since 1989) that

invertebrate communities in the Upper Hurunui are typical of other mountain-fed rivers that drain largely unmodified land.

50. At paragraph 61 Dr Keesing states that the mainstem downstream of Lake Sumner ranked as 6<sup>th</sup> of 63 river sites throughout New Zealand in terms of food producing habitat availability at the median flow.
51. I also presented the same data in my first statement of evidence and commented that this same reach was also ranked 3<sup>rd</sup> of 63 sites for adult brown trout drift feeding habitat at the mean annual low flow. When looking at these two measures combined, this reach of the Hurunui River was the top ranked river in the country.
52. At paragraph 65 Dr Keesing states that existing information on trout from the South Branch from Jellyman & Graynoth (1994) differs from the results of his fish survey and is inclined to rely on his own information because the data was 25 years old and “angular” (presumably meant to be “angler”) reported.
53. The time between Jellyman and Graynoth’s 1994 study and Dr Keesing’s is of course only 15 years, although the survey of fishery managers that was used to compile the information was conducted in 1989. However, as Dr Jellyman mentioned in his first statement of evidence the information is unlikely to have changed over that time. As I mentioned above (Paragraphs 27-32) I have serious concerns about the electric fishing survey conducted by Dr Keesing (electric fishing is an inappropriate method for sampling yearling and adult trout in a relatively large river like the South Branch) and believe that the differences in the results are due to methodological matters rather than real differences.
54. At paragraph 67 Dr Keesing comments on drift dive data from the Lake Sumner outlet, a site below Lake Sumner, and two measures for Lake Taylor and mentions that he has incorporated his own drift dive data for the Lower South Branch.
55. There is some misunderstanding here – The measures for Lake Taylor that Dr Keesing refers to are actually from the Hurunui River mainstem at Lake Taylor, not Lake Taylor itself. Drift diving can not be conducted in a lake. Also I can’t find Dr Keesing’s drift dive data for the South Branch anywhere in Appendix 1 to his evidence.
56. At paragraphs 73 and 74 Dr Keesing comments that only a short reach of the mainstem of the Hurunui River downstream from Lake Sumner ranks as outstanding in terms of brown trout abundance.
57. As I mentioned in my first statement of evidence, trout fisheries are normally recognised as outstanding based on the abundance of trout and/or the size of the trout available. Both of these features are apparent in the upper Hurunui catchment, although Dr Keesing makes no comment on the size of trout present. Trout densities downstream of Lake Sumner are certainly among the highest in New Zealand with long term records indicating an average of more than 200 adult brown trout per kilometre, while even downstream at the Jollie Brook dive site, trout densities are around 100 adult trout per kilometre on average and thus compare favourably with other rivers that are recognised with a Water Conservation Order including the Maruia, Motueka, and Mohaka rivers (Figure 10 in my first statement of evidence). There is little quantitative fish data further downstream towards Mandamus but I expect fish densities to be somewhat lower due to the gradual downstream decline in lake derived seston downstream of Lake Sumner that I described in my first statement of evidence.

58. At paragraphs 80 and 81 Dr Keesing states that New Zealand periphyton requires a flow of 450 cumecs to flush, but for didymo the flush required is more like 600-900 cumecs, quoting Norton (2007). He notes that flows above this level are infrequent in the upper Hurunui.
59. The flows that Dr Keesing refers to are for the lower Waitaki River and it is not appropriate for them to be applied to other rivers. The erosive power of a river, or shear stress on the riverbed, is dependent on a number of factors including the flow AND the morphology of the river bed. The same flow through a narrow steep channel will have much more power and erosive force than the same flow through a wide flat channel. A flow greater than 3 times the median flow is expected to result in significant flushing of native algae (Clausen & Biggs 1997). Didymo appears to be more difficult to dislodge than native algae, so a flow higher than 3 times the median may be required to be equally effective, although at this stage it is not clear how much higher. The median flow for the Hurunui at Mandamus is 39.1 cumecs.
60. The amount of suspended sediment carried in the water will also influence the effectiveness of algal flushing, since water with a high load of sediment is much more abrasive. The relatively high sediment load in the South Branch, in combination with the higher frequency of flows greater than 3 times the median flow (as mentioned in Mr Stewart's first statement of evidence), probably explains the marked reduction in the coverage and thickness of didymo mats in the Hurunui River downstream of the South Branch confluence, as I mentioned in my first statement of evidence.
61. At paragraph 97 Dr Keesing states that the proposed South Branch dam would bring increased stability to the South Branch river below the dam, and higher summer discharges would improve water habitat by reducing temperature stress, providing more water habitat, reducing periphyton algal issues, and improving water quality.
62. As mentioned above, the hydrological variability in the South Branch and associated sediment load is likely to be effective at scouring didymo and other algae from the Hurunui River downstream of the South Branch confluence. Any reduction in hydrological variability and sediment load resulting from a dam could lead to didymo proliferations downstream of the South Branch confluence. A reduction in sediment load could also lead to changes in river bed morphology downstream of the South Branch confluence.
63. As shown in my first statement of evidence, water temperature data collected from the South Branch indicate that it is cold throughout the year and well within guidelines for protection of aquatic ecosystem health. Therefore, there is no indication that temperature stress in the South Branch, or Hurunui River, is a concern that needs to be mitigated with a dam. In fact, water discharging from dams can be considerably warmer than what would be expected from an unimpounded river, depending on whether surface or bottom water is released from the dam (Young et al. 2004).
64. Similarly, water quality data collected by Environment Canterbury staff in the South Branch indicate no water quality problems, and therefore no need for increased dilution associated with a dam. In some situations, dams can actually cause water quality problems (Young et al. 2004).
65. Higher flows during summer may result in an increase in habitat availability for some species, or a decrease depending on the interaction between the flow and the morphology of the river. Dr Keesing mentions that an IFIM survey has been conducted downstream of the proposed South Branch dam site, but without knowing

the results of this survey it is impossible to predict whether the higher flows would be beneficial or detrimental compared with the status quo.

66. At paragraph 100 Dr Keesing states that the irrigation storage scheme would result in flow dynamics changing at a seasonal pace, rather than the daily peaking that is typical of a hydro-power station.
67. My understanding is that hydro-power generation is potentially part of the proposed South Branch dam and therefore daily hydro-peaking is possible.
68. At paragraphs 101 & 102 Dr Keesing states the proposed South Branch dam would prevent upstream fish passage affecting banded kokopu and koaro populations. He considers that passage of trout is infrequent past the gorge and that upper river fish generally come from Lake Mason spawning.
69. Dr Keesing appears to have overlooked the potential effects of a dam on salmon and the salmon fishery, and his conclusions related to trout passage appear to be based only on the very limited electric fishing data that he has collected. I have already commented on the problems that I perceive are associated with these data. In my first statement of evidence I went to considerable length to explain the studies that have been conducted which indicate that trout migrate throughout the catchment, and how unimpeded passage is required to maintain the outstanding fishery. Dr Keesing appears to have overlooked this evidence.
70. At paragraph 103 Dr Keesing states that the proposed weir structure at the outlet of Lake Sumner will allow fish access at all times of migration.
71. Very little, if any, information is provided on the likely design of this weir structure and I believe that a weir capable of raising Lake Sumner by 2 m would cause some obstruction to fish passage.
72. At paragraph 104 Dr Keesing states that the lake will be little affected by the current water storage proposals.
73. Lake ecosystems are very sensitive to changes in lake level variation (de Winton & Schwarz 2004). Therefore any alteration of lake level dynamics in Lake Sumner would have to be controlled carefully to ensure that sensitive aquatic plant beds along the lake margins, and the invertebrates and fish that they support, are not adversely affected. The trout population in Lake Sumner is an important component of the trout fishery within the Upper Hurunui River system, and since trout move widely around the catchment (as indicated in my first statement of evidence) any effects of lake level fluctuations on the trout population in Lake Sumner could also be felt elsewhere.
74. At paragraph 105, Dr Keesing suggests that inundation of the area upstream of the proposed South Branch dam would not have any effect on outstanding values.
75. Apart from the effects of the dam on fish passage, inundation of a significant length of the South Branch would result in the physical loss of part of the highly valued South Branch fishery that is notable for its large trout as mentioned in my first statement of evidence. The dam would also inundate an area that I understand is the main spawning grounds for the Hurunui's Chinook salmon population (Mr Unwin's evidence; Tony Hawker's rebuttal evidence; Fish & Game NZ North Canterbury Region unpublished data), and may also be an important spawning area for trout as well.

## Mr Bruce Norrie, evidence dated 23 March 2009

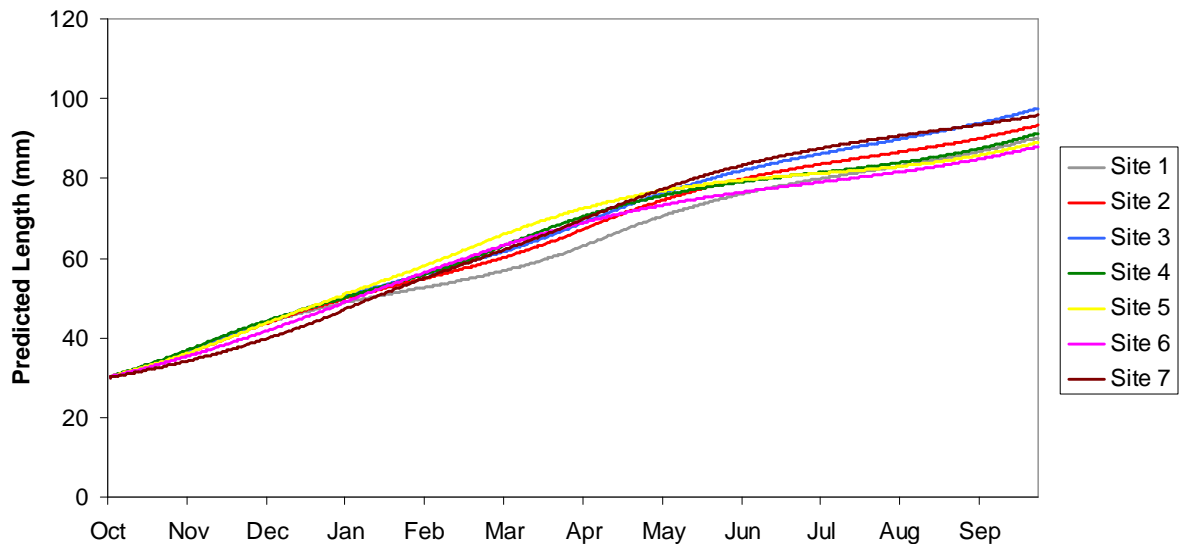
76. At paragraph 13 Mr Norrie states that the proposed weir on the outlet of Lake Sumner would raise the lake to a higher level for longer periods allowing more natural food for fish cruising in the shallower water for fly fishermen and provide better and healthier native flora and fauna around the lake edges. He also comments that the North and South river branches would have a more stable flow also providing for better fishing and other river sports.
77. As mentioned above, lake ecosystems are very sensitive to changes in lake level variation and large variations in lake level can have adverse effects on lake productivity (de Winton & Schwarz 2004). Therefore any proposal to alter the lake level dynamics in Lake Sumner would have to be controlled carefully to ensure that sensitive aquatic plant beds along the lake margins, and the invertebrates and fish they support, are not adversely affected. The stability of flows downstream of the proposed weir at the Lake Sumner outlet and the proposed dam on the South Branch would depend on the way the scheme is operated. If hydro-power is included as part of the plan then flow fluctuations could be increased. As mentioned above (Paragraph 65), higher summer flows resulting from the impoundments may have positive or negative effects on habitat availability in the river, but an IFIM habitat survey and modelling exercise would be required to determine if higher flows would be beneficial or detrimental compared with the status quo.
78. At paragraph 15 Mr Norrie states that a more stable flow would also help to control didymo and lessen its potential to become a problem.
79. As I have mentioned, the opposite is true. High flows of at least 3 times the median flow are probably required to flush didymo mats. The stabilising effects of the proposed weir at the outlet of Lake Sumner and the proposed dam on the South Branch would actually decrease the frequency of these flows and therefore increase the potential for didymo to become a problem.
80. At paragraph 20 Mr Norrie describes how the Amuri Irrigation scheme has improved the state of the Pahau River, which no longer runs dry in the summer and autumn months.
81. As I mentioned in my first statement of evidence, there are concerns with the water quality in the lower Hurunui River at SH1 with high concentrations of nutrients and faecal bacteria, which compromise the recreational value of the river. Invertebrate communities in the lower Hurunui River are indicative of sites experiencing mild or moderate pollution. Trend analyses indicate that water quality at the SH1 monitoring site is deteriorating over time, presumably reflecting the intensification of agriculture in the mid and lower parts of the catchment.
82. As part of an investigation into this issue, Environment Canterbury staff conducted monthly water quality sampling in the main tributaries of the mid reaches of the Hurunui River from April 2004 to June 2006 (Hayward 2006). High concentrations of dissolved phosphorus were observed in Dry Stream, Pahau River, Waikari River, and St Leonards Drain, while the Pahau River and St Leonards Drain had very high dissolved nitrogen concentrations. The Pahau River also had the highest concentrations of suspended solids and faecal indicator bacteria (*E. coli*).
83. In terms of their contribution to nutrient concentrations in the lower Hurunui River, the tributaries draining the Culverden basin were estimated to contribute 66% and 81% of

the load of dissolved P and dissolved N, respectively. The greatest proportion of this comes from the Pahau River (Hayward 2006).

84. Therefore, although I agree with Mr Norrie that there may have been some benefits of maintaining flows in the Pahau River, there have also been some negative consequences for the lower Hurunui River related to the intensification of agriculture that was associated with the development of the Amuri Irrigation Scheme.

**Dr Richard Allibone, evidence dated 23 March 2009**

85. At paragraph 43 Dr Allibone states that no growth rate studies of brown trout are available from the Hurunui River, and in paragraph 47 he states that my evidence is very limited with respect to growth of young-of-the-year brown trout.
86. In my first statement of evidence I described a trout growth modelling study in the Hurunui River that aimed to determine whether trout need to migrate in order to grow to the sizes observed in the anglers catch (Hayes & Quarterman 2003). I acknowledge that this study did not focus on growth of young of the year brown trout, which is the topic that Dr Allibone is focussing on in his evidence. Nevertheless, trout growth modelling could be used to predict growth rates for young of the year trout in different parts of the river based on observed water temperatures.
87. Although not validated with any observed growth rates of young-of-the-year trout from the Hurunui River, the predicted growth rates from the model are shown in Figure 2. This modelling assumed that trout fry emerged from the gravels on October 1<sup>st</sup> at a length of 30 mm. Newly emerged fry are expected to be present over the period from September through to late December based on sampling of juvenile trout emigration from the Glenariffe Stream in the Rakaia Catchment (Fox et al. 2003).



**Figure 2.** Predicted growth of juvenile brown trout based on water temperatures measured at 7 sites throughout the Hurunui Catchment. Site 1 = near river mouth, Site 2 at SH1 bridge, Site 3 at SH7 bridge, Site 4 = downstream of confluence with South Branch, Site 5 lower South Branch, Site 6 Upper South Branch, Site 7 near Lake Sumner outlet.

88. I am not aware of any data on downstream movements of juvenile trout in the Hurunui River. Research on downstream emigration of juvenile trout from Glenariffe Stream into the mainstem of the Rakaia River indicated a strong seasonal migration with 86% migrating from September to January (Fox et al. 2003). However, significant numbers of juveniles continued to move downstream until late April. Fox et al. (2003) found that 94% of juvenile trout emigrated as 0+ fry, and only 6% as 1+ yearlings in the Glenariffe Stream, which contrasts markedly with the study reported by Dr Allibone where 73% of fry remained in Scott's Creek (a tributary of Lake Alexandrina) after they emerged from the gravels (Hayes 1988). In my opinion, data from the Glenariffe/Rakaia system is probably more similar to the situation in the Hurunui River (because it is also a East Coast braided river) than the data from Scott's Creek/Lake Alexandrina.
89. There is little information available on the rate of downstream movement by juvenile brown trout in New Zealand rivers, therefore it is difficult to determine the number or size of juvenile trout that will encounter the Amuri Irrigation Intake screen. Hayes (1988) reported that juvenile rainbow trout dispersed downstream at a rate of at least 1 km per night, so it is possible that juvenile trout spawned in the upper reaches of the river could migrate downstream to the lower reaches over a period of several weeks. Jamieson et al. (2007) reported that juvenile brown trout less than 50 mm in length were present for up to 5 months in the lower reaches of the Rakaia River. As Dr Allibone states brown trout are likely to spawn and rear throughout the catchment, although as mentioned in my first statement of evidence, tributaries in the upper part of the catchment appear to have higher densities of juvenile trout. Juvenile trout spawned close to the intake are presumably more likely to encounter the intake when they are small than juvenile trout spawned in the upper catchment.

**Dr Greg Burrell, evidence dated 23 March 2009**

90. At paragraph 22 Dr Burrell states fish passage in the lower river is not as important as further upstream and that trout do not have to migrate to sea to complete their life history.
91. I agree that trout do not HAVE to migrate to sea to complete their life cycle. However, as pointed out in my first statement of evidence there is evidence that brown trout undergo substantial migrations within the Hurunui Catchment and a small proportion of the fish may go to sea. Any barrier preventing upstream or downstream migration could have an adverse effect on the brown trout population, particularly in the North and South Branches, which probably are dependent on the influx of large trout that have grown fast in the more benign thermal regime downstream of Lake Sumner, or in the Lower Hurunui River where access to forage fish is more likely.

**Dr Ruth Goldsmith, evidence dated 23 March 2009**

92. At paragraph 3.2 Dr Goldsmith states that my evidence, relating to the failure of fish passes in New Zealand, is simplistic given that past failures were often due to a lack of knowledge and that recent fish pass designs are more effective.
93. Like most things, knowledge relating to fish pass design has improved over the years and a fish pass designed today would have a higher chance of success than a fish pass designed in the 1930's. However, successful upstream and downstream fish passage is not necessarily guaranteed for a fish pass designed today, even with our current knowledge of pass design, and fish behaviour and life histories.

94. At paragraph 3.3 Dr Goldsmith refers to the Branch River fish pass and reports on a monitoring programme that observed an average of 54 large trout using the fish pass each year in 2002, 2003 and 2005 (Jellyman 2007). Dr Goldsmith also disagreed with my conclusion that there is substantial risk involved in relying on a fish pass to maintain fish passage.
95. The monitoring referred to by Dr Goldsmith indeed indicates fish present in the recording chamber within the Branch fish pass (Jellyman 2007). However, there were some uncertainties with the fish counts since it appeared that some fish moved upstream through the recording chamber and then shortly afterwards moved back downstream through the recording chamber without actually exiting the fish pass above the weir (Jellyman 2007). Efforts were made to account for these multiple movements by the same fish by applying a rule where only net movements upstream or downstream within 15 minutes were considered to be genuine. Despite this correction, the close correlation between the number of fish recorded moving upstream and downstream on any particular day suggests that this issue may not have been satisfactorily resolved.
96. In my first statement of evidence I said that it is not known what proportion of the potential migrating population is successfully negotiating the few fish passes in New Zealand that are considered to be effective. I have subsequently become aware of some additional monitoring information from the Mararoa Weir, which I've already described in Paragraph 22, that indicated that approximately one third of the radiotagged trout released downstream of the weir successfully passed through the fish pass but the remaining fish did not go through the fish pass. This information supports my earlier statement that there is substantial uncertainty and risk in relying on a fish pass to main fish passage for all of the migrating population.
97. At paragraphs 3.4 & 3.5 Dr Goldsmith comments on my colleagues involvement in a resource consent application to construct a 77 m high dam on the Mokihinui River and their recommendation that trap and transfer of upstream migrant adult trout (or trout stocking) may be undertaken if monitoring after dam construction indicates a significant decline in the fishery.
98. I have not been involved with this project, but understand that my colleagues consider that the dam will block trout passage and that a fish pass is not a practical or cost effective method of mitigating any effects, should they arise. Moreover, at present it is uncertain whether a trap and transfer facility is warranted or will be cost effective – although it is an option being considered for mitigation. More importantly, and pertinent to this last point, studies on migration and growth modelling of trout in the Mokihinui River, similar to what has been conducted in the Hurunui Catchment, indicate that water temperatures within the river are sufficient to grow trout to the sizes observed in anglers catch, and there is no evidence that trout need to migrate to the lower reaches of the Mokihinui River or ocean to maintain the river's valued headwater fishery (Hayes et al. 2007). This contrasts with the situation in the Hurunui where evidence indicates that the fishery in the North and South Branches is dependent on the influx of large trout that have grown fast in the more benign thermal regime downstream of Lake Sumner or in the Lower Hurunui River.

#### **Dr Phillip Mitchell, evidence dated 31 March 2009**

99. At paragraph 30 Dr Mitchell draws a comparison between the Hurunui River and the Tongariro River where the Tongariro Power Scheme (TPS) results in a flow regime

that has been specifically set to sustain the Tongariro River's world class trout fishery and optimises habitat for the iconic whio (Blue duck).

100. There are considerable differences between the trout fishery in the Tongariro River, which is based on rainbow trout that spawn in the river but live most of their life in Lake Taupo, and the trout fishery in the Hurunui River, which is based on brown trout of which a large proportion of the population are river resident. It is also notable that the TPS does not involve a weir or dam that blocks fish movement to and from the major trout spawning and rearing areas.

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**Roger Young**

**17<sup>th</sup> April 2009**