Before Hearing Commissioners at Christchurch

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*under:* the Resource Management Act 1991

*in the matter of:* Submissions on the Proposed Hurunui and Waiau River Regional Plan

*between:* **Fonterra Co-operative Group Limited**
*Submitter*

*and:* **Dairy NZ**
*Submitter*

*and:* **Canterbury Regional Council**
*Local Authority*

# Statement of evidence of **Shirley Ann Hayward** (Water Science) for Fonterra Co-operative Group Limited and Dairy NZ

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**STATEMENT OF EVIDENCE OF SHIRLEY ANN HAYWARD**

**INTRODUCTION**

1 My full name is Shirley Ann Hayward.

2 I hold the degrees of Bachelor of Science in Plant and Microbial Sciences and Master of Science in Environmental Science. I am a member of the New Zealand Freshwater Sciences Society.

3 I am employed by Pattle Delamore Partners Limited as an Environmental Scientist. I was previously employed by DairyNZ for three years as a Water Quality Specialist within the Sustainability Team. In this role, I provided technical expertise on water quality issues relating to impacts of dairy farming and have been involved in various regional policy processes with regional councils including:

3.1 As Co-leader of the science team for the Land Use and Water Quality Hurunui pilot project. The science team provided technical analysis of catchment water quality, hydrological and ecological issues and options for input into stakeholder and governance group deliberations. I contributed to the two main output reports from the Hurunui pilot project: *Nutrient Management in Hurunui: A Case Study in Identifying Options and Opportunities* (Brown et al., 2011) and *Developing a Preferred Approach for Managing the Cumulative Effects of Land Use On Water Quality* (Environment Canterbury 2012);

3.2 As a member of the Waituna Lagoon Technical Group, which was tasked with developing a science research programme and recommendations to prevent this highly-valued coastal lagoon degrading. Recommendations from the Group included water quality triggers for managing lagoon opening regime and interim nutrient load limits; and

3.3 As a member of Environment Southland's Water and Land 2020 Steering Group, which comprised of representatives of the key stakeholders with interests in the region's water quality issues. The group's aim was to assist Environment Southland in developing effective policies for managing land use and its effects on water quality.

4 I was previously employed by Canterbury Regional Council for 16 years in a succession of roles including Microbiologist, Groundwater Quality Officer, Environmental Quality Analyst and Surface Water Quality Scientist. Over an 11 year period with Environment Canterbury I was involved with river water quality and stream ecology investigations and have authored numerous peer reviewed technical reports on groundwater quality, river and lake water quality and aquatic ecosystem health. As Surface Water Quality Scientist I

had responsibility for a number of surface water quality monitoring and investigation programmes. I established a water quality and flow monitoring programme for the mid-reach tributaries of the Hurunui River in response to community concern about the effects of agricultural land use in the Culverden Plains on the Hurunui River. I have undertaken periphyton surveys in the Hurunui River. I worked closely with Environment Canterbury's Living Stream team and the Pahau Enhancement Group to identify issues and options for managing water quality in the Pahau River in order to manage any adverse effect on the Hurunui River.

5 I have read the Environment Court's Code of Conduct for Expert Witnesses, and I agree to comply with it. My qualifications as an expert are set out above. I confirm that the issues addressed in this brief of evidence are within my area of expertise, except where I state 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 expressed.

6 I am familiar with the Proposed Hurunui and Waiau River Regional Plan (*the Proposed Plan*) to which these proceedings relate, given my extensive involvement in the work underpinning components of it.

7 I have reviewed reports that have been prepared for, and presented to, the Land Use and Water Quality Catchment Workshops and the Hurunui Waiau zone committee. These reports have ultimately influenced the formulation of the Proposed Plan. The reports include catchment nutrient modelling (Lilburne et al 2011) and catchment nutrient load options (Norton and Kelly 2010).

8 I refer to the evidence of Mr Callander who describes a model developed by Pattle Delamore Partners that predicts nitrogen loads from the flat irrigable areas of the catchment above SH1 based on recent land use information.

9 I have also read the evidence for the Council of Mr Parrish, Mr Edward (Ned) Norton, and Dr Ton Snelder and comment on aspects of it in this brief.

**SCOPE OF EVIDENCE**

10 My evidence will deal with the following:

10.1 A brief description of the extensive technical work leading up to the notification of the Plan.

10.2 A description of the water quality outcomes sought in the Proposed Plan, those outcomes which I support and those which I do not support and my reasons.

10.3 A discussion of the link between numerical water quality measures and outcomes sought. I discuss other factors affecting those outcomes.

10.4 A discussion of the derivation and practicality of the nitrogen load limits for the Hurunui River which are proposed in the Plan.

10.5 A summary of catchment nutrient modelling that has been undertaken to define potential implications of different nitrogen load limits on land use scenarios.

10.6 My suggested alternative nitrogen load limit option to achieve the broader water quality objectives.

**SUMMARY OF EVIDENCE**

11 Although Objective 5.1 contains broad narrative statements, I consider them appropriate for providing for the current instream water quality values in the Hurunui River.

12 I support the Hurunui Waiau zone committee's submission (echoed by other parties such as Fish and Game) which proposes changes to Policy 5.1 to include numeric outcomes for periphyton biomass, nitrate toxicity and dissolved reactive phosphorus (DRP) concentrations. In my view these numeric outcomes provide a more direct and measurable link to the outcomes sought in Objectives 5.1.

13 However, the numeric outcomes for nitrate toxicity limits need to incorporate the most up to date guideline revisions prepared by C W Hickey of NIWA, which I discuss later in my evidence.

14 I also support the Hurunui Waiau zone committee's submission which proposes changes to Policy 5.2 to include numeric limits for periphyton biomass and nitrate toxicity risks for the four main mid-catchment tributaries. As generic limits in the absence of 'agreed community outcomes', the periphyton biomass limits are appropriate to adequately protect instream values of these hill-fed rivers. I agree that chronic nitrate toxicity risks need to be managed for hill-fed rivers, and that it is appropriate the limit is set at the 95% level of protection providing the nitrate toxicity limits incorporate Hickey's recent guideline revisions.

15 The nitrogen load limit proposed for the lower Hurunui River is unnecessarily conservative. In my view the current nitrate concentrations and therefore load in the lower Hurunui River could be increased by between 25% to 50% provided that phosphorus concentrations are maintained at current levels. I consider that risks of increased periphyton growth and toxicity from such increases are minor. I therefore consider an increased nitrogen load limit approach

would continue to support Objectives 5.1 and 5.2. Such an approach would, however, need to be supported by measures that ensure that phosphorus concentrations are maintained within current levels, lag periods in nutrient transport are appropriately managed and that, and appropriate monitoring of the objectives in the Proposed Plan is undertaken.

**Technical work leading up to notification of the Proposed Plan**

16 The Land Use and Water Quality (LUWQ) project trialled a collaborative approach to establishing nutrient limits using the Hurunui catchment as a pilot project, as described by Mr Ryan and Mr Parrish.

17 As co-leader of the science workstream along side Dr Tim Davie (Environment Canterbury) I helped co-ordinate various pieces of work that fed into the community/stakeholder workshops and governance group meetings. Key pieces of work delivered from the science workstream included catchment nutrient modelling reported by Lilburne et al (2011) and Norton and Kelly's (2010) assessment of nutrient load limit options. Two technical workshops were held involving all science contributors to share current understanding of catchment processes and brainstorm issues and options including developing various water quality and land use scenarios. Because of the tight timeframes of the overall project, there was very little opportunity for the science team to reflect on feedback from each presentation to the community and governance group meetings. Consequently, it is my view that the project was unable to fully explore and refine optimal water quality outcomes for the catchment within the context of the broader community goals. This is not a criticism of the process or teams involved, but reflects a learning about the investment of time and resources needed for these challenging processes to proceed to a successful conclusion.

18 As the Hurunui Waiau zone committee further explored the findings from the LUWQ project, questions started to emerge about some of the assumptions of the technical work (particularly mitigation predictions) and the feasibility of maintaining current nutrient loads while developing significant areas of irrigated land. I was requested by Environment Canterbury's planning team to consider whether there were technical justifications for alternative nutrient load limits and consequently wrote a discussion paper for Environment Canterbury (Hayward 2011a). Note that the review of alternative nutrient load limits was not, as suggested by Mr Norton, driven by the dairy industry. I presented a summary of the discussion paper to the zone committee along with Mr Norton, who presented his risk assessment of the alternative load limits (Hayward 2011b, Norton 2011).

19 As discussed by Mr Norton and Mr Parrish, exploration of nutrient load limits and land use scenarios did not integrate the effects of

potentially significant changes in the flow regime because of inadequate information to describe a water storage scenario that was likely to be broadly acceptable. I agree with Mr Norton that analysis of the implications of significant flow alterations is critical to understanding links with water quality outcomes, and specifically needs to be accounted for in any nutrient load limits. However, this analysis does need to be undertaken using realistic scenarios of abstractions and storage schemes.

**WATER QUALITY OUTCOMES SOUGHT IN THE PROPOSED PLAN**

20 The Proposed Plan contains high level water quality objectives relating to a number of activities including groundwater and flow setting and allocation, and the cumulative effects of land use on water quality. I focus on the water quality objectives in the Proposed Plan that relate to the effects of land use on water quality (Objectives 5.1 and 5.2 and associated policies) for the Hurunui catchment. The objectives state:

> *Objective 5.1*
>
> *Concentrations of nutrients entering the mainstems of the Hurunui, Waiau and Jed rivers are managed to:*
>
> *a) maintain and enhance the mauri of the waterbodies;*
> *b) protect naturally occurring biota including riverbed nesting birds, native fish, trout, and their associated feed supplies and habitat;*
> *c) control periphyton growth that would adversely affect recreational, cultural and amenity values;*
> *d) ensure aquatic species are protected from chronic nitrate toxicity effects; and,*
> *e) ensure concentrations of nitrogen do not result in water being unsuitable for human consumption.*
>
> *Objective 5.2*
>
> *Concentrations of nutrient entering tributaries to the Hurunui, Waiau and Jed rivers are managed to meet agreed community outcomes while ensuring they do not give rise to:*
>
> *a) chronic nitrate toxicity effects on aquatic species; and,*
> *b) water being unsuitable for human consumption.*

21 As I understand, the objectives are a narrative description of the outcomes sought by the community as reflected in the Hurunui Waiau Zone Implementation Plan. I support the objectives as broad outcomes.

22 However, the translation of narrative statements such as these into measurable effects in-stream is relatively subjective. In my view, greater clarity and certainty as to water quality expectations can be

provided when narrative objectives are supported by numeric limits that have a clear link to the objectives.

23 The main numeric limits used in the Proposed Plan to support the objectives are the nutrient load limits, minimum flows, and river and groundwater allocation limits. The nutrient load limits are only set for the Hurunui River.

24 The water quality outcomes for the tributaries are not yet defined other than Policy 5.2 a) which describes the need to manage nutrients to avoid nitrate toxicity effects on aquatic species and to ensure water is not unsuitable for human consumption. Although not specifically stated, I am assuming the reference to water not being unsuitable for human consumption relates to nitrate concentrations not exceeding the Drinking Water Standards for New Zealand maximum acceptable value for nitrate nitrogen of 11.3 mg/L. As I will explain later, the nitrogen loads that I propose for the Hurunui River would be well below those standards.

25 Policy 5.3 sets instream annual nutrient load limits for dissolved inorganic nitrogen (DIN) and DRP for two sites on the Hurunui River based on an average of the annual loads for the period 2005-2009 derived by Norton and Kelly (2010). In my view the use of instream nutrient load limits alone does not provide a clear link to the water quality outcomes sought in Objective 5.1. It is the concentration and type of nutrients (DIN and/or DRP), in conjunction with other factors such as flows, habitat and climate, that determine the amount and type of periphyton growth in rivers. In the case of ammonia and nitrate, their concentrations determine toxicity risks to aquatic fauna. As I will explain later, the science on toxicity risks is being refined as more international and New Zealand-based research is undertaken.

26 Instream nutrient load estimates are based on measured nutrient concentrations multiplied by the flow. Calculation of instream nutrient loads attempts to establish the linkage between nutrient losses from the land (yields e.g. kg N/ha) and instream nutrient concentrations. However, flow conditions are a dominant driver in year to year variations in instream nutrient load estimates. Mr Callander illustrates these annual variations in measured loads in his evidence.

27 In my view there are gaps in the Proposed Plan between the narrative water quality objectives and the nutrient load limits set to protect those objectives.

28 The Environment Canterbury/Hurunui Waiau zone committee and Fish and Game submissions address this through proposing the following policies in order to provide greater clarity through numeric outcomes to provide for the objectives.

*<u>Policy 5.1</u>*
*To manage water quality in the mainstem of the Hurunui River to ensure that:*

*a) Periphyton biomass of the mainstem of the lower Hurunui River (below Pahau River Confluence) do not exceed 120 mg/m² and 20% cover of filamentous algae in 4 years out of 5*
*b) Nitrate nitrogen concentrations do not exceed the chronic nitrate toxicity threshold for 99% level of protection (1.0mg/l)*
*c) Average annual dissolved reactive phosphorus concentrations do not exceed the annual average (0.0044 mg P/L)*

*<u>Policy 5.2</u>*
*To manage water quality in the Pahau River, Waitohi River, Dry Stream and Waikari River tributaries of the Hurunui River to ensure that:*

*a) Periphyton biomass do not exceed 200 mg/m² and 30% filamentous cover 4 out of 5 years.*

*b) Annual average nitrate nitrogen concentrations at the confluence with Hurunui River do not exceed the chronic nitrate toxicity threshold for 95% level of protection (1.7 mg N/L) and do not exceed the chronic 90% level of protection threshold (2.4 mgN/L) at any time.*

29 These policies describe measures of periphyton and nutrient concentrations that link to the outcomes sought in the objectives 5.1 and 5.2. I consider the choice of indicators used (periphyton biomass, phosphorus and nitrate nitrogen concentrations) are appropriately targeted to the outcomes sought in relation to nutrient management. I also largely agree with these numerical policies. The following sections describe these indicators in more detail and the few areas where I disagree with the above proposed policies.

**PERIPHYTON**

30 Periphyton is the algae-dominated community that grows on the beds of streams and lakes. It has both beneficial and detrimental impacts on waterways. Periphyton plays a key role in streams by converting dissolved nutrients into food for invertebrates, which in turn become food for fish and birds. However, too much periphyton can negatively impact on cultural, aesthetic, recreational and biodiversity values.

31 Periphyton communities comprising films and thin mats of diatoms are typically found in low nutrient and/or highly disturbed environments and are generally a high quality food source for invertebrates (Biggs, 2000; Biggs and Kilroy 2000). Nuisance growths of thick mats and long filamentous forms are typically found in nutrient enriched environments with low to moderate water velocities and stable flows. These growth forms are generally poorer quality food for invertebrates and are likely to degrade the habitats of fish and invertebrates (Biggs 2000). It is the interaction of geology, climate, flows and nutrients that determine the frequency and

duration of excessive nuisance algal growths. At the reach scale, habitat conditions such as shading, substrate type and water clarity also control periphyton type and biomass.

32 The Proposed Plan Objective 5.1 includes a narrative statement regarding managing periphyton effects on recreation, cultural and amenity values. The Hurunui Waiau Zone Committee (*HWZC*) HWZC/ Environment Canterbury (*ECan*) and Fish and Game and other parties' submissions, recommend policies that describe measures of periphyton biomass based on differing levels of protection. Their proposed policy 5.1 a) sets a periphyton biomass limit in the mainstem of the Hurunui River of 120 mg/m² of chlorophyll a and 20% cover of filamentous algae in 4 years out of 5.

33 These thresholds are similar to the NZ periphyton guidelines for the protection of trout habitat and angling values and protection of aesthetic/recreational values. The periphyton thresholds proposed by the submissions are, in my view appropriate, for the Hurunui River, in that they represent levels of periphyton indicative of a moderately productive (mesotrophic) systems (Biggs 2000, Quinn 2010), and represent levels of filamentous algae that are currently found in the river (Quinn 2010).

34 In paragraph 47 of Dr Snelder's Section 42A report, he refers to 20% cover of filamentous algae as the limit at which many people would consider the amount of periphyton undesirable. However, the MfE periphyton guidelines recommend that up to 30% cover of filamentous algae is acceptable to protect aesthetic/recreational values (Biggs 2000). The guidelines also recommend a maximum 60% cover of thick periphyton mats to protect aesthetic/recreational values. I find Dr Snelder's choice of a nominated threshold for total cover (mats of various thickness plus filamentous algae) of 30% extremely conservative and likely to result in maximum chlorophyll a concentrations well below the recommended limit of 120 mg/m$^2$.

35 The HWZC/ECan and Fish and Game submissions also recommended that periphyton biomass in the hill-fed tributaries (Pahau, Waitohi, Waikari rivers and Dry Stream) do not exceed 200 mg/m² of chlorophyll a and 30% cover of filamentous algae in 4 years out of 5 (Policy 5.2 a). These thresholds represent the mesotrophic/ eutrophic boundary, and are adequately protective of aesthetic/ recreational values (Biggs 2000).

36 I consider that the periphyton thresholds as proposed are appropriate for the Pahau and Waitohi rivers and Dry Stream in maintaining aesthetic/recreational and biodiversity values at levels appropriate for hill-fed rivers in Canterbury.

37 However, the Waikari River may naturally exceed the thresholds because parts of its catchment have natural sources of phosphorus

(soft sedimentary geology). When combined with routinely low summer flows, periphyton biomass is likely to exceed the thresholds proposed. My own observations of the Waikari River indicate it is prone to development of nuisance algae during low summer flow periods.

**NUTRIENTS AND NITRATE TOXICITY**

**Background**

38 The HWZC/ECan and Fish and Game submissions contain recommended concentrations of DRP for the mainstem of the Hurunui River and nitrate nitrogen concentrations for both the Hurunui mainstem and tributaries in relation to risks of toxicity effects (Policies 5.1((b) and 5.2(b)).

39 Nutrient concentrations are one of the factors that influence the risk of nuisance periphyton growth, along with river flow and habitat conditions. Nitrogen and phosphorus are the two main plant nutrients that influence periphyton growth in rivers and streams. However, periphyton growth may be controlled by availability of one or both nutrients (Biggs 2000).

40 In addition to being plant nutrients, ammonia and nitrate have potential toxicity risks for humans, livestock and aquatic fauna at relatively high concentrations (compared to concentrations that stimulate algae/periphyton growth). There is a sliding scale of vulnerability based on species sensitivity.

**Debate among scientists regarding management of nitrates**

41 There has been considerable debate among water scientists about the merits of managing one or both nutrients to control periphyton in circumstances where it is clear that one nutrient is limiting periphyton growth and not the other.

42 From a general perspective, in my view, management strategies for both nutrients are undoubtedly needed. However the question remains whether the limit for the secondary (non-limiting nutrient) needs to be as stringent as the limiting nutrient. In addressing this question, risk to water quality is an important consideration, but as well as identifying those risks they need to be quantified. Other considerations that need to be taken into account include risks to downstream receiving environments, seasonal switches between limitation status, and risks of failure to control the limiting nutrient (Wilcock et al, 2007, Wilcock 2011). I discuss these considerations further in the following sections.

**Current scientific knowledge on nitrate toxicity**

43 Hickey and Martin (2009) undertook a review of nitrate toxicity data and provided a revised set of trigger values for managing risks to aquatic fauna in Canterbury to differing thresholds of protection.

These trigger values have been used in the policies recommended in the HWZC/ECan and Fish and Game submissions.

44 More recently, Dr Hickey has undertaken a further revision of the nitrate toxicity thresholds incorporating new data from Environment Canada and data for the New Zealand native fish species (inanga – *Galaxias maculatus*) and a native mayfly (*Deleatidium* sp.). These revised thresholds have formed the basis of advice by Dr Hickey to the Hawkes Bay Regional Council on nitrate thresholds for the region's waterways (Hickey 2012). Hickey (2012) states that '*this updated database and guideline derivation will form the basis for the ANZECC*[1] *interim revised nitrate guidelines scheduled to be completed in 2012'*. I understand that the revision of the toxicity thresholds is part of a broader review of water quality guidelines for New Zealand (ANZECC water quality guidelines), but that these revised figures represent the most up to date numbers (Dr Hickey personal comms).

45 Hickey (2012) follows the ANZECC 2000 methodology to derive risk-based trigger values for chronic (long-term) effects (i.e, growth and reproduction effects) based on differing levels of ecosystem protection. The differing levels of protection reflect degree of modification and disturbance of a waterway such that:

45.1 99% species protection level is appropriate for high conservation/ecological value systems (such as those occurring in national parks)

45.2 95% species protection level is appropriate for slightly to highly modified systems where biological communities may have been adversely affected to a relatively small but measurable degree by human activity.

45.3 80 to 90% species protection level is appropriate for highly disturbed systems.

46 Hickey (2012) proposes a framework for managing nitrate risks for aquatic species by defining for each level of protection threshold an annual median trigger value as well as a seasonal maxima trigger value (based on the $95^{th}$ percentile of monitoring data).

47 Table 1 describes the proposed framework and revised trigger values for managing nitrate risks for aquatic species (Hickey 2012). These revised trigger values are higher than those in Hickey and Martin (2009) but reflect an updated dataset and for the first time include some native New Zealand species. They also provide clarity for

1 ANZECC refers to the Australian and New Zealand Environment and Conservation Council (ANZECC), which released the '*Australian and New Zealand guidelines for fresh and marine water quality'* in 2000. These guidelines are currently under revision.

determining compliance by providing for each species protection threshold an annual median trigger values and a seasonal peak trigger value (based on a 95% percentile of annual data). These values are more up to date and better reflect scientific understanding of New Zealand conditions and species. In addition, the values are likely to become national guidelines and will replace the existing guidelines also prepare by Dr Hickey. In my view, it is appropriate, that nitrate toxicity concentrations in the Proposed Plan incorporate these most recent values.

**Table 1 Proposed Framework for managing Nitrate risk for Aquatic Species (source: Hickey 2012)**

| **Management Classification (ANZECC protection threshold)** | **Grading Nitrate concentration (mg $NO_3$-N /L)** | **Surveillance Nitrate concentration (mg $NO_3$-N /L)** | **Description of Management Class** |
|---|---|---|---|
| Excellent (99%) | 1.1 | 2.0 | Pristine environment with high biodiversity and conservation values. |
| Very Good (95%) | 2.3 | 3.6 | Environments which are subject to a range of disturbances from human activities, but with minor effects. |
| Good (90%) | 3.6 | 5.1 | Environments which have multiple disturbances from human activities and seasonally elevated concentrations for significant periods of the year (1-3 months). |
| Fair (80%) | 6.3 | 8.7 | Environment which are measurably degraded and which have seasonally elevated concentrations for significant periods of the year (1-3 months). |
| Monitoring statistic: | Annual median | 95th percentile | |

**Current state and trends in Nitrogen and Phosphorus concentrations**

48 The follow paragraphs describe the state and trends in nutrient data for the Hurunui River and mid-reach tributaries. I have undertaken analysis for trends in water quality data for the Hurunui River and tributaries as described in Appendix 1. There are two sources of water quality data for the Hurunui catchment:

48.1 NIWA's national rivers water quality network data for two sites on the mainstem of the Hurunui River; one at just above the Mandamus confluence and the other at the State Highway 1 (SH1) bridge. Sites have been sampled monthly for the main range of water quality parameters since 1989 (Quinn 2010).

48.2 Environment Canterbury's water quality and flow monitoring programme for the Hurunui catchment initiated in April 2005 (Ausseil, 2010). This includes two sites on the Hurunui River and at least one site on the main mid-reach tributaries.

49 Current nutrient concentrations and trends over time are summarised in Table 2 (Appendix 1). The data shows the commonly found pattern of increasing nutrient concentrations at the downstream sites of the mainstem of the Hurunui River (the same patterns were also found by Quinn (2010) and Norton and Kelly (2010)).

50 The data is generally consistent with expectations that nutrient concentrations upstream of the mid reach tributaries reflect high water quality of the upper catchment. The downstream sites show the influence of productive agricultural land in its mid to lower reaches. Nutrient concentrations are generally higher in the tributaries.

51 Figures 1 and 2 shows the ratio of DIN to DRP for 3 sites on the Hurunui River. This ratio can be used to indicate when one nutrient occurs in excess of the other when considering periphyton nutrient needs. Plants generally utilise nitrogen and phosphorus at a ratio of about 7:1. It is generally considered that when the ratio of DIN to DRP exceeds 15, then P may become a limiting nutrient. Conversely when the ratio is below 7, nitrogen becomes the most limiting nutrient (McDowell et al, 2009). At ratios between 7 and 15, co-limitation occurs where both nutrients may limit plant growth.

52 The data for the Hurunui River shows clear differences in ratios for the two upper sites (above SH7 and Mandamus) compared to the ratios for the SH 1 site (Figures 1 and 2). Ratios for the two upper sites indicate co-limitation (ratios between 7-15) whereas ratios for the SH1 site strongly indicate P limitation.

53 Ausseil (2010) drew similar conclusions that periphyton growth in the lower reaches of the Hurunui River (below Pahau confluence) to be phosphorus limited but not nitrogen limited while reaches above the Pahau confluence may be predominately P limited but with possible N limitation at times. Similarly Norton and Kelly (2010) commented that based on nutrient ratios, they expected P-limitation to be more common in the Culverden Basin.

54 In comparison to the recent Hickey (2012) nitrate toxicity trigger values, nitrate nitrogen concentrations at all three regularly monitored sites on the Hurunui River mainstem are well below the most conservative species protection thresholds (99%) (Table 6). All tributary sites except for St Leonards Stream are below the 95% species protection level. St Leonards Stream is a groundwater-fed stream, where groundwater nitrate concentrations strongly influence stream concentrations.

55 Analysis of trends in the tributary water quality data over the monitoring period of 2005 to 2012 shows a significant trend of improving water quality in the Pahau River at Dalzells Bridge in nitrogen, phosphorus and E. coli (Table 3). This can be largely attributed to efforts by the local landowners (Pahau Enhancement

Group and Amuri Irrigation Company) to address management of border-dyke wipe off water and stock access issues (Hayward, 2009).

56 The other tributaries showed varying trends, with decreases in phosphorus at St Leonards Stream (DRP only) and Dry Stream. St Leonards Stream and Waitohi River showed trends of increasing nitrogen.

57 Analysis of trends in the longer term NIWA dataset for the two sites on the Hurunui River show little changes in the upper site (above Mandamus) but increases in nitrogen and phosphorus at the lower site (SH1) over the 23 year monitoring period (Table 4). Analysis was also undertaken for two separate time periods reflecting comments from Quinn (2010) that recent improvements in phosphorus and periphyton in the lower Hurunui River were apparent. This analysis shows increases in nitrogen for both time periods, indicating a long-term consistent pattern of increasing nitrogen trends. Increasing trends of DRP concentrations occurred during the 1989 to 1999 period, but as suggested by Dr Quinn, this trend has not continued in the period 2000 to 2011.

**Nutrient concentrations proposed by HWZC/ECan and Fish and Game submissions**

58 The Hurunui Waiau zone committee/Environment Canterbury submission proposes Policy 5.1 which includes a phosphorus concentration of 0.0044 mg/L for the Hurunui River. This concentration reflects current concentrations measured by Environment Canterbury (ECan) at SH1 (Table 2). In my opinion, this concentration is likely to support the relevant water quality outcomes sought in Objective 5.1 and will, in particular support periphyton biomass limits proposed by the HWZC submission. I consider this limit is appropriate for the Hurunui River, recognising that phosphorus management is critical to managing periphyton growth.

59 The HWZC submission proposed Policy 5.1 b) and 5.2 b) proposed nitrate toxicity limits based on a chosen level of species protection with the corresponding nitrate concentration given by Hickey and Martin (2009). For the Hurunui River the submission recommends a high level of protection from chronic nitrate toxicity risks, at 99% level of species protection, which equated to 1.0 mg/L nitrate nitrogen based on Hickey and Martin (2009).

60 The revised trigger values for this level of protection are 1.1 mg/L as annual median and 2.0 mg/L a seasonal peak concentration (Hickey 2012). This is a high level of protection, but I consider it can be justified for the upper Hurunui River on the basis of the high biodiversity values supported and its largely unmodified condition. For the lower Hurunui River, the 95% level of protection criteria for slightly to highly modified system better describes the river environment. However, the 99% level of protection is also in my

view appropriate for the lower Hurunui River because of its high community values.

61 For the hill-fed tributaries, Pahau, Waikari and Waitohi rivers, and Dry Stream, the HWZC submission recommends a 95% level of protection for average nitrate nitrogen concentrations and 90% level of protection for seasonal peak concentrations. A 95% level of species protection is generally appropriate for moderately disturbed systems such as the hill-fed rivers listed above and is adequately protective of their biodiversity values. Therefore, I support this level of protection using the revised trigger values of Hickey (2012) for annual median and seasonal peak concentrations (2.3 mg/L and 3.6 mg/L respectively).

**DETERMINING NUTRIENT LOAD LIMITS**

62 The Proposed Plan sets nutrient load limits for the Hurunui River at current levels. As described by Mr Norton, this is based on an assumption, which developed through the LUWQ project and subsequent zone committee deliberations, that current loads will protect current instream values as identified in objective 5.1.

63 The HWZC submission proposes nutrient load limits based on an average of the past 6 years data, which provides for an increase in the limits in the Proposed Plan from 693 tonnes/year to 770 tonnes per year, but based on an assumption that they are still protective of current values.

64 The Proposed Plan and HWZC submission recognise the importance of managing phosphorus at current levels as a mechanism for managing periphyton biomass. I support this as being an effective and pragmatic approach.

65 The current nutrient load limits in the Proposed Plan at SH1 are considerably higher than that which would constrain periphyton development (about 7 times higher). Table 5 below illustrates the concentrations of DIN that would be needed to co-limit periphyton growth in the Hurunui River at SH1. In my view, this acknowledges that phosphorus levels in the lower reach of the river will be the controlling nutrient on periphyton growth. Mr Norton states that "*The HWRRP (Schedule 1) DIN and DRP load limits are based on managing both nutrients with no relaxation of the DIN limit that would put reliance on the DRP limit*." This appears to be a point of difference between myself and Mr Norton.

**Table 5 Summary of current average nutrient concentrations and ratios in the Hurunui River, and the concentration of DIN that would co-limit periphyton growth at SH1**

| | Average DRP<br>mg/L | Average DIN<br>mg/L | Ratio |
|---|---|---|---|
| **Hurunui River above Mandamus (2005-2012)** | 0.002 | 0.018 | 11 |
| **Hurunui River above SH 7 (2005-2012)** | 0.002 | 0.048 | 42 |
| **Hurunui River above SH1 (2005 - 2012)** | 0.004 | 0.40 | 175 |
| **DIN concentration needed at SH 1 to be co-limiting on periphyton growth (based on a DIN:DRP ratio of 15:1)** | | **0.06**<br>**(7 times lower than current concentrations)** | **15** |

66 The question then is whether the nitrogen load limit can be set higher without compromising the in-stream objectives of the Proposed Plan.

67 As I outlined earlier, the scientific debate is whether periphyton growth can be effectively managed by focussing management on the most limiting nutrient. Considerations that need to be taken into account when considering levels of control on both nutrients include:

67.1 Seasonal switches between limitation status;

67.2 Risks to downstream receiving environments; and

67.3 Risks of failure to control the limiting nutrient.

*Seasonal switches between limitation status*

68 For the lower Hurunui River the data strongly indicates P limitation dominates at all times except during flood events. The data points in Figure 2 which show ratios below 15 occur during floods, during which periods periphyton is generally scoured from the river bed. At all other times, the data indicates P limitation.

69 However, the upper catchment (above SH7) does appear to exhibit both N and P limitation at times and as such the load limits set for the Hurunui River above Mandamus appropriately reflect this situation.

*Risks to downstream receiving environments*

70 In the Hurunui River, the river mouth (hapua) and coastal marine area are the receiving environments. Under normal flow conditions the hapua is continuously discharging to the sea, and is generally a well mixed area with low risk of developing algal blooms. Similarly, the hapua discharges into the high energy coastal environment with low risk of significant algal blooms.

71 Therefore, receiving environments of the Hurunui River do not appear to change in their relative sensitivity to nutrients. However, I acknowledge there is an absence of data for the hapua, and therefore there is uncertainty around the level of risk posed by differing levels of controls of nutrients.

*Risks of failure to control the limiting nutrient*

72 Consideration of the risk from failure to control the limiting nutrient is valid and important. Nitrogen cannot be left completely uncontrolled. However, the lower Hurunui River currently has nitrogen concentrations in the order of 7 times higher than those that would be needed to co-limit periphyton growth. Therefore, the current nitrogen load limit will not reduce risk of periphyton growth and it is generally considered that periphyton growth in the affected reaches is currently acceptable (Brown 2011)..

73 In my view the risks from failure to control nitrogen would not increase significantly if N concentrations (and loads) are increased providing toxicity risks are avoided.

**ALTERNATIVE NITROGEN LOAD LIMIT**

74 An alternative approach to that set out in the Proposed Plan is to set nitrogen load limits in the lower Hurunui River based on avoiding nitrate toxicity risks, while phosphorus limits are used to manage nuisance periphyton growth.

75 Taking a very conservative approach, average nitrate nitrogen concentrations in the lower Hurunui River (at SH1) could be increased from the current concentration of 0.4 mg/L to between 0.5 to 0.6 mg/L without risk of exceeding the annual median trigger value (1.1 mg/L) or seasonal peak trigger value (2.0 mg/L) (Hickey 2012). This converts to an increase in loads of between 963 tonnes/year to 1,155 tonnes/year, representing a load increase of between 25 to 50 percent.

76 While there is always some uncertainty regarding nutrient increases, the approach I propose will be supported by a range of measures that aim to limit phosphorus concentrations to current levels and account for factors such a lag times in nutrient transport. On this basis, it is my view that the outcomes sought in the Proposed Plan objectives can be achieved with a higher nitrogen load limit.

77 It would also be appropriate to implement an appropriate monitoring programme that allows evaluation of the actual nutrient inputs and indicators of in-stream outcomes sought in the Proposed Plan.

**IMPLICATIONS OF NUTRIENT LOAD LIMITS ON LAND DEVELOPMENT**

78 Pattle Delamore Partners have developed a Hurunui catchment nitrogen load model using up to date land use information. This is described in detail in Mr Callander's evidence. The model estimates N loads from all irrigable land (flat land) in the middle reaches of the Hurunui catchment.

79 Dr McCall's analysis of dairy farms within the Culverden Basin indicate that existing dairy farmers could create a 17% load reduction (headroom) by achieving technical efficiency in their use of nutrients and conversion of border dyke to spray irrigation.

80 Table 5 below summarises the modelling of the area of land that could be converted to irrigated dairy land under different N load limit scenarios. The results indicate if N loads are maintained at current levels, about 3,000 to 6,000 ha of dryland could be converted to irrigated dairy.

81 If the nitrogen load limit in the lower Hurunui River (below SH7) is increased to either 25% or 50% of current loads, a predicted increase in irrigated dairy land of 18,600 to 32,000 ha could be developed, providing the instream values sought are able to be maintained. This analysis does not account for the effects of abstraction on river flows. I agree with Mr Norton that these effects need to be considered, but it is my view that this analysis needs to be undertaken using specific abstraction scenarios to more realistically account for timing and location of takes.

**Table 5 Summary of estimates of area of land that can be converted to irrigated dairy based on different N load limits.**

| Baseline | Nitrogen Load tonnes/year | Area hectares (ha) |
|---|---|---|
| Total modelled area load | 1,037 | |
| Existing irrigated area | | 22,615 |
| **Scenario if N load remains the same and 17% headroom created** | | |
| 17% reduction in N loads from existing dairy+ support | 91 | |
| Area that can be converted from dryland sheep and beef | | 6,679 |
| Area that can be converted from Balmoral forest | | 3,159 |
| **Scenario if N load increased by 25%** | | |
| Additional load from 25% N limit increase | 259 | |
| Sum of headroom from existing farmers (17% load reduction) plus 25% load limit increase | 350 | |
| Additional dryland area converted to irrigated dairy+ support (5,000 ha Balmoral, 8,000 ha S&B, 5,600 ha sheep) | | 18,600 |
| Total modelled load | 1,295 | |
| **Scenario if N load increased by 50%** | | |
| Additional load from 50% N limit increase | 518 | |
| Sum of headroom from existing farmers (17% load reduction) plus 50% load limit increase | 609 | |
| Additional dryland area converted to irrigated dairy+ support (9,000 ha Balmoral, 14,5000 ha S&B, 8,500 ha sheep) | | 32,000 |
| Total modelled load | 1,557 | |

## CONCLUSIONS

82 While the Proposed Plan provides appropriate water quality objectives, the main mechanism for managing water quality effects to relate to the objectives is in my view poorly linked via nutrient load limits.

83 The Hurunui Waiau zone committee's submission proposed changes to Policy 5.1 and Policy 5.2 that included numeric outcomes for periphyton biomass, nitrate toxicity and dissolved phosphorus concentrations. In my view these numeric outcomes provide a more direct link to the outcomes sought in Objectives 5.1 and 5.2. I support these numeric outcomes providing the nitrate toxicity limits incorporate the recent guideline revisions.

84 In my view the nitrogen load limit proposed for the lower Hurunui River is unnecessarily constraining. I consider the nitrate load in the lower Hurunui River could be increased by between 25% to 50% which will still support Objectives 5.1 and 5.2. This approach would need to be supported by measures that maintain phosphorus concentrations within current levels, manage for lag periods in nutrient transport, and appropriate monitoring of the objectives in the plan.

**Shirley Ann Hayward**

12 October 2012

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## Appendix 1 Analysis of state and trends in water quality data for the Hurunui River and tributaries

Table 2 Summary of nutrient and E. coli concentrations

| | | Dissolved inorganic nitrogen | Total Nitrogen | Dissolved Reactive Phosphorus | Total Phosphorus | DIN_DRP ratio | *E. coli* |
|---|---|---|---|---|---|---|---|
| | | mg/L | mg/L | mg/L | mg/L | | n/100 ml |
| Hurunui R at Mandamus (NIWA) | average | 0.02 | 0.07 | 0.002 | 0.02 | 11 | |
| Apr 2005 - Mar 2012 | max | 0.10 | 0.33 | 0.008 | 0.79 | 35 | |
| Hurunui R at SH1 (NIWA) | average | 0.40 | 0.49 | 0.003 | 0.05 | 201 | |
| Apr 2005 - Mar 2012 | max | 1.19 | 1.27 | 0.022 | 2.19 | 981 | |
| Hurunui R at SH7 | average | 0.05 | 0.06 | 0.002 | 0.02 | 42 | 120 |
| Apr 2005 - Aug 2012 | max | 0.16 | 0.52 | 0.009 | 0.42 | 164 | 520 |
| Hurunui R at SH1 | average | 0.37 | 0.43 | 0.004 | 0.02 | 175 | 85 |
| Apr 2005 - Aug 2012 | max | 1.02 | 1.60 | 0.038 | 0.37 | 938 | 820 |
| Pahau River at Top Pahau Rd | average | 0.14 | 0.17 | 0.008 | 0.04 | 20 | 99 |
| Nov 2008 - Aug 2012 | max | 0.50 | 0.54 | 0.028 | 0.58 | 248 | 820 |
| Pahau River at SH7 bridge | average | 1.12 | 1.24 | 0.013 | 0.04 | 245 | 350 |
| Jun 2007 - Aug 2012 | max | 3.82 | 4.00 | 0.250 | 0.64 | 2036 | 2400 |
| Pahau River at Dalzells Bridge | average | 1.64 | 1.77 | 0.016 | 0.05 | 148 | 353 |
| Apr 2005 - Aug 2012 | max | 3.32 | 3.50 | 0.072 | 0.99 | 825 | 2400 |
| St Leanoards Stream at Lowry Peaks Rd | average | 1.97 | 2.27 | 0.028 | 0.06 | 89 | 760 |
| Jun 2007 - Aug 2012 | max | 7.63 | 8.40 | 0.180 | 0.50 | 343 | 2400 |
| St Leonards Stream at Pahau confluence | average | 3.32 | 3.61 | 0.015 | 0.04 | 356 | 567 |
| Apr 2005 - Aug 2012 | max | 6.55 | 7.20 | 0.065 | 0.24 | 2203 | 2400 |
| Dry Stream at Balmoral Station Road | average | 0.95 | 1.23 | 0.025 | 0.05 | 71 | 501 |
| Jul 2009 - Aug 2012 | max | 2.22 | 2.50 | 0.140 | 0.21 | 331 | 2500 |
| Dry Stream at SH7 | average | 0.48 | 0.64 | 0.054 | 0.09 | 39 | 644 |
| Jul 2009 - Aug 2012 | max | 2.53 | 2.70 | 1.300 | 1.70 | 139 | 2400 |
| Dry Stream above Hurunui confluence | average | 0.88 | 1.04 | 0.015 | 0.03 | 121 | 581 |
| Apr 2005 - Aug 2012 | max | 4.71 | 5.70 | 0.130 | 0.24 | 1057 | 2400 |
| Waitohi River 1.6 km above Hurunui confluence | average | 1.26 | 1.38 | 0.007 | 0.02 | 415 | 245 |
| Apr 2005 - Aug 2012 | max | 2.97 | 3.20 | 0.052 | 0.21 | 3824 | 2400 |

## Table 3 Trends in water quality of the mid-reach tributaries of the Hurunui River*

| **Environment Canterbury data** | | **DRP** | **TP** | **DIN** | **TN** | ***E. coli*** |
|---|---|---|---|---|---|---|
| Pahau River at Dalzells Bridge | raw | **decrease** | **decrease** | **decrease** | **decrease** | **decrease** |
| Apr 2005 - Aug 2012 | flow-adjusted | **decrease** | **decrease** | **decrease** | **decrease** | **decrease** |
| St Leonards Stream at Pahau confluence | raw | **decrease** | - | - | **increase** | - |
| Apr 2005 - Aug 2012 | flow-adjusted | - | - | - | - | - |
| Dry Stream above Hurunui confluence | raw | **decrease** | - | - | **decrease** | - |
| Apr 2005 - Aug 2012 | flow-adjusted | **decrease** | **decrease** | - | - | - |
| Waitohi River 1.6 km above Hurunui confluence | raw | - | - | **increase** | **increase** | - |
| Apr 2005 - Aug 2012 | flow-adjusted | - | - | **increase** | **increase** | - |

*Seasonal Kendall trend analysis (with and without flow adjustment) was undertaken on the four main tributary sites where monthly samples have been collected since Apr 2005. Trend analysis carried out in TimeTrends 3.2 (2011) (www.niwa.co.nz). Decrease/increase – means statistically significant ($p<0.05$) and meaningful (annual rate of change >1% of median) trends detected.

**Table 4 Trends in water quality at the two NIWA monitoring sites**

| NIWA data | | DRP | TP | DIN | TN |
|---|---|---|---|---|---|
| Hurunui River above Mandamus | | | | | |
| full record 1989 - 2011 | raw | - | - | **decrease** | - |
| | flow-adjusted | - | - | - | **increase** |
| 1989 - 1999 | raw | - | - | **decrease** | - |
| | flow-adjusted | - | - | **decrease** | - |
| 2000-2011 | raw | - | - | **decrease** | - |
| | flow-adjusted | - | - | - | - |
| Hurunui River at SH1 | | | | | |
| full record 1989 - 2011 | raw | - | - | **increase** | **increase** |
| | flow-adjusted | **increase** | **increase** | **increase** | **increase** |
| 1989 - 1999 | raw | **increase** | - | - | - |
| | flow-adjusted | **increase** | - | **increase** | **increase** |
| 2000-2011 | raw | - | **decrease** | **increase** | **increase** |
| | flow-adjusted | - | - | - | - |

*Seasonal Kendall trend analysis (with and without flow adjustment) was for the two NIWA monitoring sites. Analysis was undertaken on the full 23 year record as well as separated into two time periods. Trend analysis carried out in TimeTrends 3.2 (2011) (www.niwa.co.nz). Decrease/increase – means statistically significant (p<0.05) and meaningful (annual rate of change >1% of median) trends detected.

**Figure 1 DIN:DRP ratios in the upper Hurunui River**

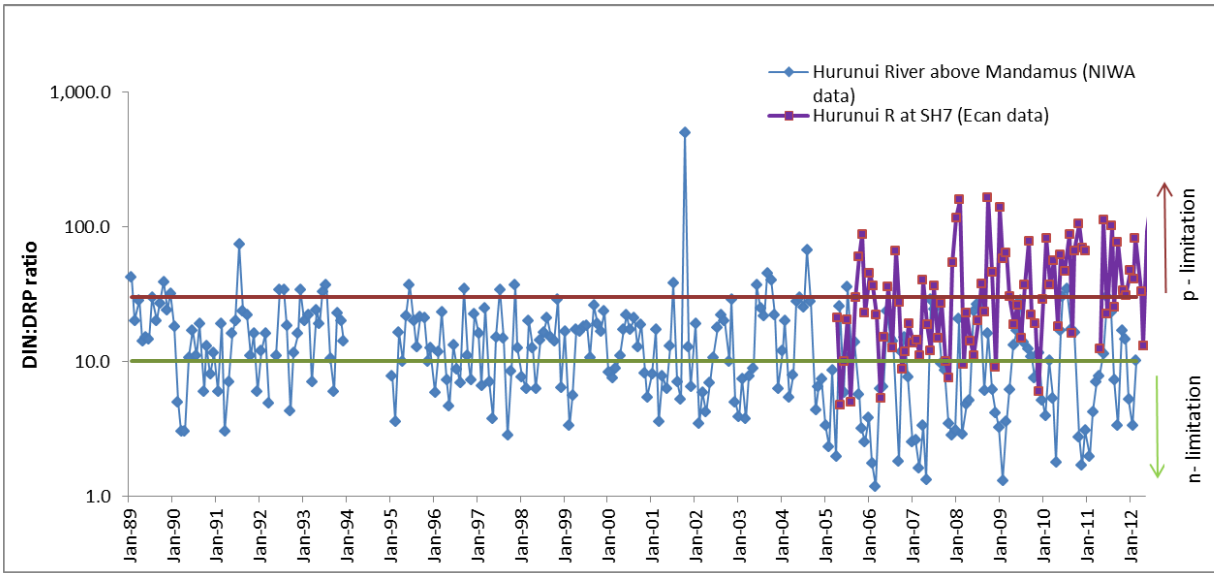


**Figure 2 DIN:DRP ratios in the lower Hurunui River**

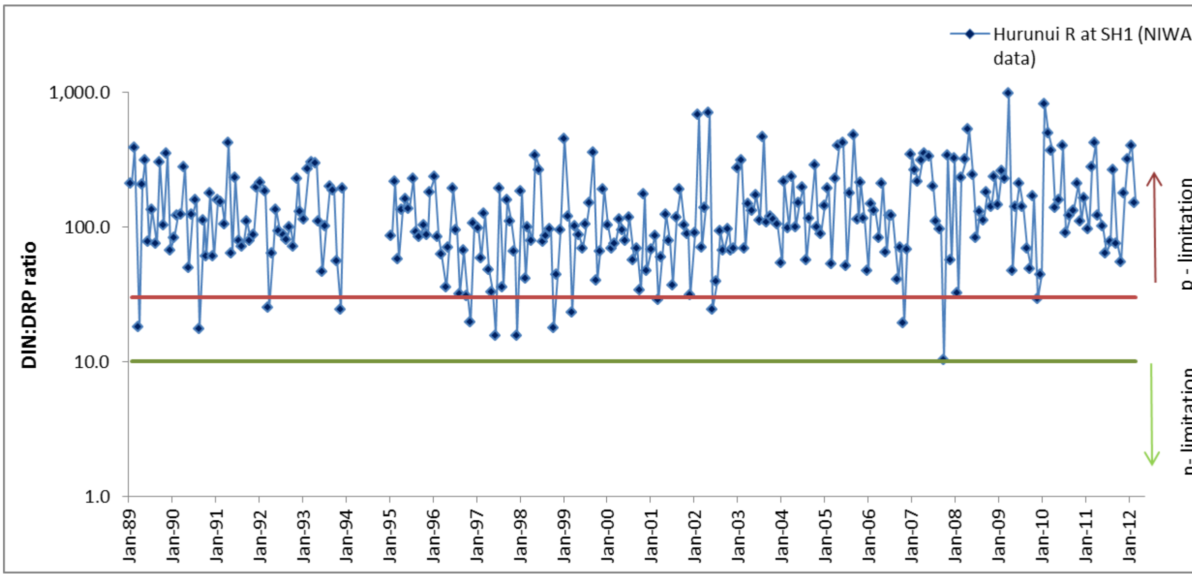

**Figure 3 Relationship between DIN concentration and DIN:DRP ratios in the Hurunui River at SH1 (NIWA data) for 2001 - 2011**

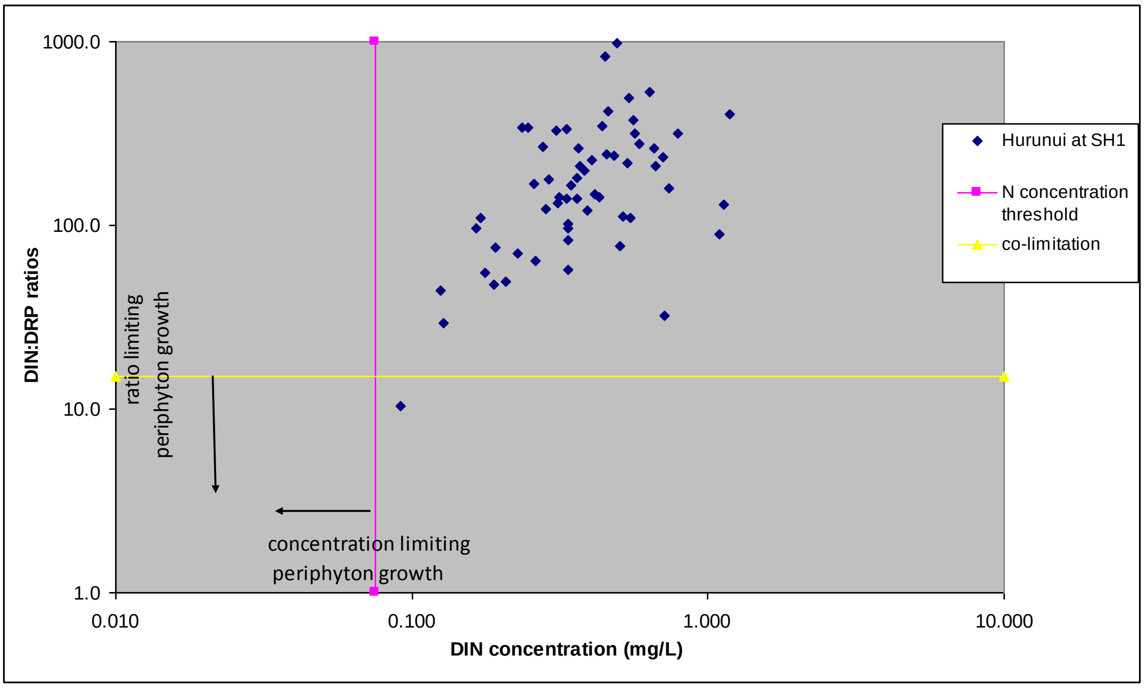

**Table 6 Summary of nitrate nitrogen concentrations in the Hurunui River and tributaries. Cell highlighted in yellow do not meet the Hickey 2012 95% species protection thresholds.**

| | | Nitrate + Nitrite Nitrogen |
|---|---|---|
| | | mg/L |
| Hurunui R at Mandamus (NIWA) | median | 0.01 |
| Apr 2005 - Mar 2012 | 95th percentile | 0.07 |
| Hurunui R at SH1 (NIWA) | median | 0.36 |
| Apr 2005 - Mar 2012 | 95th percentile | 0.86 |
| Hurunui R at SH7 | median | 0.03 |
| Apr 2005 - Aug 2012 | 95th percentile | 0.10 |
| Hurunui R at SH1 | median | 0.32 |
| Apr 2005 - Aug 2012 | 95th percentile | 0.75 |
| Pahau River at Top Pahau Rd | median | 0.07 |
| Nov 2008 - Aug 2012 | 95th percentile | 0.33 |
| Pahau River at SH7 bridge | median | 0.74 |
| Jun 2007 - Aug 2012 | 95th percentile | 3.08 |
| Pahau River at Dalzells Bridge | median | 1.50 |
| Apr 2005 - Aug 2012 | 95th percentile | 2.87 |
| St Leanoards Stream at Lowry Peaks Rd | median | 0.75 |
| Jun 2007 - Aug 2012 | 95th percentile | 6.22 |
| St Leonards Stream at Pahau confluence | median | 3.10 |
| Apr 2005 - Aug 2012 | 95th percentile | 4.69 |
| Dry Stream at Balmoral Station Road | median | 0.90 |
| Jul 2009 - Aug 2012 | 95th percentile | 1.84 |
| Dry Stream at SH7 | median | 0.13 |
| Jul 2009 - Aug 2012 | 95th percentile | 1.73 |
| Dry Stream above Hurunui confluence | median | 0.46 |
| Apr 2005 - Aug 2012 | 95th percentile | 2.59 |
| Waitohi River 1.6 km above Hurunui confluence | median | 1.20 |
| Apr 2005 - Aug 2012 | 95th percentile | 2.23 |