UNDER	The Environment Canterbury (Temporary Commissioners and Improved Water Management Act) 2010 and The Resource Management Act 1991
AND	
IN THE MATTER OF	Hurunui Water Project's submission on the Proposed Hurunui and Waiau River Regional Plan.

EVIDENCE OF PETER FRANCIS CALLANDER

1 My name is Peter Francis Callander. I hold the qualifications of BSc (Geology) from the University of Auckland and MSc (Earth Sciences) from the University of Waterloo (Canada). I am a member of the New Zealand Hydrological Society, Water NZ and the USA based National Ground Water Association. Since 1991, I have been employed as a Senior Environmental Scientist with Pattle Delamore Partners Limited, an environmental consulting firm specialising in ground and water resources. In 1997, I was appointed as a Director of that firm. Previously I had been employed for eight years by the Canterbury Regional Council and its predecessor the North Canterbury Catchment Board.

2 I have been involved with the management of water resources for a large part of my career, including many projects involving water quality assessments. This has included work on numerous projects where I have modelled and advised on the management of water quality impacts associated with irrigation including work for the Waimakariri Irrigation Scheme, Rangitata South Irrigation, Barhill-Chertsey Irrigation, the Southern Valleys Irrigation Scheme and Wairau Valley Water Enhancement Scheme. I have also reviewed work completed by other parties for the Central Plains irrigation scheme (on behalf of the

Christchurch City Council and others) and applications for irrigated land use change in the MacKenzie basin (on behalf of Meridian Energy).

3 A copy of my CV is attached to my evidence as Appendix 1.

4 I have read the Expert Code of Conduct contained in the Environment Court's Practice Note 2011 and I agree to comply with it. I have prepared this evidence in accordance with the Practice Note.

EXECUTIVE SUMMARY

5 The Hurunui Waiau Zone Committee Zone Implementation Programme (ZIP) has been based on information they received that the current nutrient concentrations in the Hurunui mainstem are acceptable in terms of periphyton growth issues and that full irrigation within the catchment can occur without altering the current nutrient loads, provided mitigation measures are put in place. That would seem to be an ideal outcome in terms of the approach that is advocated by the Canterbury Water Management Strategy (CWMS). However, the specification of nitrogen load limits is a potentially significant constraint on agricultural land use activities and some of the mitigation measures required to maintain the current nitrogen loads may not be feasible. Therefore, changes to the proposed Hurunui and Waiau River Regional Plan (the Plan) are required over and above those set out in the ZIP to achieve a more realistic and better outcome based on the CWMS approach.

6 The key changes to achieve this better outcome are to incorporate the following key points:

a) Periphyton growth is dependent on a range of factors. Only one of those factors is the concentration of nutrients. In the lower mainstem of the Hurunui River, periphyton growth is most sensitive to the phosphorous concentration and relatively insensitive to the nitrogen concentration. Therefore, some increase in nitrogen concentration can occur without adverse periphyton increases.

b) The Hurunui River is a slight to moderately modified river, particularly in the tributaries in the Culverden Basin and in the mainstem downstream of State Highway 7. Therefore the appropriate fish and invertebrate toxicity criteria to use for water quality management purposes are those that achieve a 95% level of protection for aquatic species.

c) The most relevant nitrate toxicity guidelines are those recently published in Hickey (2012). These are:

   i. An annual median nitrate concentration of 2.3 mg/L; and

   ii. An annual 95th percentile nitrate concentration of 3.6 mg/L

d) Load limits based on measurements of river flow and measured nutrient concentrations are highly variable from year to year and even on a long term (6 year) average the historical data shows variations of +/- 20%. A more certain approach for management of land use activities is to base the load limit on a modelled evaluation of current land use and an allowable level of future change.

e) Based on the currently available information the following criteria could be adopted:

   i. No increase above current values for phosphorous load;

ii. A 50% increase above current values for nitrogen load.

f) Such a management regime is designed to achieve:

i. No adverse increase in periphyton;

ii. No adverse effects on fish and invertebrate toxicity;

iii. Development of irrigation activities with a high (but feasible) degree of mitigation;

iv. A more consistent approach between the Water Quantity and Water Quality management strategies set out within the Plan

This is a considerably better CWMS outcome than what is currently specified in the Plan.

g) In order to achieve this outcome, some improvements to current irrigation activities are required. It is considered that these can be facilitated by setting a nitrogen load limit for Permitted land use activities at 35 kg/ha/year for current and future land use activities.

7 I am concerned that much of the Section 42A Officers reports are based on an unrealistically conservative view of changes to river flow that could arise from the Plan. These simulations of future river flow assume that all allocated water is abstracted continuously and with no acknowledgement for actual water demand requirements or for mitigation to allow for the passage of higher flows down the river. Such an assessment is very conservative to the point of being not realistic and consequently the likelihood of the Plan achieving its water quality

outcomes is more positive than is indicated by several of the Section 42A reports.

SCOPE OF EVIDENCE

8 The Hurunui Water Project proposes to deliver water to a number of properties in the catchment of the Hurunui River, to be used for irrigation. The proposed Hurunui and Waiau River Regional Plan (the Plan) contains a number of objectives and related polices and rules which will have a direct impact on irrigation development in the Hurunui River Catchment and therefore on the Hurunui Water Project. These include the policies and rules in the Plan related to nutrient impacts in the river and its tributaries.

9 PDP has been engaged by the Hurunui Water Project to provide technical advice related to the proposed nutrient load limits in the Plan. The purpose of my evidence is to describe the work we have undertaken and to outline the technical background to the changes that the Hurunui Water Project are seeking for the Plan.

BACKGROUND

10 I will first briefly review the background to Objective 5.1 (which relates to mainstem water quality) and Objective 5.2 (which relates to tributary water quality). I will also review the background to the proposed load limits in Schedule 1 of the Plan, which are based on an estimate of the current measured loads.

11 Objectives 5.1 and 5.2 are based on the water quality outcomes set out in the Hurunui-Waiau Zone Committee's Zone Implementation

Programme (ZIP) (July 2011), which was developed to give effect to the Canterbury Water Management Strategy (CWMS). It is important when considering nutrient management for a catchment to keep in mind the desired outcome of the CWMS, which is: *"To enable present and future generations to gain the greatest social, economic, recreational and cultural benefits from our water resources within an environmentally sustainable framework".* Therefore, the approach required by the CWMS is to achieve an optimised outcome for a number of water uses, rather than favouring one use at the expense of others.

12 The water quality outcomes set out in the Zone Implementation Programme were informed from presentations from various experts to the public Zone Committee meetings. At these meetings, the Zone Committee received information from scientists indicating that higher nutrient concentrations, in particular phosphorus, in the past have led to periphyton problems in the mainstem of the Hurunui, but that current concentrations appear to be acceptable in terms of their contribution to periphyton growth at State Highway 1 (e.g. Kelly (2010), Quinn (2010) and Brown et al. (2011)). The Zone Committee also received information to the effect that irrigation of the full irrigable area could occur, without altering nutrient loads at State Highway 1, provided mitigation measures were implemented (Lilburne et al., 2011).

13 Based on this information, the Zone Committee set the following water quality outcomes for the mainstems. These are shown alongside Objective 5.1 of the Plan.

Table 1: Water quality outcomes for mainstems in the ZIP and Objective 5.1 in the proposed HWRRP	
Water quality outcomes for mainstem of major rivers (e.g. Hurunui and Waiau Rivers): • **achieve in most years periphyton limits as identified in NRRP (that is, four years in every five);** • **maintain or enhance the mauri of the river;** • **safe for contact recreation;** • **toxin producing cyanobacteria shall not render the river unsuitable for recreation or animal drinking water;** • **nutrients (particularly nitrate and phosphorous) will decrease over time at sufficient rate and to a level such that additional irrigation development can occur without compromising water quality outcomes for the river (i.e. reduce current loads to create "headroom" for new irrigation development).**	**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,** **(a) ensure concentrations of nitrogen do not result in water being unsuitable for human consumption.**

14 The Hurunui Water Project generally supports the desired water quality outcomes in the ZIP for the mainstems of the Hurunui and the Waiau, although it is considered that nitrate, which is not the limiting nutrient, can increase without adversely affecting the other outcomes. I will discuss this further in my evidence.

15 The Hurunui Waiau Zone Committee is seeking, in their submission to the Plan, inclusion of a policy (Policy 5.1) that sets a maximum nitrate-nitrogen concentration at the 99% level of protection chronic nitrate-nitrogen toxicity threshold for the Hurunui River. Ms Liz White adopts this

recommendation in her proposed changes to the plan set out in her evidence (Policy 5.3). However, this is the incorrect criteria to use for the river. Based on the recommendations in the ANZECC[1] guidelines and Hickey and Martin (2009) for slightly to moderately disturbed systems, the appropriate level of protection for the lower Hurunui River is a 95% level of protection. A 95% level of protection is relevant to a reach of river already affected by land use, which is the appropriate criteria for this section of the Hurunui River. For consistency, I recommend that, if Environment Canterbury adopt the Zone Committee's recommendation, it is modified to require a 95% level of protection. Such a requirement could be incorporated into Policy 5.3 and 5.4 of the Plan (through modification of the suggested changes in Ms White's evidence) and should allow for the implementation of the most relevant guidelines, such as those specified in Hickey (2012).

16 It is important to recognise that short term exceedances above the chronic toxicity threshold are not expected to have adverse effects on fish, as outlined in Hickey and Martin's (2009) report for Environment Canterbury detailing recommended freshwater guidelines for nitrate-nitrogen toxicity suitable for application to freshwaters of Canterbury. The chronic toxicity thresholds are based on long-term exposure to nitrate-nitrogen concentrations. The guideline value recommended by Hickey and Martin (2009) for acute toxicity (i.e. short term exposure) is 20 mg/L, which is well above the chronic toxicity threshold. On this basis, if Environment Canterbury adopt the Zone Committee's policy suggestion, it would be appropriate to specify a timeframe for the exceedance, for example specify that average concentrations over a 2 month period should not exceed the 95% chronic toxicity threshold or to use the 95th

[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.

percentile thresholds outlined in Hickey (2012), which I will introduce shortly.

17 The Zone Committee also received information (e.g. Ausseil 2010) at the Zone Committee meetings to the effect that monitoring has shown that concentrations of phosphorus and nitrogen are elevated in some tributaries (including St Leonards Drain, Dry Stream and the lower Pahau River) and that the nutrient loads from these tributaries form a significant component of the load measured in the lower Hurunui River. I have attached to my evidence Appendix 1 of the agenda for the Hurunui-Waiau Zone Committee Meeting 21 May 2012 (from Ausseil (2010)), which illustrates this contribution.

18 Based on the information received, the Zone Committee set the following desired water quality outcomes for the tributaries. These are shown alongside Objective 5.2 of the Plan.

Table 2: Water quality outcomes for tributaries in the ZIP and Objective 5.2 in the proposed HWRRP	
Water quality outcomes for tributaries of major rivers (e.g. Pahau and Waitohi Rivers): • **achieve in most years periphyton limits as identified in NRRP;** • **maintain or enhance the mauri of the tributary;** • **safe for contact recreation;** • **toxin producing cyanobacteria shall not render the river unsuitable for recreation or animal drinking water;** • **have nitrate concentrations that protect fish;** • **contribute to achievement of the mainstem water quality outcomes, in particular to reducing current loads where required to create "headroom" for new irrigation development;** • **achieve ecosystem health outcomes agreed for the particular tributary through a collaborative community-based process.**	**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.**

19 The Hurunui Water Project generally supports the desired water quality outcomes in the ZIP for the tributaries, although given that concentrations already exceed the current 95% protection nitrate-nitrogen fish toxicity limit at times, if this was a limit that was to be used then achieving nitrate concentrations below this threshold is likely to be difficult with additional irrigation, particularly in the Waitohi River. Ms Shirley Hayward provides further information on this in her evidence on behalf of DairyNZ and Fonterra's submission to the Plan.

20 Ms Hayward also outlines in her evidence the revised guidelines for managing nitrate aquatic toxicity risks that have recently been released

by Hickey (2012). These revised trigger values are higher than those in Hickey and Martin (2009) and are based on more recent data, including for the first time, assessment for some native New Zealand species. The Hickey and Martin (2009) numbers are shown for comparison in brackets beside the new numbers in Table 3 below. Ms Hayward notes how these provide more clarity than the current guidelines for determining compliance by specifying thresholds as both annual median trigger values and seasonal peak trigger values (based on the 95th percentile of annual data). Because these are expected to become the national guidelines, it would be appropriate for the Plan to use these most recent values.

Table 3: Proposed Framework for managing Nitrate risk for Aquatic Species (source: Hickey 2012)

Management Classification (ANZECC protection threshold)	**Annual median Nitrate concentration (mg NO_3-N /L)**	**Annual 95th percentile Nitrate concentration (mg NO_3-N /L)**	**Description of Management Class**
Excellent (99%)	1.1 (1.0)	2.0	Pristine environment with high biodiversity and conservation values.
Very Good (95%)	2.3 (1.7)	3.6	Environments which are subject to a range of disturbances from human activities, but with minor effects.
Good (90%)	3.6 (2.4)	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 (3.6)	8.7	Environment which are measurably degraded and which have seasonally elevated concentrations for significant periods of the year (1-3 months).

Note: Hickey and Martin (2009) thresholds are shown in brackets

21 The Hurunui Waiau Zone Committee is also seeking, in their submission to the Plan, inclusion of a policy (Policy 5.2) and restriction of discretion to a rule (Rule 2.3) that set a maximum annual average nitrate-nitrogen concentration at the 95% level of protection chronic nitrate-nitrogen toxicity threshold for the Pahau River, Waitohi River, Dry Stream and the Waikari River. Ms White adopts this recommendation in her proposed changes to the plan set out in her evidence (Policy 5.4). The location of the current downstream sampling points in these waterways is shown in **Figure 1**. This level of protection is generally consistent with the recommendations in the ANZECC guidelines and Hickey and Martin (2009), however, as noted in paragraph 19 and illustrated in **Figure 2**, the proposed limit of 1.7 mg/L in the Zone Committee's submission is not currently being met in all years. However, the revised limit of 2.3 mg/L in Hickey (2012) has been met. Note that the Waikari River does not have any nutrient quality data in recent years.

22 In addition, the Hurunui Waiau Zone Committee is seeking that the policy also specifies a maximum nitrate-nitrogen concentration for these tributaries equal to the 90% level of protection. Ms White adopts the Zone Committee's recommendation in her proposed changes to the plan set out in her evidence (Policy 5.4). As shown in **Figure 3** of this evidence, it appears that the currently proposed limit of 2.4 mg/L may be very difficult to meet based on the existing concentrations, even without additional irrigation occurring.

23 Hickey (2012) indicates that the appropriate threshold for managing seasonal peaks would be 3.6 mg/L and that this should be referenced against the 95^{th} percentile readings. This is in line with the earlier suggestion of Hickey and Martin (2009) that a value of 3.6 mg/L could be applied to manage seasonal peaks. It would be important for the Plan to be consistent with the most recent research in this area if nitrate toxicity

limits are to be applied. However, it should be noted that a 3.6 mg/L limit may still be difficult to achieve in Dry Stream, based on the measurements shown in Figure 3.

24 The revised thresholds that I have just described are all consistent with the ZIP and are a more accurate and current description of the appropriate guideline values than what is currently set out in the Zone Committee's submission, which was based on the guideline values at that time.

HURUNUI WATER PROJECT'S KEY CONCERNS

Load limit methodology

25 Rule 10.2 in the Plan is currently written in a way that means any land use after 2017 that results in an increase in the discharge of nutrients to surface waterways can only occur as a permitted activity if the annual measured load at State Highway 1 does not exceed the load limit specified in Schedule 1 of the Plan (currently estimated to be 693 tonnes/year). Ms White has suggested two options for the date at which Rule 10.2 becomes operative and her proposed changes to the plan set out in her evidence suggest this Rule would become operative from the date the Plan becomes operative.

26 Because there are large fluctuations in the measured loads, above and below the limit set in the Plan, as shown in **Figure 4** included with this evidence which shows the load calculated using ECan's data at State Highway 1, this means that in one year, a land use change could proceed as a permitted activity, while the following year, the change would be a discretionary activity if the measured load happened to fluctuate upwards. Actual land use change is likely to be a small cause of

the measured fluctuations illustrated in **Figure 4**, with climatic variability having a much greater impact. Having a load limit in a rule that varies from year to year would create major inconsistencies in the rule implementation.

27 Because of this variability, if measured loads rather than modelled loads are going to be maintained as the monitoring and management system in the Plan rules, the Hurunui Water Project supports the proposal by the Zone Committee in their submission for a change to a load that is averaged over a number of years, rather than an annual load. The Zone Committee are proposing a 6 yearly average load, which Ms Liz White adopts in her proposed changes to the plan set out in her evidence (Part 5 – Definitions, Schedules and Maps). However, given that the period of Environment Canterbury's monthly water quality data is only 7 complete years (July 05 to July 12), it is difficult to assess whether large fluctuations in the 6 yearly average load might occur even without any change in land use. Using the averaging method outlined in Norton and Kelly (2010), I have calculated that the 6 yearly average load to July 2011 was 775 tonnes/year, while the 6 yearly load to July 2012 was 772 tonnes/year. This suggests that the change in the 6 yearly load will be small, however, closer inspection shows that this is due to the 2012 load being very similar to the 2006 load. Based on the fluctuations in **Figure 4**, the 6 yearly load for subsequent years could easily fluctuate significantly.

28 In order to better understand the fluctuations that may occur in the 6 yearly average loads, I have analysed the water quality data NIWA has been collecting monthly in the Hurunui River at Mandamus and State Highway 1 since January 1989. This data includes monthly dissolved reactive phosphorus and dissolved inorganic nitrogen concentrations. I

have calculated loads using these concentrations and Environment Canterbury flow data at both sites.

29 **Figure 5** shows the calculated yearly load together with the percentage changes in the 6 yearly average load at State Highway 1. The percentages are relative to the long term average load over the period shown. **Figure 6** shows the same information at Mandamus. These graphs illustrate how fluctuations even in the 6 yearly average load are significant compared to the overall average annual load (more than +/- 20%). Although land use change is likely to have some impact on these fluctuations, a lot of the variation is likely to be due to climatic variability.

30 While reviewing the NIWA monthly water quality data, I realised that the annual load calculated from the data differed from the load calculated using the ECan monthly water quality data between 2005 and 2011. This is illustrated in **Figure 7**. The calculated nitrogen loads are similar in most years, however, the calculated phosphorus load varies significantly. **Figure 7** suggests that the concentration measurements are not currently measured frequently enough in order to calculate a yearly load accurately. While ECan and NIWA both measure nitrogen and phosphorus concentrations, these are on different days, which is the reason for the difference in calculated load. Even if the data sets were combined to improve temporal coverage, further measurements would likely be required to provide a sufficiently accurate assessment of the yearly nutrient load in the Hurunui. The frequency of monitoring required may be unrealistic. This further suggests that the current approach based on “measured” load limits is inaccurate and a better approach may be to structure the Plan around a modelled rather than purely measured approach. I will discuss possible modelling options later in my evidence.

Incompatibility between irrigation and water quality objectives

31 The Plan is intended to reflect the Zone Implementation Programme's recommendations that infrastructure and storage options and environmental flow and allocation regimes for the Hurunui and Waiau Rivers will have the capacity to provide appropriate irrigation to all the potential irrigable land in the zone in the long term (e.g. Objective 6). While the Zone Implementation Programme notes that this does not mean all irrigable land will necessarily be irrigated, the provision in the Plan to allocate sufficient water for irrigation sits alongside a load limit that is considered to represent the current impacts of land use. A load limit based on current measured loads and current land use only allows for continuation of the same land uses in the catchment, unless existing users can sufficiently reduce nutrient leaching. The Plan as currently written does not provide sufficient incentive for existing users to create headroom, as will be discussed further.

32 Work was carried out by Lilburne et al. (2011) as part of the Land Use and Water Quality project to establish links between the currently measured water quality in the Hurunui and current land use. Future land use scenarios were also considered. This work indicated that full irrigation of suitable land in the Hurunui Catchment could not occur under the proposed load limits unless major mitigation measures are implemented. The modelled mitigation for dairying included implementation of reduced winter grazing, which could be achieved by herd sheds or wintering off in another catchment, lower nitrogen application or nitrification inhibitors, wetlands and best practice effluent management. Mitigations for sheep and beef including riparian protection and use of wetlands. The economic feasibility of these measures was not evaluated and may mean that the measures are not practical to implement.

33 It was acknowledged that there was considerable uncertainty as to how effective the mitigation measures might actually be. For dairying, the reduction in leaching of 50% is likely to be difficult to achieve on many properties and, where it is achievable, it would be costly, possibly to the point of being impractical.

34 Lilburne et al. (2011) also assessed what changes could occur in the tributaries in order to achieve the nutrient loads presented in Norton and Kelly (2010) corresponding to a mean concentration at the fish toxicity 95% protection limit (1.7 mg/L at that time).

35 This assessment indicated that St Leonards and the Pahau River would require a reduction in nitrogen leaching to achieve the nitrogen loads based on fish toxicity, as the mean concentrations at the time of the Norton and Kelly (2010) study exceeded 1.7 mg/L in both these waterways. The high concentrations in these waterways means that they contribute a combined total of nearly 80% of the total dissolved inorganic nitrogen inputs to the middle Hurunui River (Ausseil, 2010). Ausseil (2010) noted that including Dry Stream, they also contribute a combined total of nearly 57% of the total dissolved reactive phosphorus measured inputs to the middle Hurunui River.

36 The assessment indicated that the nitrogen load could only increase by 28% in the Waitohi River without exceeding the nitrogen limit Norton and Kelly (2010) calculated based on fish toxicity, as the mean concentration is less than 1.7 mg/L. Because there is currently little irrigation in this catchment at present and mitigations on the current dry farm land would not create much headroom, Lilburne et al. (2011) noted that this would allow for only a small increase of irrigation in the catchment.

37 In summary, the work by Lilburne et al. (2011) indicated that it would be a major challenge to achieve full irrigation of the whole area and maintain current nitrogen loads in the mainstem, even with extensive mitigation and only part conversion to dairy farming.

38 The study also showed that irrigation in the Culverden Basin will be limited further if limits based on maintaining an average concentration equal to the 95% protection threshold for fish toxicity is adopted (1.7 mg/L at that time) for the tributaries, in line with Objective 5.2 of the Plan, the Zone Committee's submission and the recommendations for Policy 5.4 in the evidence of Ms White. Major mitigation on current farms would be required in St Leonard's Drain and even then, additional irrigation is unlikely to be possible. The Pahau would also require major mitigation to create headroom for any more irrigation. While a 28% increase in load was shown to be possible in the Waitohi, this will provide for only a small amount of additional irrigated area. Overall, it appears that limits based on fish toxicity in the tributaries do not enable the development of irrigation infrastructure and storage options as intended by the ZIP recommendations. To better achieve this desired outcome then Objective 5.2 needs to be reconsidered for the tributaries, if the Plan is to provide for economic growth, given the current state of the tributaries. The revised 95% protection fish toxicity limit of 2.3 mg/L (Hickey, 2012) would allow for some additional development but may not be sufficient to allow for full development. A focus on improving the tributaries in other ways, for example riparian planting and habitat enhancement, may be more effective in achieving the ZIP's desired water quality outcomes.

39 Given the potential implications of the current nitrogen limit in the Plan, which does not provide for irrigation development, we have completed a separate modelling study for the Hurunui Water Project to assist in

understanding how much headroom could be created on existing farms and what development that would provide for.

40 The first stage of the study was completion of a land use survey to improve certainty on the current land use, in order to improve the accuracy of the current modelled load. We used the same approach to generate nitrate-nitrogen leaching rates from land use information as was used in the Lilburne et al. (2011) study. This was the use of Environment Canterbury's estimates of nitrate leaching rates for different land uses (Lilburne et al., 2010). These numbers may alter in future based on further work being undertaken by Environment Canterbury. We used current land use, soil type and rainfall information for the modelling. We assessed full conversion to dairy, which is considered to be more realistic to the Hurunui Water Project from an economic perspective than the 58% dairy conversion assumed in the Lilburne et al. (2011) study.

41 As with the Lilburne et al. (2011) study, our modelling indicates that the current load will increase significantly with full irrigation development unless mitigation measures are implemented on both existing and new farms. Our modelling indicates that the nitrogen load from farmland in the catchment could increase by around 66% on average if all existing unirrigated farmland converts to dairy with farms with good management and no headroom is created on existing irrigated farmland. Note that good management is explicitly assumed in Environment Canterbury's estimates of nitrate leaching rates for different land uses (Lilburne et al., 2010), however, as indicated by the Lilburne et al. (2011) study, some further leaching reductions are possible with different mitigation options.

42 Our modelling indicated that, in order to maintain a similar load to the current load at State Highway 1, restrictive limits would likely need to be placed on existing and future farms. We assessed that, if a limit on the

maximum leaching rate from new and existing farms was set at 30 kg/ha/year, full dairy conversion and irrigation in the catchment, including on the remaining irrigable farmland, would increase current nitrogen leaching by around 40% on average. Even if only 60% of the land was converted to irrigated dairy, with the remainder comprising 30% irrigated sheep and beef and 10% irrigated arable, current nitrogen leaching would still increase by around 22% on average with a cap of 30 kg/ha/year.

43 In addition we modelled a scenario where, by October 2017, all farms are restricted to 35 kg/ha/year and Stage 1 of the Hurunui Water Project has been developed with conversion to irrigated dairy. This indicated an increase in nitrogen leaching of around 8% on average. This provides an idea of the change that may occur with the staged development proposed under Hurunui Water Project and if an allowance was made for existing and new farms to make a gradual reduction to their leaching rates. These scenarios with full dairy conversion are shown in **Figure 8**.

44 If a limit on the maximum leaching rate from new and existing farms was set at 35 kg/ha/year, the modelling indicated that full dairy conversion and irrigation in the catchment, including on the remaining irrigable farmland, would increase current nitrogen leaching by around 53% on average.

45 Therefore the achievement of irrigation development in the area, as promoted by the ZIP, relies on improvements by existing farms to reduce their leaching losses. The Hurunui Water Project is concerned that the Plan does not provide sufficient incentives for existing farmers to create headroom. The matters to be addressed in any system, agreement or plan outlined in Schedule 2 of the Plan at present do not provide any

incentives for reducing nitrate leaching and need to be more prescriptive. I will outline suggestions for improved incentives later in my evidence.

46 My view is that, at present, the Plan's approach to nutrient management provides for little, if any, irrigation development, which is contrary to the expectations of the Zone Committee and not an appropriate outcome for the CWMS approach. By not providing sufficient incentives for existing farmers to create headroom, the Plan is unlikely to improve the overall outcomes for water management in the Hurunui –Waiau Catchment. If the Plan remains in its current form then it is important that the community are provided realistic expectations in terms of what further development the Plan does or does not provide for.

SUGGESTED ALTERNATIVES

Increased load limit

47 Nitrogen is not considered to be the limiting nutrient for periphyton growth in the middle and lower Hurunui (Ausseil, 2010; Norton and Kelly, 2010). By adopting a nitrogen limit on the basis of periphyton issues then the Plan imposes the most significant constraint on future productive land options whilst creating a relatively poor opportunity to create an environmental gain. A better overall outcome would be achieved using a nitrogen limit based on preventing fish toxicity and a phosphorus limit based on preventing periphyton issues. In his evidence Mr Ned Norton, on behalf of Environment Canterbury, notes that it is a risky approach to manage only phosphorus and not nitrogen. My view is that nitrogen should still be managed, but that it does not need to be restricted to current concentrations, given that it is not the limiting nutrient for periphyton growth. It could be increased by some degree provided this does not adversely increase the risk of not meeting the water quality

outcomes. Such an approach is more in line with seeking an optimal water management outcome, as promoted by the CWMS.

48 Hayward (2011) presented an alternative increased nitrogen limit based on preventing fish toxicity rather than periphyton growth, given the phosphorus limited conditions that occur in the lower Hurunui. A nitrogen limit of 983 tonnes/year at State Highway 1 was suggested based on 2004 to 2009 flows, which was calculated to still maintain average dissolved inorganic nitrogen concentrations at 0.5 mg/L, which is well below the 95% nitrate toxicity threshold at the time of 1.7 mg/L and the new limit in Hickey (2012) of 2.3 mg/L. Hayward (2011) also concluded that an average dissolved inorganic nitrogen concentration of 0.6 mg/L would also be acceptable. Ms Hayward in her evidence for this Plan hearing, notes how if this concentration of 0.6 mg/L was converted to a load, it would provide around a 50% increase from the current load, based on current average concentrations. The calculations presented in Hayward (2011) were based on the earlier fish toxicity guidelines shown in Table 3. If the new guidelines were used, the concentration changes could theoretically increase further without causing exceedances of the fish toxicity thresholds.

49 Norton (2011) considered the implications of the alternative limit presented by Hayward (2011) on water quality outcomes at State Highway 1 and assessed that this would achieve the same likelihood of meeting the water quality outcomes, with the exception of an exceedance of the chronic nitrate toxicity threshold 1.7 mg/L not occurring shifting from “Almost certainly” to “Probably/possibly”. However, even if an occasional exceedance occurred, this is not expected to cause fish toxicity problems based on Hickey and Martin (2009), as the chronic (long term) toxicity thresholds were based on exposure thresholds of 1-3 months. The chance of an exceedance of the

new thresholds in Hickey (2012) are even less. The guideline value recommended by Hickey and Martin (2009) for acute (short term) toxicity is 20 mg/L. Considering current concentrations and likely land use change, there is no likelihood and that such a high concentration would occur.

50 An increase to the nitrogen load limit at State Highway 1 seems reasonable on the basis that the desired water quality outcomes in the Zone Implementation Programme could still be met with some increase, as suggested by this previous work. An increased limit could provide for additional irrigation to occur but would not significantly affect water quality outcomes. If a measured nitrogen load is maintained in the Plan, the Hurunui Water Project are supportive of increasing this nitrogen load by at least 50% based on the work completed by Ms Hayward, which could provide for full irrigation of the irrigable area, depending on the level of management of nutrient losses on new and existing farms. Based on the current average 6 yearly load presented in the Zone Committee's submission of 770 tonnes/year, a revised load limit based on an average concentration of 0.6 mg/L and a 50% increase would translate to 1155 tonnes/year. If Schedule 1 with a measured nitrogen load is maintained in the Plan, the Hurunui Water Project would support a nitrogen load of 1155 tonnes/year at State Highway 1 being included in Schedule 1 in place of the currently proposed limit.

51 In his Section 42A Officers report Mr Ned Norton has modelled, for illustrative purposes, an extreme scenario that is unlikely to occur, but which concludes that the reduced river flow arising from abstraction could cause a reduction in nutrient load headroom of -43% of the current load if no land use changes took place. This indicates existing farmers would need to reduce leaching by 43% and no land use change could

occur if current concentrations of phosphorus and nitrogen at State Highway 1 were to be maintained.

52 In my view this assessment is unrealistic because of the assumed changes in river flow (which I will discuss later) and because the assessment does not allow for any nutrient load to be removed in the water that is abstracted from the river.

53 The converse to this suggestion that there might not be able to be any increase in irrigation area is to recognise that a higher nitrogen load limit could be justified based on the revised nitrate toxicity guidelines (Hickey, 2012), given the understanding of phosphorus limited conditions. Using the annual median nitrate toxicity threshold of 2.3 mg/L proposed for 95% protection, it could be argued that the limit could be increased by 700% based on the median concentration of nitrate nitrogen of around 0.3 mg/L in the ECan water quality data measured at State Highway 1 since 2005. The Hurunui Water Project are not advocating for such a significant increase, but to put things in perspective, **Figure 9** compares the various load limit options that are being suggested.

54 Mr Norton also recommends nutrient discharge allowances (NDA's) and perhaps implies that these need to be specified for individual farms. However, for irrigation schemes these would be better managed on a scheme-wide basis – much like a water users group for water allocation.

Modelled approach

55 Given climatic effects on the measured load and the load measuring accuracy issues, together with possible changes in flow due to allocation, use of a model may be a more practical management tool rather than relying solely on measurements at State Highway 1 to track load

changes. The model would need to be first benchmarked against current land use. The total nutrient load leached each year could then be summed from leaching estimates or land use information for individual properties or groups of properties, if provision of this information was made a requirement of the management plans, industry certification systems or catchment agreements outlined in Schedule 2 of the Plan. Such a tool would enable the Regional Council to make informed decisions on consents to change land use. The Regional Council, or other party that runs the model, could also make the results of the model available to land managers and decision makers to improve awareness of the changes in the nutrient loads in order to assist them in decisions on land use change and consent applications. It would still be important to continue monitoring flows and concentrations in tandem with any modelling to observe what actually occurs.

56 The modelled approach could be carried out using the nitrogen look-up tables (Lilburne et al., 2010), or subsequent updates, together with information on the current land use, as we have performed in our modelling study for the Hurunui Water Project. This model could be updated with new information on land use. This process would be akin to Environment Canterbury keeping track of groundwater allocated within a zone to compare with the calculated groundwater allocation limit. If for example, it was decided that an increase in the load to the rivers of 50% was acceptable, based on the alternative limit presented in paragraph 48 of my evidence, then the modelled nitrogen leaching could be allowed to increase by this percentage (e.g. 50% of the current modelled load).

57 If a modelled approach was taken, the measured load could be removed as a limit in the plan and replaced with a modelled limit. However, it would be important to retain policies in the plan relating to water quality, including periphyton growth and fish toxicity outcomes. The water quality

monitoring results could be compared to the desired water quality outcomes as part of the assessment for resource consent applications.

58 Overall, a modelled approach would enable the community to better understand the current load, which would assist them in making decisions on land use change. It would also make the process of applying for a consent much less onerous for an individual farmer and provide greater certainty of the outcome. Such an approach could be described in Policy 5.3 and would replace the need to specify numbers in Schedule 1. For example, Policy 5.3 could be worded as follows:

Policy 5.3 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 confluence) does not exceed 120mg/m^2 and 20% of cover of filamentous algae in 4 years out of 5 years.

b) Annual median nitrate nitrogen concentration does not exceed 2.3 mg/L and the 95^{th} percentile nitrate nitrogen concentration does not exceed 3.6 mg/L. This provides a 95% level of protection.

c) The modelled nutrient loads do not change by the following amounts:

(i) Dissolved inorganic nitrogen can increase by not more than 50% above the leaching load at the date the Plan becomes operative; and

(ii) Dissolved reactive phosphorus must not increase above the leaching load at the date the Plan becomes operative.

The modelled load is determined by a catchment wide modelling methodology approved by the Canterbury Regional Council.

Tributary loads

59 Although loads for the tributaries are not included in the Plan at present, it is proposed that these will be included at a later date. It will be important to allow for flexibility in the management of the Waitohi in the load limit for that river. The Hurunui Water Project will have the ability to provide flushing flows if necessary, to control periphyton growth and the associated nutrient concentrations. While a flushing flow would be useful in terms of reducing nutrient concentrations and periphyton growth, the additional flow may result in a higher calculated measured load, depending on when measurements were taken. It will be important to allow for this type of management if loads based on measured concentrations and flows are developed for the tributaries. This is another example of how nutrient limits are only one of a number of tools that can be used to manage water quality issues and it would be remiss of the Plan to focus on load limits whilst missing the opportunity to manage water to achieve a wide range of benefits.

Incentives for Improved Land Management Practices

60 At present, Rule 10.1 provides existing land users until 1 January 2017 to implement one of the management plans, industry certification systems or catchment agreements outlined in Schedule 2 of the Plan. In order to create headroom in the catchment, good management to minimise

environmental effects needs to begin now. The Hurunui Water Project are seeking that the timeframe is reduced to 1 October 2013.

61 Schedule 2 does not provide sufficient direction on what the systems or agreements or plans should contain. The Hurunui Water Project are seeking that individual farm environment management plans (FEMPs) be required by Rule 10.1. These plans should contain information demonstrating that good practice irrigation management, nutrient management, soils management, wetland and riparian management, livestock management and effluent management is either already being implemented on farms or processes are in place to implement this over a reasonable timeframe. Nutrient budgets prepared using OVERSEER, or a similar programme, should also be a requirement of the FEMPs. The FEMPs should be audited by a suitably qualified person and a summary of the information provided to Environment Canterbury. This will help in understanding how much headroom is being created and assist in decision making on applications for additional irrigation development. I note that the suggested changes in Ms White's evidence on Schedule 2 will address many of Hurunui Water Project's concerns, particularly the requirement for nutrient budgets (Part 1f) and sections on irrigation management, nutrient management, soils management, wetland and riparian management and effluent management (Part 1d).

62 FEMP's or equivalent management documents will be particularly important for irrigated farms or unirrigated farms that provide for wintering off of dairy cows. It might be reasonable not to require FEMP's for unirrigated farms, provided the leaching rate is not excessive (a 20 kg/ha/year threshold or similar could be used). However, it will still be important to understand load changes from the unirrigated farms, so they should be required to provide either OVERSEER (or similar) model results or sufficient information on their land use such that the lookup

table values (Lilburne et al., 2010) could be used to estimate their leaching.

63 The requirement of FEMPs or other similar plans on its own may not provide sufficient incentive for existing farmers to reduce their overall nitrogen leaching rate or for new farmers to minimise their leaching. Hurunui Water Project are suggesting that, to achieve permitted activity status, farms should be required to meet a specified maximum nutrient leaching rate. The establishment of a leaching rate limit should be linked to the setting of the overall limit for the catchment so as to achieve a realistic requirement for existing irrigators and a realistic allocation for future productive and economic development in the area. In order to achieve the nitrogen load at State Highway 1 sought by the Hurunui Water Project (an increase of 50%) and to provide a more certain mechanism of creating headroom then leaching limits to achieve permitted activity status could be set as follows in Rule 10.2 of the Plan:

- A nitrogen load limit of 35 kg/ha/year for all areas of new and existing farms by 1 October 2013.

The final leaching limit numbers used in Rule 10.2 would need to be based on those required to achieve the accepted load limit. These limits are based on the look-up tables in Lilburne et al. (2010). If an alternate method is used, such as Overseer, the values should be the equivalent for that land-use.

64 Such limits would encourage the phasing out of border dyke irrigation. Border dyke irrigation is a significant contributor to both phosphorus and nitrogen loads, as outlined in Brown et al. (2011) and indicated by the nitrogen modelling carried out by Lilburne et al. (2011) and our more recent nitrogen modelling.

65 Given the proposed load limits, it will be important that Environment Canterbury compliance monitoring officers monitor for compliance with the rules relating to nutrient management in this Plan, the operative regional plan (NRRP) and the proposed regional plan (LWRP). For example, farmers will continue to be required to meet the permitted activity rules in the NRRP related to the discharge of fertiliser (Rule WQL19), discharges relating to stock access to waterways (Rule WQL21) and the discharge of animal effluent (Rule WQL25) and the newer versions of these rules in the proposed LWRP. It is important that these activities are well controlled, to ensure that they do not contribute unnecessarily to both phosphorus and nitrogen concentrations and loads.

Monitoring

66 It is important that detailed monitoring is used to track the effectiveness of the Plan. If a modelled approach is adopted, monitoring data will be important to compare the modelled loads to. As outlined previously, I consider that more frequent measurements of nutrient concentrations are required in the Hurunui River if measured loads are to be retained in the Plan. The comparison described in paragraph 30 of my evidence indicates that measurements would need to be at least twice per month, and possibly more frequently to obtain a sufficient accuracy in the estimated yearly loads. It will be important for measurements of nutrient concentrations in the tributaries to continue. Ideally, continuous monitored flow sites should be installed in the tributaries, particularly if measured loads are to be imposed as limits for the tributaries.

COMMENTS ON OFFICER SECTION 42A TECHNICAL REPORTS

67 Much of the assessment provided in the Section 42A Officers reports is based on the evaluation of potential changes in river flows presented in the evidence of Dr Jeff Smith. As noted in paragraph 95 of his evidence, he determined the residual river flows for the Amuri reach of the Hurunui River, "… by subtracting applicable A-block, B-block and C-block allocations if flow at the Mandamus (site number 65104) recorder was greater than the respective minimum flow for the scenario being modelled." In Table 10 of his evidence he shows this corresponds to a maximum abstraction of 49.2 m^3/s for the HWRRP (the Plan) scenario (made up of 6.2 m^3/s A-Block, 10 m^3/s B-block and 33 m^3/s C-Block).

68 However that is not a likely scenario as it is based solely on water availability. A more realistic evaluation needs to consider both the water availability and the water demand. An example of the largest feasible demand for consumptive purposes is that undertaken in simulations for the Hurunui Water Project (HWP).

69 HWP has applied for consents to irrigate an area of approximately 72,100 ha (gross irrigable area) as shown in **Figure 10**. Approximately 46,850 ha of this area is in the Hurunui Catchment with another 25,250 ha in the Waipara and Kowai catchments. Based on developing storage in the Waitohi Catchment the effects of the proposal on flows in the Hurunui River have been estimated utilising an irrigation demand and supply model. Stage 2 of the HWP proposal takes run-of-river water based on the (post storage) HWRRP flow regime for the Hurunui. When taking into account existing allocation and the proposed stage 2 HWP abstraction (both run-of-river irrigation takes and storage refill) this means that at times the full allocation of 49.2 m^3/s of abstraction is taken.

However, the mean take from the Hurunui River for HWP stage 2 is much less, at 11.8 m^3/s.

70 **Figures 11 a, b and c** show the abstraction from the Hurunui River and resulting hydrographs for a dry, wet and typical year for the HWP stage 2 proposal and for HWRRP as presented in the evidence from Dr Smith (similar to Figure 21 in his evidence). Note that my evidence shows 1989/1990 as a dry year whereas Dr Smith's evidence shows 1970/1971. I have chosen this year since the modelling for HWP starts in 1972. The required climate data for the demand model starts in 1972 hence constructing an accurate demand-supply model before 1972 was not possible.

71 As seen in **Figure 10** the HWP proposes to irrigate almost all of the irrigable land within the Hurunui Catchment. Therefore I consider that the abstraction proposed by HWP stage 2 is at or close to the maximum likely consumptive abstraction that would realistically occur from the Hurunui River.

72 As can be seen in the overlay plots (**Figures 11 a – c**) the effects on the Hurunui River flows are smaller than shown in Dr Smith's evidence when assuming HWP stage 2 abstraction rates from the Hurunui River. Abstraction rates are often lower than the maximum available abstraction (based on the 'post-storage' flow regime) and abstraction is more intermittent due to the timing of irrigation demand from the irrigable area. For example when there is no irrigation demand and the storage reservoirs are full no water is abstracted. **Figure 12** in my evidence shows abstraction rates and flow statistics, for a dry, typical and wet year for the proposed HWP stage 2 abstraction and the HWRRP assumed abstraction in Dr. Smith's evidence.

73 Therefore, the conclusion in paragraph 133 of Dr Smiths evidence that the Hurunui River flows, "would be flatlined at or below 20 m^3/s for approximately 80% of the time" is not likely to occur.

74 Unfortunately Dr Smiths overly conservative hydrology assessment has then been utilised by authors of other Section 42A Officers reports to consider potential effects and reach conclusions that the Plan's water allocation regime may make it unlikely that other water quality and ecological objectives will be achieved. Such a conclusion is reached in the following reports:

a) Mr Ned Norton's consideration of implications for Water Quality

b) Dr Ton Snelder's consideration of river flow effects on periphyton

c) Dr Murray Hicks' consideration of sediment transport, channel maintenance and river mouth openings

d) Dr Don Jellyman's consideration of fish migration and

e) Dr Ken Hughey's consideration of riverbed nesting birds.

Some of the key points raised by these experts in relation to the change in river flow are discussed in the following paragraphs.

75 As noted earlier, Mr Norton's Section 42A report describes an assessment of how abstraction from the river will reduce the dilution of nutrients, and therefore how the "headroom" to allow for future irrigation areas will reduce accordingly. This is based on the difference between current mean river flows and the theoretical flows described by Dr Smith, thereby resulting in an unrealistic conclusion that existing farmers would need to reduce leaching by 43% and no land use change could occur if

current concentrations of phosphorus and nitrogen at State Highway 1 were to be maintained.

76 Mr Norton acknowledges how this is a coarse estimation and that specific project assessments would be required to determine exactly how much water could be taken and how much land could be irrigated under the specific proposal. I note that these project specific assessments will indicate much less of a reduction in dilution than is indicated by Mr Norton's calculations.

77 As pointed out by Mr Norton, seasonal variations would also be required to assess the effects of a specific proposal in order to assess the effect of any particular proposal. For example, if water is abstracted for storage predominantly in winter and early spring, altered nutrient concentrations would likely be less of an issue for periphyton because nuisance periphyton growth typically occurs during summer and autumn. In addition a certain load of nutrients would need to be removed with the abstracted water, based on concentrations at that point. This is particularly relevant for phosphorus - phosphorus concentrations increase by a much smaller amount between Mandamus and State Highway 1 than nitrogen concentrations. It would also be appropriate to account for irrigation return water, and flow regime changes, such as the residual flow proposed by the Hurunui Water Project for the Waitohi River.

78 This range of factors that influence the assessment indicates that it would be unwise to revise the load calculations based on a scenario where the full allocation is used. Therefore, it would be appropriate to establish an appropriate load for the current flows in this plan hearing process. It would also be appropriate to consider the impacts of consent

applications to abstract water from the river on water quality as these applications arise.

79 Dr Ton Snelder's Section 42A Officers report on flushing flow effects for periphyton concludes in paragraph 53 that, "the levels of total abstraction that could occur in the Hurunui and Waiau Rivers under the HWRRP would significantly change the flow regimes, and in particular, the mid-range flows in the main-stems of these rivers. The frequency of small floods could be reduced by more than 30% and the mean duration between floods could increase by more than 50%. In addition, there could be long periods of steady flows (flat lining) between floods"

80 Once again, this is an overly conservative conclusion based on the extreme water abstraction scenario presented in Dr Smith's hydrology assessment.

81 Dr Snelder does make brief mention (in paragraph 51 of his report) of how, "delaying the abstraction or diversion of water to storage after extended periods of low flow can be used to flush periphyton." That is correct and it is worth noting that the impacts of abstractions on flushing flows can be managed simply by reducing large abstractions during periods when flows of a magnitude considered to be a beneficial flushing flow occur and are required to clear the river. This mitigation measure is already included in the Plan as Objective 3(c) and Policy 3.5(b). These measures, combined with a more realistic assessment of river flows would result in a more positive conclusion than described in Dr Snelder's report.

82 Dr Hicks' assessment of sediment transport, channel maintenance and river mouth openings, is in a similar position. A negative conclusion has been reached based on the extreme change in simulated river flows yet

in paragraph 84 the effective mitigation is described as flood by-pass rules, which is the approach promoted in the Plan in Objective 3(c) and Policy 3.5 (b).

83 Similarly both Dr Jellyman (fish migration) and Dr Hughey (river bird nesting) both list the removal of freshes in the river and the low prolonged river flow as one of the effects of the Plan that makes it less likely that the objectives in their area of expertise will be achieved.

84 It appears that a more realistic view of the river flow patterns that can be achieved under the plan would not result in such a dire view of the future for the river environment.

CONCLUSIONS/RECOMMENDATIONS

85 The Plan as currently worded with nutrient limits based on current estimated measured loads potentially provides no opportunity for additional irrigation to occur, which is at odds with the provisions in the Plan for additional irrigation and storage infrastructure development. While improvements to nutrient management on existing farms may create a small amount of headroom, the Plan does not provide sufficient incentives for this headroom to be created at present. The Hurunui Water Project are seeking better incentives for this headroom to be created for both phosphorus and nitrogen in addition to an increase in the nitrogen load, on the basis that the load can be increased while still meeting the desired water quality outcomes for the Hurunui River. This would provide for the economic growth desired for the region and would tie in with the irrigation infrastructure development that the water quantity sections of the Plan provide for.

86 Given climatic effects on the measured load and the load measuring accuracy issues, consideration should be given to the use of a model as the tool to manage loads rather than relying solely on measurements at State Highway 1 to track load changes. The model would require nutrient load estimates to be generated for farms. Such a tool would provide greater understanding on the load changes in the catchment and enable the Regional Council to make informed decisions on consents to change land use.

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