
in the matter of: the Resource Management Act 1991

and

in the matter of: applications for resource consent by applicants in the
lower Waitaki River Catchment under the Waitaki
Catchment Water Allocation Regional Plan

Brief of evidence of Edward John (Ned) Norton

Dated: 28 August 2008

BRIEF OF EVIDENCE OF EDWARD NORTON

QUALIFICATIONS AND EXPERIENCE

- 1 My full name is **Edward John (Ned) Norton**.
- 2 My qualifications and experience are set out in the evidence I presented to the Hearing Panel in August 2007 for NBTC and October 2007 for HDI.
- 3 I have read the Code of Conduct for Expert Witnesses and agree to comply with it. I have complied with it in the preparation of this statement of evidence.
- 4 In preparing my evidence I have read:
 - 4.1 The evidence of others on water quality at this hearing, namely that of Ms Torgerson, Mr Heller, Mr Sutton, Ms Begley and Mr Boyes.
 - 4.2 The evidence of others on water quality and related evidence on hydrology, flow regimes and aquatic ecosystems at the HDI hearing (October 2007) and the NBTC hearing (August 2007).
 - 4.3 A series of reports that provided pre-cursor information for my own reports assessing the effects of irrigation on water quality in the Hakataramea, the lower Waitaki River, the McKenzie Basin and surface waters (rivers and Wainono Lagoon) down-gradient of the proposed HDI scheme. I will reference these where relevant in my evidence.
 - 4.4 The Water Quality Chapter 4 of Environment Canterbury's Proposed Natural Resources Regional Plan (PNRRP)

SCOPE OF EVIDENCE

- 5 I have been asked by Meridian to prepare evidence in relation to water quality.
- 6 I have also been asked to comment on issues raised by others in their evidence on water quality.

BACKGROUND FOR ASSESSING EFFECTS OF WATER TAKES ON WATER QUALITY

- 7 Water abstractions for irrigation can adversely affect water quality in two ways:
 - 7.1 Taking water reduces the flow of water in rivers and thus reduces the capacity of rivers to dilute contaminants.
 - 7.2 Using water for irrigation allows intensified land-use which generally results in greater loads of contaminants entering groundwater and/or surface waterways.

- 8 Key water quality contaminants that arise from intensified land-use include nutrients (i.e., nitrogen and phosphorus), sediment and micro-organisms. These are important because:
 - 8.1 Nitrate has toxic effects for humans and aquatic fauna at relatively high concentrations (i.e., the New Zealand Ministry of Health's human drinking Maximum Acceptable Value (MAV) is 11.3 mg/L nitrate-N, and the ANZECC (2000) trigger value for toxicity to aquatic species is 7.2 mg/L nitrate-N).
 - 8.2 At much lower concentrations (i.e., in the order of less than 1 mg/L) nitrate and other forms of dissolved inorganic nitrogen (DIN) can, in combination with dissolved reactive phosphorus (DRP), cause proliferations of algae and other aquatic plants, sometimes leading to eutrophication effects such as reduced dissolved oxygen concentrations and diurnal pH fluctuations which have adverse effects on aquatic fauna.
 - 8.3 Suspended sediment decreases water clarity and sedimentation may smother habitat.
 - 8.4 Some micro-organisms increase the risk of illness from drinking water or contact recreation.

- 9 Chapter 4 of the PNRRP establishes water quality outcomes for rivers and lakes (in Objective WQL1), and sets receiving water quality standards for discharges (in Schedule WQL1). Objective WQL1 contains Table WQL5 which sets numerical outcomes for nutrient indicators and riverbed sedimentation. Schedule WQL1 defines water quality classes for different types of rivers and sets receiving environment standards (for at least 15 variables including micro-organism indicators) to be applied to discharges.

- 10 Together, PNRRP Objective WQL1 and Schedule WQL1 provide the relevant water quality criteria against which to test the significance of effects that arise from water takes for irrigation.

EFFECTS OF THE PRESENT SUITE OF WATER TAKE APPLICATIONS ON WATER QUALITY

- 11 In general terms, each of the water takes being considered under the present process will increase the risk of breaching Objective WQL1 and standards in Schedule WQL1, by reducing dilution capacity of groundwater and/or surface water, or by increasing contaminants, or both. The degree of effect will vary between individual takes but will increase cumulatively the more takes are granted.
- 12 Whether or not each individual water take will cause breaches of the PNRRP standards and objectives depends on a number of factors including:
- 12.1 The type of land use and the way the land is managed. Intensive activities (e.g., dairying and cropping) may increase risk more than low intensity activities (e.g., dryland sheep). Poor management increases risk of a breach of standards.
 - 12.2 Local geography and physical characteristics such as topography, soil, drainage, and surface/groundwater interactions.
 - 12.3 The sensitivity of the nearby receiving environment. Small streams and rivers with infrequent floods will be most sensitive because they have a small capacity to dilute contaminants and because accumulated periphyton and fine sediment are flushed only infrequently. Large rivers have a larger dilution capacity. Rivers that flood frequently allow less accumulation of periphyton and sediment.
 - 12.4 The ability of nearby receiving environments (e.g., groundwater, streams and wetlands) to assimilate contaminants (e.g., take up nutrients and/or trap sediment) and to therefore buffer receiving environments further downstream.
 - 12.5 The sensitivity of receiving environments further downstream. Lakes tend to be particularly sensitive because they can accumulate contaminants on their beds (e.g., nutrients and

sediment) and provide favourable conditions for algal blooms and associated negative eutrophication effects on aquatic ecosystems. Large rivers and coastal marine environments have large dilution capacities but still may be affected by increased contaminant loads. Physical mixing and disturbance events (e.g., floods, coastal waves and currents) help reduce effects in large rivers and coastal environments.

- 12.6 The implementation of mitigation measures. These include best available farm management practices, riparian strip retirement and planting, wetland enhancements, maintenance of suitable minimum flows and flood or flushing flows in receiving streams and rivers.
- 13 To comprehensively assess the effects of the presently proposed water takes on water quality both individually and cumulatively would require an analysis of all the factors listed in paragraph 12, at a local scale (i.e., for each applicant's land) and then at sub-catchment and Waitaki catchment scales (to assess cumulative effects). I have not done such an all-encompassing assessment and I have not seen such an assessment in the applicants' evidence. Some partial assessments have been made of parts of the catchment by expert witnesses for the applicants (e.g., Ms Torgerson and Mr Heller) and I will comment on these later.
- 14 While I have not done an all-encompassing assessment, I can comment on several areas of study that I have been involved with. These help answer parts of the overall question about effects of water allocation decisions on water quality in the catchment below Waitaki Dam. These fall into five categories:
- 14.1 Effects of water takes on lower Waitaki River below Stonewall
 - 14.2 Effects of Waitaki River minimum flow
 - 14.3 Effects of water use in the Hakataramea catchment
 - 14.4 Effects of water use extrapolated to other parts of the Waitaki catchment
 - 14.5 Mitigation measures for water quality effects

1. Effects of water takes on lower Waitaki River below Stonewall

- 15 In my HDI evidence (October 2007) I predicted the cumulative effects of all allocated takes (i.e., 90 m³/s) on dilution (and therefore water quality) in the lower Waitaki River below Stonewall. With respect to reduced dilution those predictions are relevant for all the take applications presently being considered. They are summarised in paragraphs 94 to 97 of my HDI evidence.

2. Effects of Waitaki River minimum flow

- 16 In my HDI evidence (October 2007) I also predicted the effects of the proposed 100 m³/s minimum flow compared to 150 m³/s. Those predictions are also relevant for the present consent applications. They are summarised in paragraph 98 of my HDI evidence.

3. Effects of water use in the Hakataramea catchment

- 17 In a report prepared for Environment Canterbury titled *Assessment of effects of increased nutrient concentrations due to catchment land use changes in the Hakataramea River*, Norton & Rouse (2007) predicted effects of three potential future landuse scenarios on water quality. Those predictions are directly relevant for all the present applications for takes in the Hakataramea catchment. The predictions are also generally relevant for all other present applications for takes because they indicate the nature of effects that could potentially occur in other sub-catchments of the lower Waitaki River.
- 18 Norton & Rouse (2007) reported that periphyton blooms in the Hakataramea River already periodically exceed the biomass threshold defined in the PNRRP Objective WQL1, particularly during summer low flow periods and probably for periods of weeks or months until blooms are cleared by floods. Current water abstraction contributes to this problem by reducing flows and allowing intensified land use under irrigation.
- 19 Norton & Rouse (2007) predicted that allowing all new abstractions currently applied for could increase algal biomass in the Hakataramea River by about 20%, as illustrated in Figure 1. Constructing a community irrigation storage scheme that would allow further intensification of all irrigable land (beyond the consents presently being considered) could increase algal biomass by about 60%.

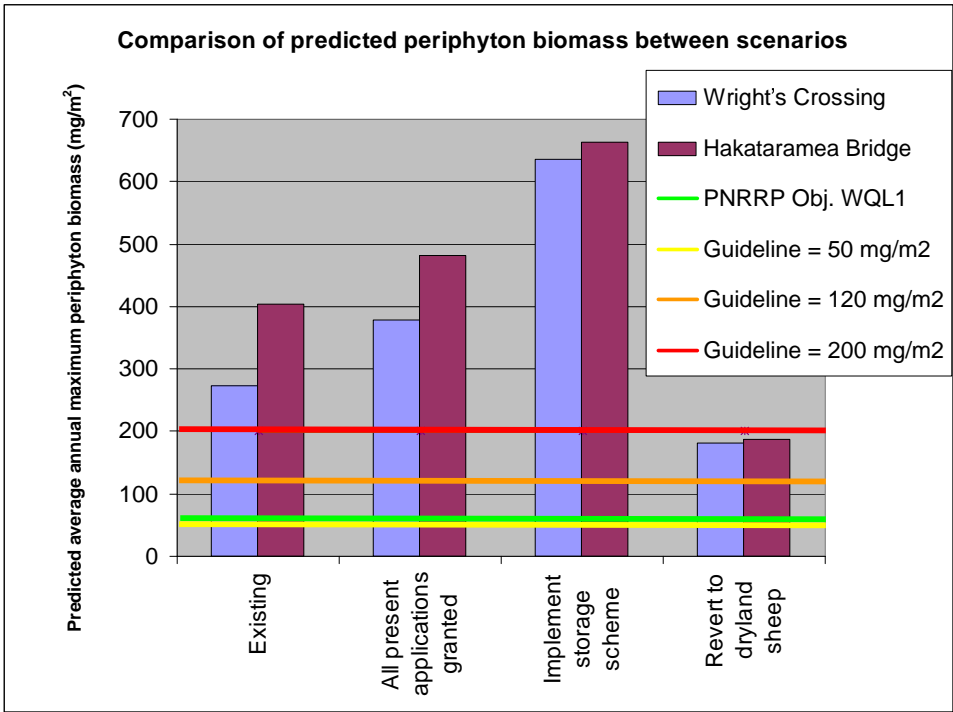


Figure 1. Predicted periphyton biomass (as chlorophyll *a* in mg/m²) for two sites in the Hakataramea River. The plot shows comparisons between land-use scenarios and against the PNRRP Objective WQL1 biomass threshold and New Zealand Periphyton Guideline (MfE 2000) criteria. (Figure modified from Norton & Rouse 2007).

- 20 Norton & Rouse (2007) described the availability of a suite of best land management practices that could potentially reduce nutrient losses from land to groundwater and rivers. It also discussed a number of assumptions and biases in the methods used and, in particular, noted the possibility that blooms would not proliferate to the extent predicted, in areas where there is significant riparian vegetation shading the river.
- 21 It was also noted that if *Didymosphenia geminata* (didymo) becomes established in the Hakataramea River, it will probably grow to biomass levels that exceed the guidelines and the biomass outcome defined in PNRRP Objective WQL1 under existing and future increased irrigation scenarios.

4. Effects of water use extrapolated to other parts of the catchment

- 22 To make comments about the likely effects of water abstraction and intensified land-use in other parts of the Waitaki catchment below Waitaki Dam, I rely on my experience with the Hakataramea study and other similar water quality assessments for the upper Waitaki catchment (Snelder et al., 2005) and the proposed HDI scheme (Norton et al., 2007). I also rely on my reading of relevant scientific literature and discussions with NIWA colleagues who authored some of the New Zealand literature.
- 23 Without examining all the factors listed in paragraph 12 above for each applicant, I can't predict whether any individual applicant will cause a breach of the biomass outcomes of PNRRP Objective WQL1. However I can say that granting the consents will generally increase the risk of localised breaches in every case.
- 24 The greatest risk of breaches will be in small streams and rivers that have little riparian vegetation cover and that have periods of low flows with infrequent floods. The Hakataramea falls into this category. Other examples include all spring-fed streams, the Maerewhenua River, the permanently flowing sections of the Kurow, Otiake and Otekaieke Rivers, and streams of the plains below Stonewall such as Awamoko Stream and Welcome Creek.
- 25 The risk will be less for the mainstem Waitaki River because it is large (offering significant dilution) and subject to frequent flow events that disturb periphyton growths. Currently this periphyton disturbance is provided by short-term (daily-weekly) flow fluctuations and occasional freshes and floods. If NBTC were granted, the disturbance would be provided by the proposed flushing and flood flows. Nonetheless, the risk of nuisance growths in small side braids of the mainstem Waitaki would increase as a result of nutrient increases from intensification under the present applications.

5. Mitigation measures for water quality effects

- 26 In my evidence at HDI hearings (October 2007) I outlined the types of mitigation measures currently available for reducing water quality effects (paragraphs 79 to 82) and described the likely effectiveness of these measures (paragraphs 83 to 85). Many of these measures were incorporated into proposed farm management plans (FMPs) described at the HDI hearings in the evidence of Ms Mulcock.

Further measures (e.g., riparian planting and wetland enhancements) may be possible under HDI through the implementation of an irrigation levy and environment enhancement fund initiatives proposed at HDI hearings (e.g., in the evidence of Ms Mulcock and Ms Dawson). These types of mitigation measures are also relevant for the present applications.

- 27 In his evidence for the present applications Mr Potts describes how some of the measures described above could be incorporated into FMPs.
- 28 I concluded in my HDI evidence that the currently available tool-box of mitigation measures (FMPs, stock exclusion, riparian buffers, wetlands etc) could reduce, but not completely offset, the effects of intensification. The benefits of the mitigation measures can be additive so the more measures that are employed the greater the likely success. However I note that it is not correct to simply add the performances of multiple measures together because there is overlap between some performance mechanisms and potential for multiplicative effects of others. The only possible way to achieve no net reduction in water quality with further intensification would be to proportionately reduce existing contaminant loads by improving current land-use practices. I suggested that the dairy industry goal of 50% reduction of nutrient loads by using a tool-box of best management practices might be achievable for some areas.
- 29 Having recently attended the Rotorua Lakes Symposium on Nutrient Sensitive Zones – Nitrogen and Phosphorus, Lakes and Waterways (12-13 August 2008, Rotorua) I can update my HDI hearing evidence on mitigation measures. Comments made by symposium presenters are relevant. Dr S. Ledgard (AgResearch) referred in his presentation to recent studies that indicated nitrification inhibitors (e.g., dicyandiamide [DCD]) reduced nitrogen loss from farm pasture by approximately 20% over a three year study period in Rotorua (see Ledgard et al., 2007). Dr Ledgard also referred me to Dr R. Monaghan at AgResearch Invermay who informed me of a similar study (to be published shortly) over four years in Southland that showed DCD reduced nitrogen loss by 20 – 50% (R. Monaghan pers. comm.). Dr K. Rutherford (NIWA) in his presentation summarised recent studies and the general performance of nutrient loss mitigation measures (e.g., grass filter strips, riparian buffers and wetlands) at 30-60% for the portion of runoff/infiltration that can be intercepted. He noted that it isn't possible to intercept, and therefore treat, the entire 100% of flow leaving land, and so overall performance percentages would be influenced by this.

- 30 On this basis I remain comfortable with my earlier conclusions about the effectiveness of mitigation measures, but note that a 50% nutrient load reduction is ambitious, being at the upper end of the performance of mitigation measures reported in recent studies.

COMMENTS ON APPLICANTS' EVIDENCE

- 31 I have read some of the applicants' evidence on water quality (as listed previously in para 4). Most of my comments relate to the evidence of Ms Torgerson (giving evidence for the Hakataramea Irrigation Water Quality Group, the Mid Rivers New Applicants Group and Waihao Downs Irrigation Limited) and Mr Heller (giving evidence in support of applications by Mr R. H. Robertson).

- 32 Ms Torgerson has raised four points that I agree with. These refer to the need to:

32.1 get stock out of direct contact with waterways;

32.2 resolve an apparent wind-blown dust problem in the Hakataramea catchment;

32.3 produce and implement Farm Management Programmes (or Plans) (FMPs);

32.4 organise a community stream-care group (in the Hakataramea and elsewhere) because water quality issues are a catchment-wide responsibility, not just that of the current applicants.

- 33 Ms Torgerson and Mr Heller have also raised several issues that concern me, and I believe it is necessary to comment on these.

1. Unfounded dismissal of relevant science

- 34 Both Ms Torgerson and Mr Heller dismiss the reports produced by three Crown Research Institutes for Environment Canterbury (ECan) without, in my opinion, adequate justification.

- 35 First, there has been an unusual and confusing referencing system used by many when referring to the reports prepared for ECan on water quality in the Hakataramea catchment. To be clear, reports were prepared for ECan by GNS, AgResearch and NIWA. The references for these reports are Zemansky et al., (2006); McDowell (2006); and Norton & Rouse (2007) respectively. ECan Report No.

U05/13 (ECan 2007) compiles all three reports in one document and gives an executive summary. The reports were deliberately prepared in sequence so that results from the first report could be built upon by subsequent reports. The final conclusions on environmental outcomes in rivers appear in the NIWA report (Norton & Rouse 2007) and are repeated in the ECan executive summary report.

- 36 Both Ms Torgerson and Mr Heller dismiss all these earlier reports principally on the basis of one observation; that the reports predicted in-river nutrient (DIN and DRP) concentrations for the existing scenario that were higher than those shown by measured data for the Hakataramea. Ms Torgerson describes how the applicants were concerned that the ECan study did not reflect what is happening in their catchments. The applicants subsequently commissioned AgResearch to conduct a more detailed modelling prediction of increased nutrient loadings, taking account of site-specific characteristics of their properties.
- 37 The AgResearch work (referenced in Ms Torgerson's evidence as AgResearch 2008 – her paras 26-31) predicted in-river concentrations that are very similar to the original predictions made for ECan by Zemansky et al., (2006) and McDowell (2006) (also of AgResearch). I find this result somewhat comforting because it shows me that the two modelling approaches used by GNS and AgResearch (i.e., the models SPASMO and OVERSEER respectively) have independently given similar results. Ms Torgerson concludes that the AgResearch (2008) results are inaccurate because they also don't match the measured data. Then, apparently without further discussion or reference to the conclusions (on environmental outcomes) of the reports prepared for ECan, she moves on with her analysis and draws her own conclusions. Mr Heller dismisses the earlier reports for the same reason and moves on to provide analysis for reaching his own conclusions.
- 38 I find this disappointing because the NIWA report (Norton & Rouse 2007) went to some length to compare predictions with existing nutrient and algae biomass data (section 2.7-2.8 of the report) and devoted a whole section to the discussion of assumptions and biases (in section 3 of the report) and the reasons for the conclusions drawn. As a minimum I would have expected and welcomed some commentary on the analysis and some further work to advance our collective understanding on this topic.

- 39 One reason why I would expect modelled nutrient concentrations to be somewhat higher than measured concentrations is that the model predicts nutrients lost from the land and does not take any account of nutrient uptake and conversion to biomass by periphyton in the river. Measurement of nutrient concentrations in river samples shows what nutrient is left over in solution after periphyton upstream have used what they can to produce biomass on the riverbed. Nutrient uptake can be significant (e.g., Biggs and Close 1989). It is this very process (i.e., nutrient uptake and conversion to biomass) that was modelled in the NIWA report in order to predict periphyton biomass, so that comparisons could be made with relevant criteria (e.g., PNRRP objectives and national guidelines).
- 40 In the absence of any further discussion or analysis of the CRI's work, I am not persuaded by the evidence of either Ms Torgerson or Mr Heller to dismiss the predictions made in the NIWA report or the reports prepared for ECan (Zemansky et al., 2006; McDowell 2006) on which the NIWA work relied.
- 41 On a less important matter, Ms Torgerson also raised the concern that *"...some of the farming types and locations of their properties described in the Ecan study were not accurate"* and *"Of particular concern was the broad brush approach to the assessment without regard to specific conditions"*. One of Ms Torgerson's clients, Mr Sutton describes in his evidence being disappointed with the standard of the NIWA report because, for example, it mentioned *"field tiles and border dykes"* when, as he states *"...there is no border dyking in the Valley"*. For the record these terms are not mentioned anywhere in the NIWA report. They are mentioned by McDowell (2006) appropriately in a general introduction to factors that typically influence soil phosphorus loss risk.
- 42 However, in response to the ECan study being described as *"broad brush"*, I acknowledge the project for ECan was necessarily conducted at a catchment scale and there was, and still is, room for taking our collective understanding of the effects of land-use intensification further. It was a useful initiative for the applicants to undertake further work.

2. Useful periphyton data

- 43 Ms Torgerson has provided some useful periphyton data that were not used by Norton & Rouse (2007). The data are for a site above the Hakataramea River (SH82) Bridge which has been sampled monthly by NIWA's National Water Quality Monitoring Network

programme for a period of almost 18 years. The data are observations of percentage periphyton cover taken at 10 points across a river transect (bank to bank). The data are presented as "*periphyton count*" in Figures 8 and 9 of Ms Torgerson's evidence and it is not clear to me what this means. I have re-plotted the data in my Figure 2 showing the average percentage cover of filamentous periphyton (of the 10 observations). I consider this is an appropriate statistic to compare against the PNRRP Objective WQL1 (Table WQL5) outcome and MfE (2000) guidelines.

- 44 Figure 2 shows that filamentous periphyton cover exceeded the PNRRP Objective WQL1 percentage cover threshold (15% cover) every year between 1990 and 1997, and each year from 2002 to 2008. Periphyton cover was very much lower (and below the Objective WQL1 threshold) in the years 1998 to 2001 inclusive. I do not know why periphyton cover may have been lower for these years and I haven't investigated this. It is clear that cover exceeded the Objective WQL1 threshold for 15 out of the 19 years of record. The PNRRP Objective WQL1 threshold (15% cover) is more stringent than the MfE (2000) guideline of 30% cover. Filamentous periphyton exceeded 30% cover in 9 out of the 19 years of record. I provide this latter comparison for context because the PNRRP is not yet operative.
- 45 In conclusion, these data provide further support for the conclusion reached in Norton & Rouse (2007) that periphyton blooms in the Hakataramea already periodically exceed Objective WQL1 (from my paragraph 18). The data also provide some additional support for the modelling predictions shown in Figure 1, although percentage cover data cannot be equated with biomass (chlorophyll *a* data).

3. Unfounded conclusions about relative sources of nutrients

- 46 The core of the argument made by both Ms Torgerson and Mr Heller is that the dominant contributions of nutrients to the river are currently from direct stock access to waterways (presumably from urine and faeces) and from nutrients associated with wind-blown dust falling directly into waterways, rather than losses from land via either groundwater or surface flow paths. They argue that any future increase in nutrient losses caused by irrigation (via groundwater or surface flow paths) would be minor compared to the reductions that could be made to existing loadings by removing stock from waterways and reducing windblown dust. The argument is based on their observation that, in existing river water quality

data (various datasets), dissolved forms of nitrogen (DIN) make up a smaller fraction of the total nitrogen component than organic forms of nitrogen (ON), the inference being that the former come from land-use activities and the latter from direct inputs such as stock in the river and wind-blown dust.

- 47 There are a number of weaknesses in this argument that relate to the complexity of the nutrient cycle. There are many sources, sinks, pathways and forms of nitrogen. A full accounting for the effects of agricultural intensification on these factors would be very difficult. In my opinion, it is plausible that in-river stock and windblown dust could contribute to in-river nutrient concentrations (and therefore gains could certainly be made by resolving these current problems), but it is by no means clear from the data presented that those contributions are dominant. There is no evidence that indicates that any additional load from increased irrigation and land-use intensity will be negligible in comparison to the existing load from stock in waterways and wind-blown dust. There are many published studies showing that intensified land-use under irrigation generally increases nutrient loss via groundwater and surface flow paths (e.g., McDowell et al. 2004; Smith et al. 1993; Wilcock et al. 2007a & 2007b amongst many others). The models used by GNS and AgResearch (i.e., SPASMO and OVERSEER respectively) are based on research and the nutrient concentration increases that they predict (i.e., in the order of 40% under the proposed intensification scenario in the Hakataramea) do not surprise me.
- 48 On a related matter, Mr Heller, in drawing conclusions about the effects of the applications of Mr R. H. Robertson, states (his para 9) that "*The nitrogen component of significance to the river (making up the bulk of TN) is ON [Organic Nitrogen]...*". I am unclear what he means by this because usually the nitrogen component considered of direct significance to rivers (in terms of being biologically available for nuisance algae growth) is DIN or dissolved inorganic nitrogen (i.e., nitrate nitrogen + nitrite nitrogen + ammonia nitrogen).
- 49 Mr Heller also states in his conclusions on cumulative effects for the whole catchment (his para 14) that "*Given that ON may be effectively managed via on-farm irrigation management techniques, the increases in NNN [nitrate + nitrite] of the order of 0.03 mg/L at low to medium river flows is negligible and comprises only a fraction of the ON content which currently exists in the river.*" In my opinion there are a number of problems with the way this conclusion was reached as well as the conclusion itself. Problems are:

- 49.1 The increase in NNN of 0.03 mg/L (from 0.07 to 0.1 mg/L) is a 43% increase in biologically available nitrogen and it is not clear why this is considered negligible.
- 49.2 The "*fraction of the ON content*" referred to is not clear (NNN is part of DIN not ON, so the statement may be referring to relative amounts). The statement may relate to ON concentrations given in Mr Heller's Table 1, in which case 0.03 mg/L amounts to about 30% of the ON at the Main Road Bridge or Wrights Crossing (note: there are mathematical inconsistencies in the calculated values in Table 1). It is not clear why it is inferred that this is a small fraction.
- 49.3 It is not clear what is meant by "*Given that ON may be effectively managed...*" because Mr Heller has not committed the applicants to any certain mitigation measures (his para 96) and has also acknowledged (correctly in my opinion) that such measures typically may only reduce nutrient loss by 50% (his para 97).
- 49.4 There is no conclusion as to what the increase in NNN means in terms of environmental outcomes such as the growth of periphyton in the river and related effects on aquatic fauna, aesthetic or recreation (e.g., angling) values, and the objectives of the PNRRP. The 43% increase in NNN is in fact about the same predicted proportional increase reported (44% for DIN) in the NIWA study for ECan (Norton & Rouse 2007) and this led to a predicted increase in periphyton biomass of about 20%.
- 49.5 When I ran Mr Heller's 0.1 mg/L figure through equations for predicting yearly maximum periphyton biomass (MfE 2000) I came up with a figure of 575 mg/m² (as chlorophyll *a*). This is in fact even higher than the Norton & Rouse (2007) predictions for the applicants' scenario I presented in my Figure 1. Under this circumstance it is likely that phosphorus would be the limiting nutrient and this is why the results in Figure 1 are based on phosphorus predictions (and also why they are lower than 575 mg/m²). Mr Heller did not make predictions for phosphorus so I cannot use the phosphorus equation (MfE 2000) to estimate biomass to compare with my Figure 1.
- 50 In conclusion, I am not persuaded that the arguments of Ms Torgerson and Mr Heller about relative nutrient loads are

quantitatively robust. If anything, the additional analyses they have presented (modelling by Mr Heller and by AgResearch (2008)) agree with predictions of proportional increases in nutrients made by the three earlier reports for ECan. On the basis of those reports, it is my opinion that the mitigation measures they describe will be necessary rather than optional requirements if Objective WQL1 of the PNRRP is to be met.

- 51 I also note that Mr Heller draws conclusions about the individual effects from the Foveran and Winterberg properties being negligible (e.g., his para 8). I have not looked closely at this analysis but have instead focussed on his analysis of cumulative effects. I have no doubt the effects of some individual properties will be small when considered on their own, particularly when those properties are well managed, as Mr Heller reports is the case for the Foveran property (which has won an environmental award for riparian management).

4. Mitigation measures

- 52 Ms Torgerson and Mr Heller both rely to some (albeit unquantified) extent on mitigation measures in order to draw their various conclusions that effects of the various applications will be "*negligible*", "*minimal*" or "*not adverse*".
- 53 Mr Heller offers an indication of the likely success of mitigation measures by stating (his para 97) that "*Nutrient loss reductions of up to 50% may be possible with such measures*", but he doesn't recommend committing the applicants to any of these measures. Ms Torgerson on the other hand does recommend that development of FMPs be a compulsory condition of consent, but she doesn't specifically discuss the likely performance of these measures and so doesn't incorporate this quantitatively into her conclusions.
- 54 As I described in paragraphs 29-30, it is important to acknowledge that currently available mitigation measures may reduce nutrient losses from land but will not eliminate them. Performance varies widely but the weight of scientific information currently suggests that we shouldn't expect more than about 50 % reduction of nutrient loads from all mitigation measures combined.

CONCLUSIONS

Hakataramea

- 55 In the Hakataramea River, periphyton blooms already periodically exceed the biomass outcome defined in PNRRP Objective WQL1, particularly during summer low flow periods and probably for periods of weeks or months until growths are cleared by floods. On the basis of several modelling studies (e.g., Norton & Rouse 2007) the current annual average maximum periphyton biomass significantly exceeds PNRRP Objective WQL1 and could increase by a further 20% if all current applications were granted. From the evidence of Ms Torgerson and Mr Heller it appears that poor land management practices contribute to this problem and it is likely that existing nutrient loads could be significantly reduced through improved practices. Whether these reductions could be sufficient to allow further applications to be granted and still meet Objective WQL1 is, in my opinion, uncertain based on current information.

Other Waitaki sub-catchments

- 56 For other sub-catchments of the lower Waitaki River, there has been no comprehensive assessment of effects on nutrient loads. In general terms, granting further water take applications will increase the risk of exceeding the Objective WQL1 biomass outcome in rivers down-gradient of intensified land-use. The greatest risk will be in small streams and rivers, that have little riparian vegetation cover, and which have periods of low flows with infrequent floods. This generally includes all spring-fed streams, the Maerewhenua River, the permanently flowing sections of the Kurow, Otiake and Otekaieke Rivers, and streams of the plains below Stonewall such as Awamoko Stream and Welcome Creek.

Lower Waitaki River

- 57 For the lower Waitaki River mainstem, the risk of exceeding the Objective WQL1 biomass outcome is lower, because the river is large (offering significant dilution) and subject to frequent flow events that remove periphyton growths. Currently these flow events consist of short-term (daily-weekly) flow fluctuations and occasional freshes and floods. If NBTC were granted, disturbance would be provided by the proposed flushing and flood flows. Nonetheless, the risk of localised nuisance growths in small side braids of the mainstem Waitaki would increase as a result of nutrient increases from intensification if applications for consent are granted.

Mitigation

- 58 If consents are granted, the available methods to minimise adverse ecological and water quality effects and maximise the chance of consistently achieving Objective WQL1 of the PNRRP include: preventing stock access to waterways, employing nutrient-loss reduction measures through implementation of FMPs, riparian buffer and shade planting, any possible wetland enhancements, formation of community stream-care initiatives, and eliminating dust and soil erosion problems. In my opinion these will be essential rather than optional requirements in order to achieve Objective WQL1 of the PNRRP.

Dated: 2008

Edward (Ned) Norton

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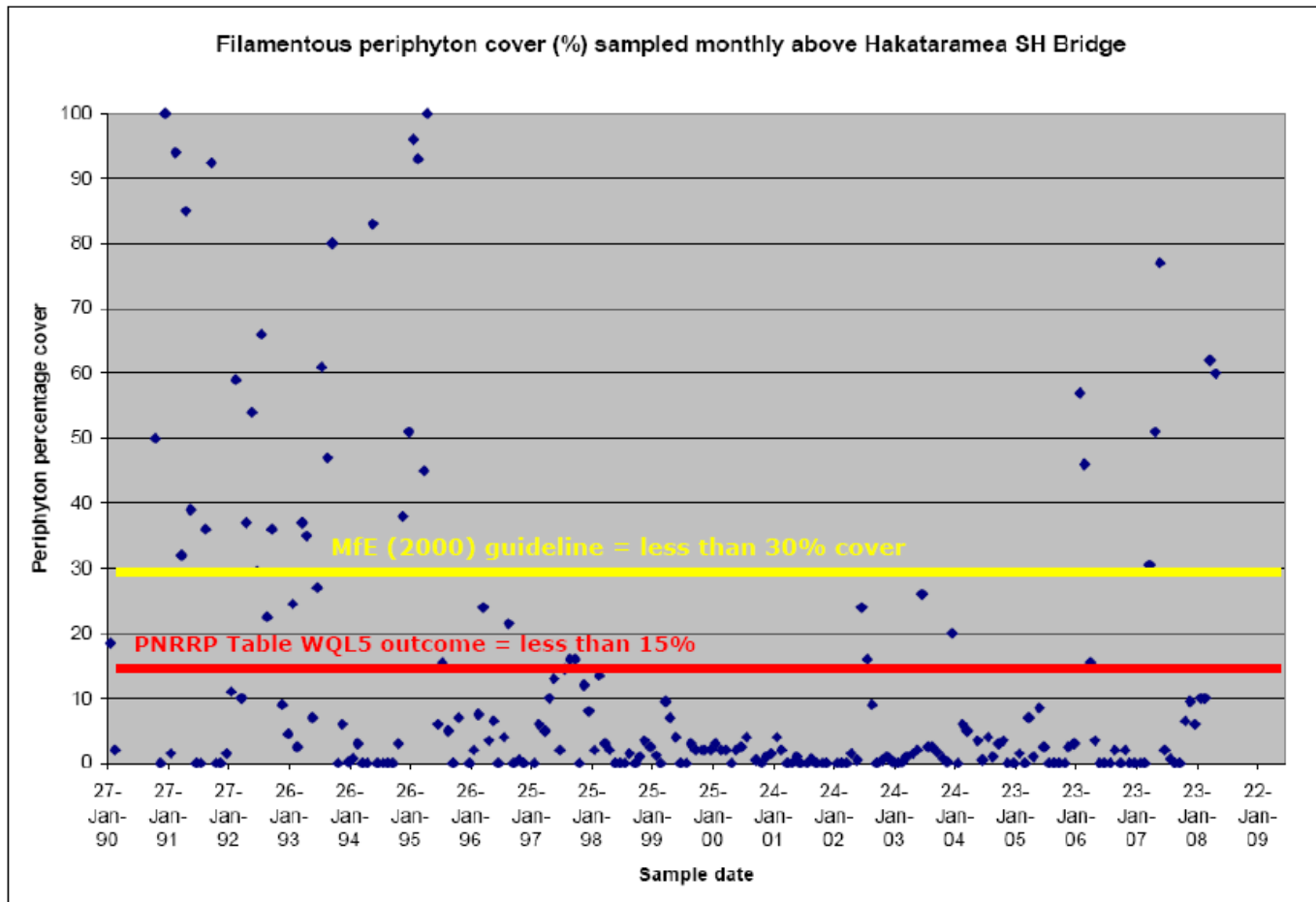


Figure 2. Filamentous periphyton (percentage cover) measured monthly in the Hakataramea River above State Highway 82 Bridge from 1990 - 2008. Data are from NIWA's National Water Quality Monitoring Network and are means of 10 observations across a transect (bank to bank) which is an appropriate statistic to compare against the PNRRP Objective WQL1 (Table WQL5) outcome and MfE (2000) guidelines.