BEFORE THE INDEPENDENT HEARING COMMISSIONERS

IN THE MATTER	of the Resource Management Act 1991 ('the Act')
AND	
IN THE MATTER	of the Proposed Canterbury Land and Water Regional Plan
BETWEEN	RAYONIER NEW ZEALAND LTD Submitter
A N D	CANTERBURY REGIONAL COUNCIL Local Authority

EVIDENCE OF DR JOHN MARTIN QUINN ON BEHALF OF RAYONIER NEW ZEALAND LIMITED

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INTRODUCTION

Summary of Qualifications and experience

1 My tertiary qualifications are a BSc (Hons) (First Class, Zoology major) from the University of Otago and a PhD from Massey University. My early professional experience involved 18 months as an advisor to the National Water and Soil Conservation Authority's Water Resources Council. For the last 27 years I have worked for NIWA and its predecessors as a research and consulting scientist.

2 My main focus has been on the ecology of rivers in relation to the effects of a variety of human activities, including wastewater discharges, forestry and agricultural land use and riparian management. I have been involved in the National Rivers Water Quality Network since its establishment in 1989. I was an instigator of the Whatawhata Sustainable Land Management Project in 1996 and continue to research the effects on stream characteristics of changes, implemented in 2001, in landuse and management of this hill-land farm on stream water quality and ecology. I have led development of conceptual and predictive models of the links between land management practices and waterway values in each of the five "Dairy Best Practice Catchments".

3 I have managed long-term studies on the effects of forest management practices on Coromandel Peninsula streams since 1993. I led the development of the Riparian Management Classification. I led research on Forestry Effects on Streams in Scion's Protecting and Enhancing the Environment through Forestry Programme (1995-2006) and NIWA research programmes on "River Ecosystems and Land Use Interactions" (2003-2010) and currently lead NIWA's "Restoration of Aquatic Ecosystems" programme. I have published over 85 scientific papers in peer-reviewed journals or books and have written over 130 consulting reports. I was part of the teams that developed the Stream Habitat Assessment Protocols (2009), the Restoration Indicator ToolKit for Streams (2010) and the Deposited Sediment Assessment Protocols (2011) and advised MfE on the proposed National Environmental Standard for forestry.

4 I was awarded a Royal Society of New Zealand Science and Technology Bronze Medal for my contributions to river ecosystems research in 2003 and the 2012 NIWA Applied Science Excellence Award.

5 I have read the Environment Court's Code of Conduct and agree to comply with it. My qualifications as an expert are set out above. I confirm that the issues addressed in this statement of evidence are within my area of expertise.

6 The data, information, facts and assumptions I have considered in forming my opinions are set out in the part of the evidence in which I express my opinions. I

have not omitted to consider material facts known to me that might alter or detract from the opinions I have expressed.

SCOPE OF EVIDENCE

7 In my evidence I address the following issues:

7.1 the impacts of sediment discharge on water quality and aquatic habitats/biota;

7.2 the general effects of forestry on water quality;

7.3 the magnitude and duration of water quality impacts of the harvest phase of production forestry ;

7.4 the issues that arise with compliance with the proposed regulatory framework in LWRP and changes proposed in the CRC Officer's report; and

7.5 Methods of monitoring the effects of fine sediment discharge.

IMPACTS OF SEDIMENT DISCHARGE

8 Sediment loss to waterways is a natural process but accelerated levels of loss can degrade aquatic values in several ways (Clapcott et al. 2011, Ryan 1991, Waters 1995). Impacts of excessive sediment input include:

(a) degradation of aesthetics (water clarity and deposits, (e.g., Davies-Colley et al. 1993));

(b) flood flow conveyance (via channel infilling);

(c) reservoir and estuary volume; and

(d) water quality and biodiversity.

9 Biodiversity is degraded via effects including reduced instream primary production due to light attenuation in the water column (e.g., Davies-Colley et al. 1992), reduced visibility for sight-feeding aquatic organisms (especially fish and birds, Hay et al. 2006), infilling of the hyporheic (within gravel) spaces with flow on effects to the hyporheic fauna (e.g., Boulton et al. 1997) and spawning habitat for some fish species, including trout, smothering of the streambed by sediment deposits (e.g., Clapcott et al. 2011, Matthaei et al. 2006, Sutherland et al. 2010). Riverine fish and invertebrate species can cope with short periods of high turbidity/suspended solids concentration (SSC). For example, Rowe et al. (2002) found that smelt, the most sensitive of the native invertebrate and fish species tested, had 50% mortality in 24 h after exposure to a clay suspension with turbidity of 3,050 NTU (ca. 3000 g/m^3 SSC for clay-dominated solids (Davies-Colley et al. 1992). On the other hand,

some migratory fish species actively avoid turbid waters (Rowe et al. 2000) and Boubee et al. (Boubee et al. 1997) recommend turbidity of less than 15 NTU to avoid reduced recruitment of native fish that migrate from the sea to freshwater as juveniles. Sediment inputs to surface water can also convey varying levels of attached nutrients (particularly phosphorus), metals, pathogens and agrichemicals that may act as pollutants in their own right.

GENERAL EFFECTS OF FORESTRY ON WATER QUALITY

Afforestation effects on water quality in streams

10 Afforestation of pasture generally reduces sediment input via removal of land, streambank and streambed disturbance of livestock, reduction of runoff/flow (due to an increase in canopy interception and evapotranspiration combining to approximately 500 mm/y), increased slope stability through increased tree-root reinforcement and groundcover (Fahey et al. 2004, Hicks et al. 2004). Afforestation of pasture also reduces nutrient input to the system (less fertiliser use and lower nitrogen fixation by legumes) and direct input of nutrients and pathogens streams by livestock.

National Overview of Production Forestry and Water Quality

11 A national review of water quality in 338 low elevation streams and rivers (Larned et al. 2004) found that sites with predominantly exotic forest catchments had similar concentrations of dissolved reactive phosphorus, nitrate-nitrogen, ammonium-nitrogen and *E. coli* (pathogen indicator bacteria) to native forest streams, all of which were significantly lower than in pasture and urban catchments. Furthermore, plantation forest streams had the highest water clarity (median 3.5 m c.f. 2.3 m in native forest and 1.4 m in pasture).

Paired catchment studies

12 Paired catchment studies of adjacent pasture and pine streams, and before and after studies of pine afforested catchments, show generally similar patterns to those summarised in Larned et al (2004) but some studies indicate there can be legacy effects of the prior pasture phase on water quality after pine afforestation. In Hawkes Bay sediment production for mature pine forest (2 years preharvest) on erodible coastal hills was one third that of nearby pasture (Fahey et al. 2003). The benefits of afforestation for erosion protection of steep hills at Whatawhata Research Centre in the Waikato were demonstrated by the low level of slip erosion (1 slip/100ha) after an intense rainstorm (90 mm in 4 h) on hills had been afforested in pine 6 years compared with 15/100 ha on adjacent pasture (Quinn & Basher 2007). This is discussed in more detail in Dr Phillips evidence.

Legacy effects of pastoral land use after afforestation

13 Pastoral land use may result in buildup of sediment in streams and streambanks (causing channel narrowing) (Davies-Colley 1997). This can result in legacy effects that slowly decline during the forestry phase but produce higher nutrient and sediment losses than would occur under pine forest established on lower production land (e.g., tussock, shrub or native forest)(Davis et al. 2012) (Quinn & Ritter 2003).

MAGNITUDE AND DURATION OF WATER QUALITY IMPACTS OF FOREST HARVESTING

Cyclical periods of higher sediment during logging

14 The effect of forestry on sediment and nutrient input to streams varies during the forestry rotation (i.e., the cycle of afforestation conversion/planting, silvicultural thinning, tree crop growth to harvest age, roading to facilitate the first rotation harvest, logging and replanting). The harvesting phase of the forestry rotation removes the forest canopy cover for the period between logging and regrowth of the new tree crop to the point of canopy closure, resulting in increased water yield in response to reduced evapotranspiration and erosion of sediment that has built up in the drainage system during the forest growing phase. These hydrological responses are expected to produce a period of increased sediment export. Export of sediment from more manageable activities, of forest roading and engineering in preparation for harvest, soil disturbance during harvest and runoff from forest roads, may add to the sediment loss to streams during the harvesting phase.

15 Forest harvest effects on stream clarity, sedimentation and ecological values are strongly mitigated by buffers that retain the forest understory and associated vegetation in the riparian zone, at the immediate land-water interface. These mitigate the impacts of logging substantially by: (i) reducing the disturbance to streambanks and soils in the areas that have high connectivity with the stream; (ii) increasing the filtration of sediment in surface runoff; and (iii) reducing the disturbance to stream habitat conditions (e.g., lighting, litter input) that otherwise occurs during harvesting (Boothroyd et al. 2004, Quinn 2005, Quinn et al. 2004b, Quinn & Wright-Stow 2008b). These roles of riparian vegetation are recognised in the NZ Forest Owners Association’s Code of Environmental Practice (NZFOA 2007) that recommends planting and replanting setbacks of at least 5 m horizontal distance from each side of permanently flowing streams. These guidelines also recommend consideration of wider planting and replanting setbacks where appropriate (e.g., around wetlands and larger water bodies (p 23 of guidelines) and where otherwise necessary to protect receiving water values at the next harvest.

16 A study of logging impacts on five Otago streams (Thompson et al. 2009) found that retention of a 10 m wide riparian buffers provided substantial mitigation of forest harvest effects on stream habitat and invertebrates in a medium size (643 ha) stream in Venlaw Forest relative to other streams that were clearfelled without retention of buffers. This is similar to findings from a larger Coromandel Peninsula study that found small- large sized streams (20-1300 ha catchment areas, 2-9 m wide channels, average 5 m) harvested with native forest buffers (6.5-27 m, average 18 m) were largely protected from streambank damage and impacts on stream habitat and biota that occurred in clearfelled sites (Boothroyd et al. 2004, Quinn et al. 2004a, Rowe et al. 2002). Eivers (2006) found that, amongst 45 Canterbury foothill streams within pine forests of different age since planting/harvest and 5 indigenous forest streams, negative effects on stream invertebrate communities associated with young pine (indicating post-harvest impact) declined as the percentage of indigenous vegetation within 5-10 m of the stream increased. Eivers (2006) suggested buffer widths of 10 m or greater may be needed to enable native regeneration through the forestry cycle.

Forestry compliance with Rule 5.72

17 Stormwater runoff from forestry must comply with Rule 5.72 requirements that the discharge meets receiving water standards in Schedule 5 after reasonable mixing (i.e., no more than 20-35% change in visual clarity, depending on the water body type) and that the suspended solids concentration in the discharge is less than 50 g/m^3, when discharged to and spring-fed river, Banks Peninsula River or to a lake, or is less than 100 g/m^3, when discharged to any other river of artificial watercourse. This raises some practical issues for measuring compliance that are discussed below after first reviewing results of long-term monitoring of the effects of forestry on water clarity in the Coromandel Peninsula (Note that no similar studies have been carried out in Canterbury).

Production Forestry Effects on Water Clarity in Coromandel streams

18 I have been involved in monitoring programmes that have measured visual clarity (black disc, fortnightly or monthly) before and after harvesting at 21 pine forest stream sites (as well as 3 pasture and 3 native forest reference sites) on the Coromandel Peninsula for up to 20 years (Wright-Stow & Quinn 2011, Wright-Stow & Quinn 2012). I would expect greater effects of forest harvest on water clarity in Coromandel than in Canterbury streams because annual flood flows per unit catchment area in the Coromandel are up to an order of magnitude higher (McKerchar & Pearson 1990), with associated greater erosion risks

Magnitude and duration of clarity effects

19 Visual clarity remained within the pre-harvest range at 11 of these Coromandel

sites during the harvesting phase whereas the maximum reduction in annual median clarity at the other 10 sites averaged 38%. The greatest reduction in annual median clarity was within the 33-50% range of the MFE clarity guideline for non-conspicuous effects on water clarity due to discharges (MFE 1994) in all but 1 case (where reduction was 52%). If clarity declined during harvesting it typically recovered to pre-harvesting levels within 2-3 years of harvest completion. In larger streams the percentage of the forest that is harvested in any 1-2 year period is low (typically < 10%) and harvest effects were minimal.

Factors influencing Coromandel clarity impacts

20 Clarity impacts were influenced by the coincidence of harvesting and severe storms and catchment size, and hence the percentage of the catchment that was harvested in any year. The five largest streams (500 to 2350 ha catchments) did not shown any statistically significant change over several years before, during and after logging, or have shown improved clarity. Smaller streams (<450 ha catchments) often showed a decline in annual median clarity during the first few years of harvesting when much of their upstream areas were logged, particularly after major storm events coincided with logging when annual median clarity declined by up to 40%. However clarity increased subsequently and the overall trends over a decade from pre-post logging were neutral or positive at most of these sites. The largest decline in annual median clarity was 52% during and after harvesting of 81% the catchment of a 100 ha stream over a 2 year period.

Overview of Coromandel stream clarity monitoring and comparison with pastoral land use

21 Overall the monitoring indicates that when impacts on water clarity do occur they may persist for a couple of years after logging, but clarities usually improve subsequently, often becoming clearer than at the beginning of logging. Notably, the logged streams had 1- to 5-fold higher annual median clarity during and shortly after active logging than the three adjacent pasture streams (where median clarities were 0.4 m, 1.5 m and 2 m) (Quinn & Kemp 2001, Quinn & Wright-Stow 2008a, Wright-Stow & Quinn 2011, Wright-Stow & Quinn 2012).

pLWRP COMPLIANCE ISSUES

Implications of Rule 5.72 - clarity change limits

22 If Canterbury streams have a similar clarity response to forest harvest to the Coromandel streams, the findings above suggest that, although forestry will meet the Rule and maintain high water clarity for the great majority of the plantation rotation, there will likely be issues with forestry complying with the Schedule 5 clarity change limits of <20-35% during and immediately after harvesting particularly in small streams. Unless this is addressed, it could create a the

perverse outcome that a land use that provides long-term water quality benefits (along with other ecosystem services) is non-complying due to short-term impacts during the necessary harvesting phase of the rotation.

23 The clarity change standards of 20% or 35% in Schedule 5 are more conservative than the MFE (1994) national guideline for "conspicuous change in clarity" in waters other than those classified as Class A under the Water and Soil Conservation Act (for which the recommended guideline is <20% change). In non-Class A waters the MFE (1994) clarity guidelines consider reductions in clarity of less than 33-50% to be protective against "conspicuous" clarity change, with the duration of effects and importance of the receiving water values influencing on where in this range the compliance standards are set. Given that forest streams are usually relatively inaccessible to the public and effects are short-term as part of the harvest phase, I suggest a standard of not more than 50% reduction in clarity for managing forest harvest impacts on small streams (<300 ha catchments) and <33% elsewhere would be consistent with the MFE (1994) guidelines.

24 It is possible that the Schedule 5 visual clarity change standards for permitted activity status were set lower than the MFE (1994) guidelines to protect against cumulative effects of multiple discharges. An alternative approach to dealing with cumulative effects of diffuse inputs from production forestry is to monitor change in clarity at medium to large scales, such as at the outlet of larger catchments within, or at downstream edge of, the forest estate (as suggested above).

25 The MFE (1994) guidelines acknowledge that dealing with effects of diffuse pollutant inputs (such as forest runoff) is not easy (e.g., what is the reference for assessing change?) and that timescales and spatial scales of effects are likely to influence what people notice and find conspicuous. The pLWRP Schedule 5 standards give no guidance on this issue for visual clarity or any other parameter. Do they apply at all times or are they annual medians or averages?

26 Where a logged forest stream discharges into a another stream it is relatively easy to assess compliance with a clarity change standard at a point in time by making near simultaneous measurements upstream and downstream below a mixing zone in the receiving stream. It is more difficult to measure change in clarity downstream of the typically diffuse effects of forestry because of the natural changes in clarity that occur with season and state of flow and the frequent absence of an upstream reference to measure change against. This can be done by comparison with longer term data at a monitoring site before the harvesting activity and/or with reference sites, as described in the Coromandel examples above, but it requires an investment in good study design and regular monitoring.

27 To avoid making forestry non-complying during the harvest phase (despite long-term water clarity benefits benefits), I recommend that either (i) schedule 5 be

amended to allow for up to 50% reduction in visual clarity (as the annual median) during the harvesting phase in small (e.g., <300 ha) catchments and <33% elsewhere; or (ii) that forestry impacts are assessed using the existing Schedule 5 standards over an appropriate timescale (e.g. rolling 4-5 year median) to account for potential temporary minor exceedence of limits during harvesting; or (iii) forestry be managed by a separate rule that requires adherence of a code of practice and meets water clarity change standards in Schedule 5 when flows are below the median (similar to the approach adopted in Horizon's One Plan).

Implications of Rule 5.72 - stormwater suspended solids limits

28 Analysis of existing river monitoring data suggests that the stormwater discharge suspended solids concentration (SSC) limits in Rule 5.72.6(b) (50 and 100 g/m^3) are likely to be difficult to meet consistently. River monitoring indicates these levels are exceeded at the two Canterbury "*baseline*" National Rivers Water Quality Network (NRWQN) sites (i.e. CH1 (Hurunui at Mandamus) and CH3 (Waimakariri at Gorge)). I used 17 years of monthly turbidity NRWQN data (204 observations) and a regression model I developed converting turbidity to SSC (SSC = 1.642 x turbidity, R^2 = 0.95, developed from 1 year's Waimakariri and Hurunui data) to predict that SSC of 50 and 100 g/m^3 would have been exceeded on 9% and 5% of the time, respectively, at CH1 and 23 and 12% of the time, respectively, at CH3. This is illustrated in the following table.

River monitoring site	SSC exceedence of 50 g/m^3	SSC exceedence of 100 g/m^3
CH1	9%	5%
CH3	23%	12%

29 Two options present themselves to address this issue of occasional high natural background SSCs,, One option is to amend Rule 5.72(b) as follows(added words in italics) to read:

> "the concentration in total suspended solids in the discharge shall not exceed: (i) 50 g/m^3, where the discharge is to any spring-fed river, Banks Peninsula river, of to a lake *except when the background total suspended solids in the water body is >50 g/m^3 in which case the Schedule 5 clarity change standards shall apply*, or (ii) 100 g/m^3 where the discharge is to and river of an artificial watercourse, *except when the background total suspended solids in the water body is >100 g/m^3 in which case the receiving water Schedule 5 clarity change standards shall apply*".

30 The second, more straightforward, option is that Rule 5.72(b) for stormwater SSC limits is deleted (or stated as not applying to forestry) and replaced by reliance on Rule 5.72(a) and the instream visual clarity change standards in Schedule 5, inclusive of the amendments discussed above. I consider that this would promote the intent of the plan to avoid unacceptable impacts of land use on water clarity and sedimentation by applying monitoring that operates at appropriate spatial and temporal scales for managing effects of forestry.

METHODS OF MEASURING STREAM CLARITY

Converting Rule 5.72(b) into clarity units

31 In the event that Rule 5.72(b) is retained I make the following comments. Visual clarity is often favoured as the primary measure of fine suspended sediment because it has the advantages of sensitivity, low cost, and direct application to aesthetic and visual feeding effects (Davies-Colley & Smith 2001).

32 The use of SSC in Rule 5.72.6(b) means that stormwater samples will have to be processed in a laboratory to assess compliance, with consequent costs and time delays that are likely to reduce monitoring frequency and immediacy of feedback to forest managers that fosters adaptive management. This also creates an inconsistency with the use of % change in clarity in Rule 5.72.6(a).

33 To overcome this I recommend either couching Rule 5.72.6(b) in clarity units or at least providing the option to assess the compliance with the SSC standards by using relationships with visual clarity using a black disc or clarity tube. For example, using the relationship between water clarity (as black disc visibility) and SSC derived from the Waimakariri and Hurunui rivers (i.e., Black disc (m) = 4.0528 x $SSC^{-0.723}$, $R^2 = 0.90$) predicts that SSCs of 50 and 100 g/m^3 corresponds to clarities of 0.24 m and 0.14 m, respectively. Such relationships could be developed for different geographic areas using existing data or new data gathered over time.

Practicalities of measuring visual clarity and the use of the clarity tube

34 Measuring visual clarity by black disc can be restricted in very small streams by the available water depth and length of suitable stream to make measurements. However, this is not normally an issue under high flow conditions when flows are up and clarities are typically low. Furthermore clarity tube clarity measurements can be made when the clarity is < about 0.9 m and converted into black disc and/or turbidity using published conversion equations (Kilroy & Biggs 2002). Field turbidity meters have similar advantages, but require the availability of more costly instruments. Use of the clarity tube or turbidity meters can also have health and safety benefits over instream black disc measurement in that the clarity of water samples collected by bucket can be assessed using the clarity tube, thus avoiding

the need to wade in streams under high flow conditions. This combination of use of the clarity tube and black disc should get around the physical problems of measuring water clarity and predicting SSC in small streams under wet weather conditions so that foresters can evaluate their compliance with ECan rules immediately, using field instruments and measurements.

CONCLUSIONS

35 Production forestry generally results in good water quality outcomes, although these are compromised to some extent during the essential harvest phase. The spatial scale and timing of impacts relative to these benefits do not appear to have been taken into account adequately when setting land and water management rules in CRC's pLWRP and amendments proposed in the Officers' Report. My analysis shows that the potential for unintended discouragement of forestry as a land use activity in Canterbury would be avoided by : (i) managing effects of production forestry against instream water quality targets in Rule 5.72(a) that are defined at appropriate spatial and temporal scales and altered to be appropriate for dealing with the short-term impacts of forestry during the necessary harvesting phase (details given in paragraph 28); (ii) either amending 5.72(b) to allow for higher stormwater suspended solids concentrations when background levels exceed the stormwater limits by reverting to the instream visual clarity change limits in Rule 5.72(a) or (iii) deleting rule 5.72(b) and using an amended to Rule 5.72(a) alone to manage forestry effects; or (iv) adopting the Horizons One Plan approach to forestry management requiring adherence to a code of practice as the primary tool for managing forestry. Each of these options would improve the fit of the way forestry is managed in the pLWRP with the goals of the plan. I contend that the One Plan Approach of relying primarily on adherence to a code of forestry practice around earthworks and forestry operations, with secondary reliance on water quality standards, has the advantage of providing a clear set of expectations that can be translated into the contract performance requirements of forestry contractors/operators.

Dr John Martin Quinn
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