BEFORE THE CANTERBURY REGIONAL COUNCIL

UNDER	the Resource Management Act 1991
IN THE MATTER OF	Proposed Plan Change 3 to the Proposed Canterbury Land and Water Regional Plan - Section 15- Waitaki and South Coastal Canterbury

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STATEMENT OF EVIDENCE OF DR MICHAEL JOY
ON BEHALF OF LOWER WAITAKI RIVER MANAGEMENT SOCIETY
Freshwater ecology

24 September 2015

Introduction

1. My name is Michael Kevin Joy.
2. I hold a BSc, MSc (1st Class Hons.) and a PhD in Ecology from Massey University. For the last twenty two years I have been a researcher in freshwater ecology, especially native fish distribution and freshwater bioassessment. I have been employed at Massey University Palmerston North since 2003 as a lecturer, now Senior Lecturer, in Ecology and Environmental Science.
3. In the last nineteen years I have published more than 20 peer-reviewed scientific papers on freshwater ecology and bioassessment, mostly in relation to New Zealand freshwater fish, and the majority of these papers are published in international journals. I have published four book chapters on native fish, bioassessment, freshwater biodiversity and pollution in New Zealand. I have also published many reports for about half the regional councils in the New Zealand, and have supplied software to run the bioassessment models I developed for these regions.
4. My areas of expertise are bioassessment of water and habitat quality in flowing waters, especially in relation to freshwater fish, and spatial predictive distributional modelling using Geographic Information Systems (GIS).
5. I am a member of the New Zealand Freshwater Sciences Society, the New Zealand Ecological Society, the Australasian Society of Fish Biology and the New Zealand Royal Society.
6. I have supervised more than 22 postgraduate (honours, Masterate and PHD) student research projects mostly directly related to freshwater ecology and bioassessment.
7. I have refereed scientific manuscripts for 9 journals including Ecological Modelling and have referred chapters for two books. I am an associate editor of the Journal Marine and Freshwater Research.
8. I have been involved in a number of hearings in relation dams, water quality, freshwater fisheries, fish distribution, river ecology and instream habitat. Some examples are: Meridian Energy application for the Mokihinui River hydro Dam, Trustpowers' re-consenting of the Patea Hydro Dam, Horowhenua and Manawatu District councils wastewater discharge consent applications, Fonterra Longburn discharge consent applications, Meridian Energy's project Mill Creek wind farm application, Horizons Regional Council's "One Plan" and Ruataniwha Water Storage Scheme and Plan Change 6 to the Hawkes Bay Regional Resource Plan ("Tukituki Catchment Proposal")

9. I have not visited the catchments in Waitaki and South Coastal Canterbury South Canterbury that this plan change addresses specifically in relation to this application. Neither have I read in any detail the existing Plan or proposed Plan Change. I have been asked by the Lower Waitaki River Management Society to provide generic evidence on what water quality limits are required for a healthy ecology in these freshwater systems and what might be expected if they are exceeded.
10. I confirm that I have read and agree to comply with the Code of Conduct for Expert Witnesses in the Environment Court Practice Note. This evidence is within my area of expertise, except where I state that I am relying on what I have been told by another person. I have not omitted to consider material facts known to me that might alter or detract from the opinions that I express.

Scope of evidence

11. I have been asked by the Lower Waitaki River Management Society Inc. to prepare evidence on whether the Plan Change 3 to the Canterbury Land and Water Regional Plan. This includes:
    a. A discussion of the current freshwater ecological state
    b. The causes of the degradation discussed above
    c. A review of the plan change outcomes/objectives, targets and limits
    d. And to recommend appropriate limits to achieve these outcomes and objectives

Terms and definitions

12. Throughout the text I use the words ‘life supporting capacity’ and ‘ecological health’ interchangeably. Although there may be some distinction between these in a planning and/or legal arena they are the same in an ecological context.

Executive summary

13. The main waterways in SCC area clearly suffer already from agricultural impacts with water and habitat quality declining with reducing elevation and increasing cumulative impacts as outlined by Kelly (2015). Thus, with the anticipated increase in farming intensity, particularly with the Hunter Downs irrigation scheme, a worsening state of freshwaters is predicted in all scenarios except where the Zone Committee's "solution package" is both fully implemented and highly effective.

14. The current poor state of waterways in the SCC is confirmed by the data from Land and Water Aotearoa (LAWA) summarised in Table 1 (Appendix 1) this table shows that the few sites in the region and the lowland end are in the worst 25% of sites of their type in New Zealand. The maps figures 1 – 4 (appendix 1) reveal the poor state of all New Zealand waterways in lowland intensively farmed areas of New Zealand. According to the Department of Conservation there are 17 threatened native freshwater fish species in the Canterbury Region. Native fish are an important component of and indicators of freshwater ecosystem health and their omission from the plan change and limits is concerning.
15. To achieve ecosystem health, instream habitat quality, water quantity, nutrients (nitrogen and phosphorus), suspended and deposited sediment and riparian margins all need to be managed appropriately. All of these factors interact together to determine ecosystem health thus all need to be managed.
16. Management should not be based on just nutrients; rather it must include a suite of metrics. Furthermore, limits for each of the metrics need to be based on ecosystem health requirements as the starting point rather than working backwards from current land practices, which has no ecological basis whatsoever.
17. Limits and rules should be set to maintain ecosystem health, not nitrogen toxicity or/and to suit current land use. In other words to ensure ecosystem health and life supporting capacity means managing the whole ecosystem all attributes, not a select few parameters.
18. Riparian buffer zones are an important management tool as they provide a range of benefits to freshwater communities including the reduction of in-stream nutrient concentrations; lowered fine suspended and deposited sediment, the exclusion of livestock, temperature control, flow variability control, maintaining natural habitat character, and providing a source of food for aquatic taxa, but of lesser value for shade on larger waterways.
19. However, riparian buffers do not significantly limit the movement of nitrogen from livestock to waterways as this happens via subsurface movement. Thus the only way to effectively control nitrogen is to limit intensification or stock time on pasture.
20. To achieve ecosystem health parameters needed to be added to assessment and goals they are continuous oxygen saturation, continuous temperature measurement Native fish should be added to the numerical goals and I suggest a minumum fish IBI (Joy and Death 2004) should be used for this purpose.

21. Table 15(a) should have a nitrogen limit added for the three waterway management units, and they should be close to the ANZEEC gideline limit of 0.61mg/l nitrate nitrogen and 0.44 mg/l total nitrogen or less than 0.8 mg/l DIN. I recommend that for all waterbodies that the maximum daily temperature during summer (October to April inclusive) be reduced from 20°C (Table 15a) to 19°C and during winter (May to September inclusive) be reduced to 11°C. The chlorophyll max biomass should reflect the Biggs (2000) periphyton guidelines of 50mg/m^2 for upland and 120 mg/m^2 for lowland and plains streams.
22. For the water quality limits table 15(c) the Annual median and 95th percentile should not exceed 0.8 (the Ruataniwha BOI limit).

Ecosystem health

23. Ecosystem Health and Life supporting Capacity - In New Zealand, section 5 of the RMA sets as its purpose the sustainable management of natural resources which requires that the life supporting capacity of air, water, soil, and ecosystems be safeguarded.
24. The National Policy Statement for Freshwater 2011 recognises the importance of values relating to "safeguarding the life-supporting capacity of water and associated ecosystems" which include the value of "healthy ecosystem processes functioning naturally". As such regional plans are required to, at a minimum; ensure that the plan safeguards the life supporting capacity and ecological processes of freshwater in the region.
25. 'Ecosystem health' has been defined as a combined measure of the vigour, organisation and resilience of an ecosystem (Rapport et al., 1998). In this context, 'vigour' can be related to the ability of an ecosystem to sustain life. In freshwaters, this may, for example, become impaired by the presence of a toxic pollutant. 'Organisation' relates to the extent of integration between ecosystem components. In freshwaters, this may, for example, become impaired by the extirpation of native species due to a change in habitat quality. 'Resilience' has been identified as an important feature of a 'healthy' ecosystem. In freshwaters, increasing pollutant levels or habitat loss would indicate instability and therefore impaired resilience (Folke et al., 2010; Dobiesz et al. 2010).
26. The principal factors driving reduced freshwater ecosystem health in rivers and streams include; increased nutrient levels (leading to many secondary effects described below), loss of riparian habitats, altered and reduced flows, and increased

suspended and deposited sediment.

27. The proposed objectives in Proposed Plan Change 3 are inadequate to safeguard or limit the declines in life supporting capacity.

28. The concept of 'ecosystem health' has become increasingly incorporated into policy for the management of freshwaters and I will concentrate on this concept in my evidence.

River biological communities

29. Within the flowing water ecosystems there is periphyton, detritus, terrestrial plant and animal matter, aquatic invertebrates, and fish. Periphyton (the coating of green or brown slime on rocks) and detritus (both in-stream and terrestrial derived plant matter, e.g., leaves) form the basis of the stream food web. Some periphyton is required as food for many aquatic invertebrates; however, too much algal growth can dramatically change the ecology and habitat conditions of a river.

30. Aquatic invertebrates consume the periphyton and plant matter either directly (along with other organic sources) or by predating the smaller grazing invertebrates. Native and sport fish eat these invertebrates and some terrestrial inputs. All of the biological components of a river food web require the correct habitat and water quality conditions in order to maintain healthy populations and functioning ecosystems.

31. To protect ecosystem health we need to protect the entire freshwater community, and I note that native freshwater fish seem to have been left out of reports in relation to Plan Change 3. I propose that fish also be monitored and that their communities attain a minimum IBI score (the New Zealand Freshwater Fish Index of Biotic Integrity) (Joy and Death 2004), which should be incorporated into table 15(a). Fish require greater interstitial spaces than invertebrates and respond to different factors than macroinvertebrates, therefore simply relying on the QMCI may not give an accurate depiction of the health of other trophic levels (Jowett and Davey 2007, Joy and Death 2004, Leathwick, Rowe, Richardson, Elith and Hastie 2005).

32. The evidence of impacts of pastoral farming on native fish communities are clear; a study of more than 25,000 sites around New Zealand showed that native fish communities in pastoral catchments had significantly lower fish biological integrity than scrub and native forest catchments catchment sites and that temporal declines were strongest in the pastoral catchment sites (Joy 2009). Currently 74% percent of

New Zealand's native fish are listed as threatened (Goodman, 2013) and loss of habitat and water quality impacts are a major cause of their heightened threat status (Joy 2009). According to the Department of Conservation there are 17 threatened native freshwater fish species in the Canterbury Region (Sjaan Bowie pers. Comm. and document entitled Schedule 17 and the New Zealand freshwater fish database NZFFDB[1]). These species would have been much more widespread throughout the South Canterbury Region but range and density has been reduced by landuse change (Joy 2009).

33. There are clear and obvious relationships between farming intensity and ecological impacts (Townsend et al. 1997, Townsend et al. 2008, Waikato Regional Council 2008) (see Appendix 1 (from (Waikato Regional Council 2008)). The impacts include increased levels of nutrients, sediment and faecal pathogens. The sediment and pathogens can be controlled to some extent by on farm management options but the nitrogen leaching through soils is not easily controlled, at least while stock are pasture fed.

34. High turbidity and deposited sediment can drastically alter community composition. High turbidity can smother fish and invertebrates as well as make it difficult for them to find food (Lenat, Penrose and Eagleson 1981, Rowe and Dean 1998, Ryan 1991). Furthermore, native freshwater fish have been shown to exhibit preference for waterways with low turbidity and avoid those with high suspended sediment (Boubée, Dean, West and Barrier 1997). Fine deposited sediment reduces the space available for freshwater organisms to inhabit.

35. The majority of New Zealand freshwater fish and organisms are benthic species and live in the interstitial spaces between substrate rocks (Jowett and Boustead 2001, Richardson and Jowett 2002, Suren and Jowett 2001). When high sediment loading occurs, the fine sediment becomes deposited and fills the spaces between the rocks. Thus leaving little room for fish and invertebrates to live and be protected, consequently reducing the life supporting capacity of the stream and driving out taxa from these areas and many to local extinction (Burdon, McIntosh and Harding 2013, Harrison, Norris and Wilkinson 2007, Jowett and Boustead 2001, Lenat, Penrose and Eagleson 1981, Ramezani, Rennebeck, Closs and Matthaei 2014,

[1] McDowall, R. M. and J. Richardson. 1983. The New Zealand freshwater fish database-a guide to input and output. Fisheries Research Division Information leaflet 12, Ministry of agriculture and Fisheries, Wellington.

Richardson and Jowett 2002, Ryan 1991, Suren and Jowett 2001, Wood and Armitage 1997)

36. Water temperature can also affect community composition as the freshwater organisms as their productivity rates change with temperature. The productivity of a trout population will suffer as water temperature approaches and exceeds 19°C. Laboratory studies looking at the impacts of high temperatures on trout, have found that brown trout ceased feeding once temperatures climbed above 19°C and that they would die if temperatures climbed above 25°C for a sustained period (Elliott and Hurley 2003).

37. Similarly, 50% of Deleatidum mayflies will die after 4 days in water at 22.6°C (Quinn, Steele, Hickey and Vickers 1994). Furthermore, Quinn and Hickey (1990) found that as temperatures surpassed 19°C that distributions of the invertebrate taxa groups Ephemeroptera and Plecoptera were restricted, thus drastically altering the community composition.

38. Whilst the native fish species each have different preferred thermal ranges (Richardson, Boubée and West 1994), the Ephemeroptera and Plecoptera are important components of native fish diet and their absence could significantly reduce fish productivity (Hollows, Townsend and Collier 2002, Jellyman 1996, Jellyman 1989, Main and Winterbourn 1987, McDowall, Main, West and Lyon 1996, Montori, Tierno De Figueroa and Santos 2006, Rowe, Konui and Christie 2002, West, Jowett and Richardson 2005).

39. Trout embryos also have a narrow thermal range. The preferred range for brown trout spawning is 3-20°C, with an optimum temperature of 10°C, and for hatching a preferred range of 2-11°C with a maximum of 20°C (Death, 2002). To maintain life supporting capacity.

40. Excessive periphyton growths are not only aesthetically unappealing, but they can also result in dramatic changes to the biological communities in rivers and streams. They lead to a change from mayfly, stonefly and caddisfly dominated communities to ones with worms, snails and midges that do not support the same abundance, biomass or diversity of fish that the former communities do. The periphyton can also build up to such a biomass that the lower layers start to rot. This can dramatically reduce the oxygen levels and change the pH of the water leading to significant adverse effects on many invertebrates and fish.

41. Whilst oxygen concentration may be very high during the day time from high rates

of photosynthesis, at night the lack of light prevents oxygen from being released into the water and oxygen levels can plummet to lethal levels (Dean and Richardson 1999, Franklin 2013). A good example of this the Manawatu River, particularly a sampling site at Hopelands Road where continuous monitoring of dissolved oxygen revealed levels swinging between 40% and 140% over 24hrs in late summer (Clapcott & Young 2009). Thus many fish and invertebrate species are unable to survive, regardless of high oxygen concentrations that are recorded from daytime measurements, leading to differences in community composition.

42. Any surviving fish would become stressed, susceptible to disease and develop poor condition as a result of undesirable dietary changes from alterations in macroinvertebrate community structure (Dean and Richardson 1999, Franklin 2013). Thus, to have any real value, oxygen measure must be continuous and the limits set must be minima and maxima. It is for these reasons that I recommend dissolved oxygen sampling being conducted over at least a 24 hour period rather than spot sampling during the day time. The limits that are set in proposed Plan Change 3 should be upheld regardless of the time of day and not exceeded for any more than 1% of the time for a given period.
43. Periphyton biomass is largely kept in check by the abundance of available resources, the amount of predation occurring, temperature, and the size and frequency of floods. Resources that limit periphyton growth are almost always shade and nutrients.
44. Maintaining the key elements of the hydrological regime of rivers and streams is also vitally important for protecting the ecological health of freshwater environments along with their geomorphology (physical form and structure). Decreased flow can mean more sediment being deposited, greater nutrient concentrations, less wetted habitat, greater temperatures, and more periphyton biomass. See the review by Dewson, James and Death (2007) for a comprehensive review of the ecological consequences of reducing flow.
45. High flow events are important for scouring periphyton and keeping the standing stock low. Manipulations that cause lower flow variability than otherwise natural mean that periphyton may grow excessively and reduce ecosystem health. Flow variability also allows for runs, riffles and pools to all occur rather than a homogenous stretch, thus supports greater habitat for biota (Biggs, Nikora and Snelder 2005, Jowett and Duncan 1990).

Nutrient management

46. For any organism to grow there must be sufficient nutrients available as nutrients are essential building blocks and without one an organism will not be able to be healthy or even grow at all. Whilst they may be essential, there can be too much of a good thing such that excessive nutrients can be detrimental to the life supporting capacity of freshwater ecosystems. High nutrient concentrations can impact freshwater taxa either by becoming toxic or by enabling competitive exclusion.
47. The New Zealand periphyton guideline (Biggs 2000) gives periphyton limits and their corresponding nutrient concentrations to achieve protection of different instream values. The guideline suggests an annual maximum biomass of 50mg/m^2 Chlorophyll-*a* for benthic biodiversity (invertebrate community health). For aesthetic and trout habitat the guideline suggests bed cover max 30% filamentous algae (120mg/l Chlorophyll-*a,* or a maximum bed cover with thick mats of 60% or 200mg/m^2 Chlorophyll (Biggs 2000).
48. The guideline recommends nutrient concentrations to prevent nuisance growth. It suggests DIN < 0.2 mg/l and DRP < 0.01 mg/l for protection of benthic biodiversity. The guideline recommends a DIN level <0.3 and DRP < 0.03 mg/l for aesthetics and trout angling.
49. The Australia and New Zealand guidelines for freshwater and marine ANZECC[2] suggest limiting nitrogen levels to less than 0.61mg/l nitrate nitrogen and 0.44 mg/l total nitrogen to protect against nuisance algal growth.
50. The Board of Inquiry into the proposed Ruataniwha irrigation dam in their final decision decided that a DIN limit of 0.8 mg/l was necessary to protect the ecosystem health of lowland rivers in Hawke Bay (BOI decision[3]). This was almost double the ANZECC guideline limit and was a compromise given the pressure from dam proponents to allow more nitrogen in rivers.
51. Nutrients need to be managed to prevent excessive periphyton growth from suffocating invertebrates and fish and the effects of their growth oxygen levels if ecosystem health is to be restored or maintained. Nitrogen toxicity is a red herring (no pun intended) because the ecosystem level effects of too much nitrogen mean that fish and other stream life are dead long before nutrient levels get to be toxic.

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[2] http://www.environment.gov.au/water/publications/quality/australian-and-new-zealand-guidelines-freshmarine-water-quality-volume-1

[3] http://www.epa.govt.nz/Resource-management/previous/Tukituki/Pages/default.aspx

52. The toxicity levels were obtained experimentally by holding all other parameters like temperature and oxygen at a constant healthy level while adding nitrogen (Hickey pers. comm.) This is the accepted experimental process to find toxic limits but is unrealistic because in real life oxygen, temperature and other life requirements all come in to play long before toxicity any effects. Thus toxicity would only be important in a tank or lined pool where all other parameters were controlled, or sites with very little light reaching the bed of the stream.

Recomendations

1. Following on from the outline I have given above I have the following reccomendations:
    a. The freshwater goals set within the Plan are given numerical values which are intended to safeguard the life supporting capacity and ecological health and processes of freshwater in tables 15(a) and 15(c) of the proposed plan change. While I am reasonably happy with the minimum QMCI requirements, to achieve them and the other goals will require tougher numbers than those given in the tables 15(a) & (c).
    b. Furthermore, key parameters are missing from the table and others are set too high. Missing measurements are continuous oxygen saturation and continuous temperature. This is because one – off measures are of very limited value and nutrient limits should be added to table 15(a).
    c. For table 15(a) should have a nitrogen limit added for the three waterway management units, and they should be close to the ANZEEC gideline limit of 0.61mg/l total nitrogen and 0.44 mg/l nitrate nitrogen total nitrogen or less than 0.8 mg/l DIN.
    d. I recommend that for all waterbodies that the maximum daily temperature during Summer (October to April inclusive) be reduced from 20°C (Table 15a) to 19°C and during Winter (May to September inclusive) be reduced to 11°C.
    e. Native fish should be added to the numerical goals and I suggest a minumum fish IBI (Joy and Death 2004) should be used for this purpose.
    f. The chlorophyll max biomass should reflect the Biggs (2000) periphyton guidelines of 50mg/m^2 for upland and 120 mg/m^2 for lowland and plains streams.

g. For the water quality limits table 15(c) the Annual median and 95th percentile should not exceed 0.8 mg/l DIN ??(the Ruataniwha BOI limit).

2. Catchment land-use is the primary driver of degradation of the waterways already seen and thus must be managed to achieve water quality limits.
3. Nitrogen toxicity should only ever be considered an extreme limit as ecosystem level lethal degradation of life supporting capacity happens long before nitrogen levels approach toxic levels.

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Appendix 1.

Table 1. SCCA Rivers water quality summary from the LAWA website (http://www.lawa.org.nz/)

Attribute	Ecoli	Turbidity	Total N	T oxid N	Ammonia	DRP	Total P
Unit	n/100ml	NTU	g/m3	g/m3	g/m3	g/m3	g/m3
Hook - near coast (Tributary of the Wainono Lagoon)							
State	Worst 50%	Best 25%	Worst 25%	Worst 25%	Best 25%	Worst 50%	Best 50%
Trend	None	None	M degrad	M degrad	None	None	None
Hook Drain							
State	Best 50%	Worst 50%	Worst 25%	Worst 25%	Worst 25%	Worst 25%	Worst 25%
Trend	None	None	M degrad	M degrad	None	None	None
Waimate Creek - near coast							
State	Worst 50%	Best 50%	Worst 25%	Worst 25%	Worst 25%	Worst 25%	Worst 50%
Trend	None	M degrad	M degrad	M degrad	None	None	None
Waihao at Gum tree flat adjacet to Waimate town							
State	Best 50%	Best 25%	Best 50%	Best 50%	Worst 50%	Best 25%	Best 25%
Trend	None	None	None	None	None	None	None
Waihao - Spring fed Buckans Creek above confluence near coast							
State	Best 50%	Best 25%	Worst 50%	Worst 25%	Best 25%	Best 50%	Best 50%
Trend	M Improv	None	M degrad	M degrad	None	None	None
Waihao - at Bradshaw Bridge near coast (affected by augmentation from Waitaki)							
State	Best 50%	Best 25%	Worst 50%	Worst 50%	Best 25%	Best 25%	Best 25%
Trend	None	None	None	None	None	None	None

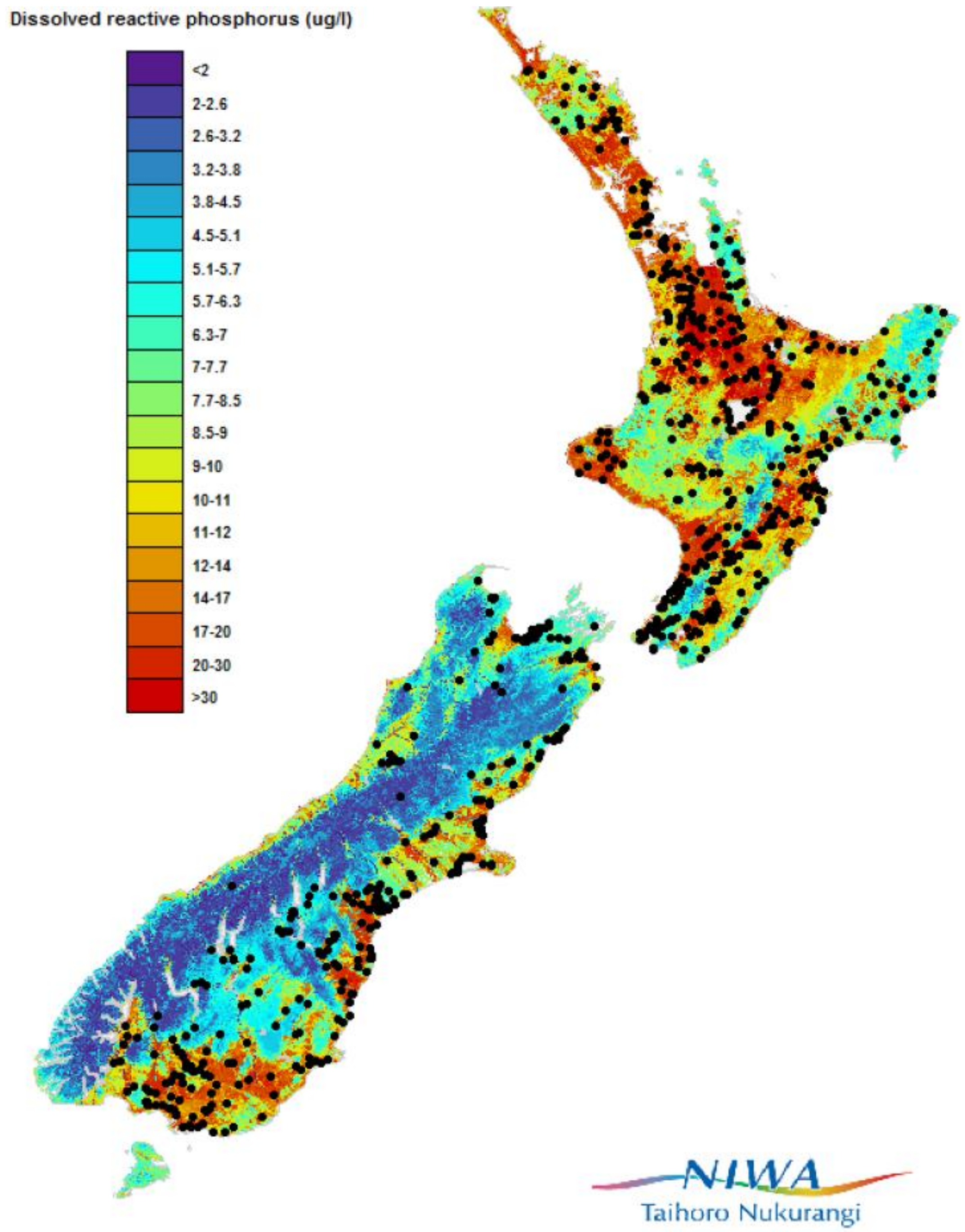

Figure 1. Predictive map of DRP levels in New Zealand Rivers based on the data from the sites marked as black dots (*Unwin, M. J., & Larned, S. T. (2013). Statistical models, indicators and trend analyses for reporting national-scale river water quality) (NEMAR Phase 3). NIWA.)*

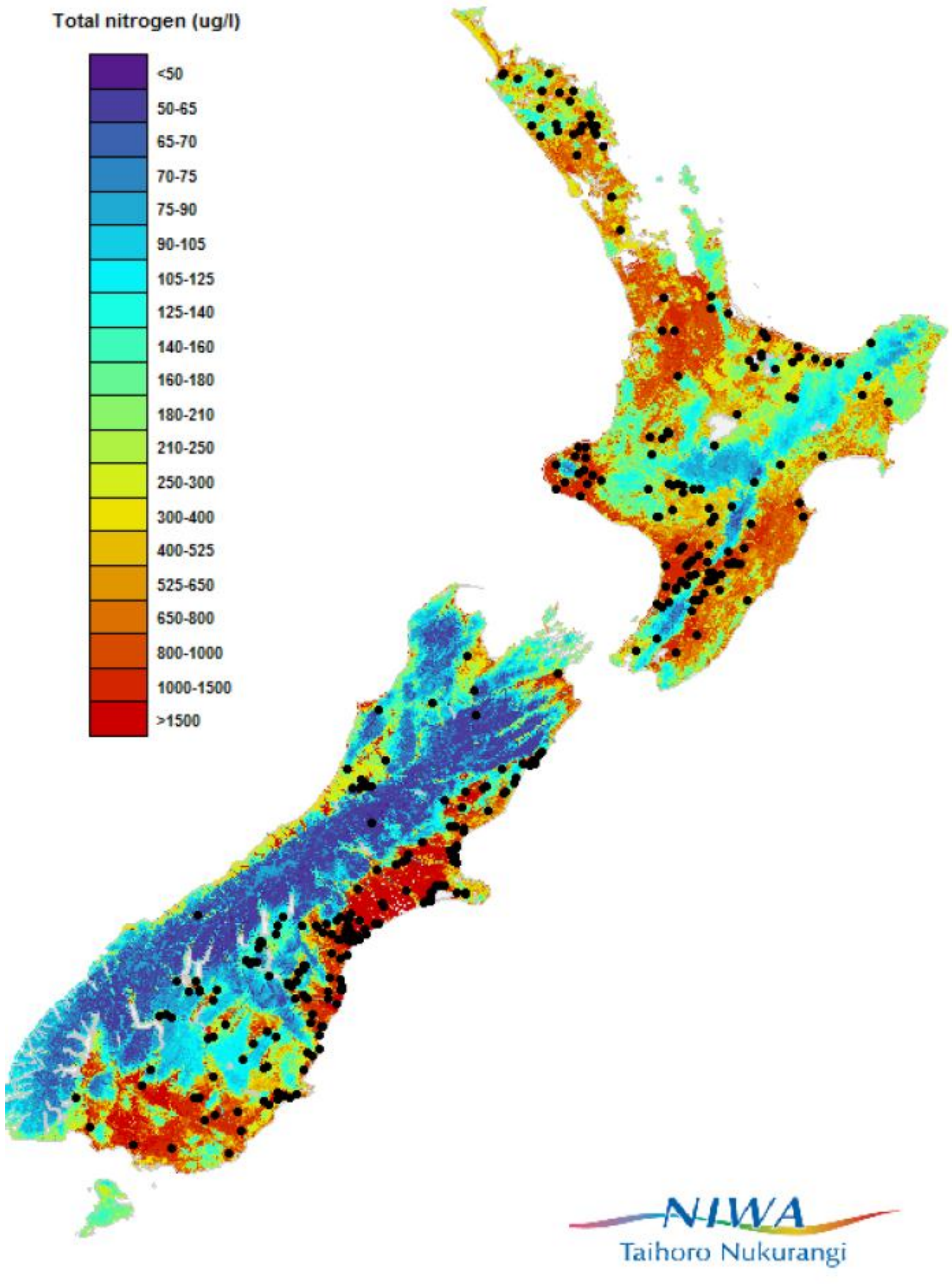

Figure 2. Predictive map of total nitrogen levels in New Zealand Rivers based on the data from the sites marked as black dots (*Unwin, M. J., & Larned, S. T. (2013). Statistical models, indicators and trend analyses for reporting national-scale river water quality) (NEMAR Phase 3). NIWA.)*

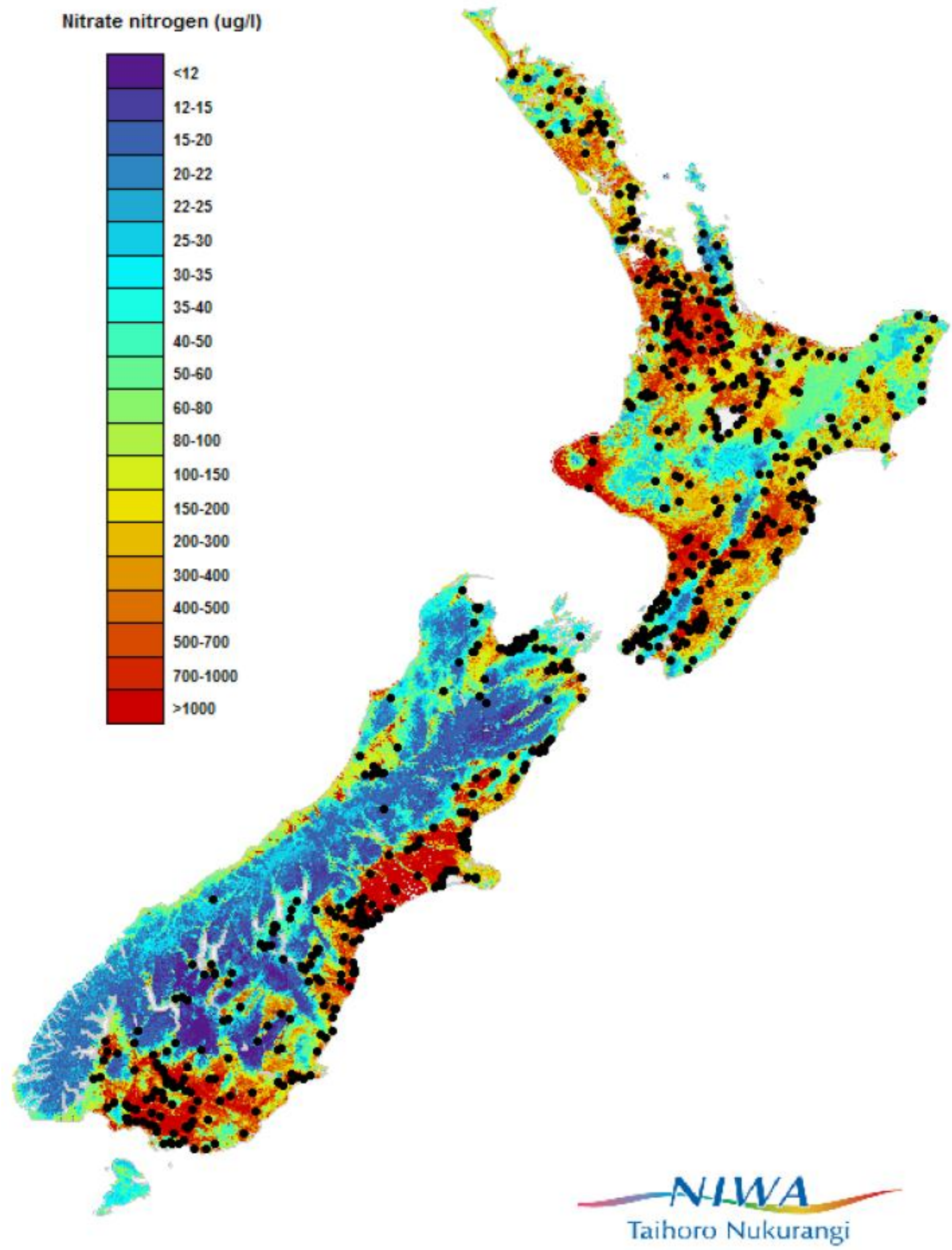

Figure 3. Predictive map of nitrate nitrogen levels in New Zealand Rivers based on the data from the sites marked as black dots (*Unwin, M. J., & Larned, S. T. (2013). Statistical models, indicators and trend analyses for reporting national-scale river water quality) (NEMAR Phase 3). NIWA.)*

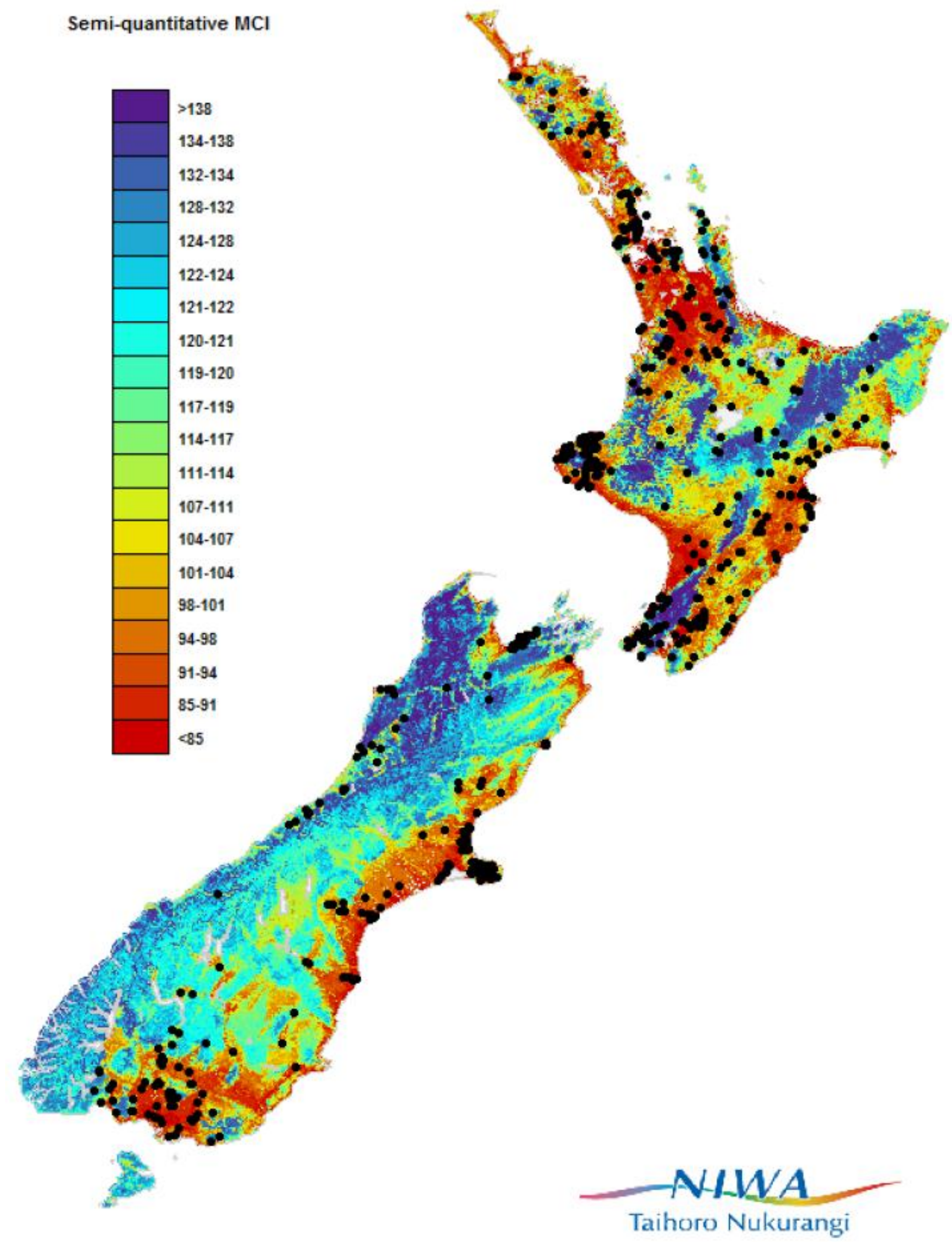

Figure 4. Predictive map of Semi quantitative MCI levels in New Zealand Rivers based on the data from the sites marked as black dots (*Unwin, M. J., & Larned, S. T. (2013). Statistical models, indicators and trend analyses for reporting national-scale river water quality) (NEMAR Phase 3). NIWA.)*