Land Use and the Proposed Nitrogen Bottom-line

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Environmental Protection Trust

Contents

Executive Summary

a. Approximately 18% of monitoring sites exceed the proposed national bottom-line for dissolved inorganic nitrogen (DIN) in rivers and streams, as part of the Government's proposed *Action Plan for Healthy Waterways*;

b. In rivers outside conservation land, approximately 10%, by length, exceed the proposed DIN bottom-line. However, this reduces to 8.8% when the existing NPS 2017 policy to reduce DIN for periphyton is accounted for;

c. Approximately 20% of the nation's dairy, 5% of other livestock (mainly sheep and beef), and 32% of cropping, occurs in catchments that exceed the proposed DIN bottom-line. However, after accounting for the existing periphyton requirements, then 9% of dairy, 2% of other livestock and 12% of cropping could be affected by the proposed DIN attribute;

d. A very small fraction of dairy (1%), other livestock (1%) and 5% of cropping occurs in catchments requiring more than a 60% DIN reduction to meet the proposed bottom-line, after accounting for the existing periphyton requirements;

e. As a national average, approximately 83% of the pastoral nitrogen leaching in catchments exceeding a DIN of 1.0 mg/L come from dairy, whilst 7% come from beef, 8.7% from sheep and 0.3% from deer;

f. Important to note, unless a grand-parenting nutrient allocation system is implemented, then not all land uses within a catchment will require a nutrient reduction. Given high variability in nitrogen loss between land uses, a catchment may achieve the DIN bottom line by reducing those emitting the most nitrogen without penalizing those leaching the least; and

g. This analysis only relates to the proposed DIN bottom-line, more stringent concentrations may be required to achieve a locally acceptable ecosystem health.

Environmental Protection Trust

The Environmental Protection Trust (EPT) is a charitable trust with the following objects and purposes:

a. Independently assess, and publicly report on, the environmental impacts of anthropogenic activities

b. Research environmental issues and publish findings in a public domain

c. Provide education on environmental issues

EPT is also a commonly used acronym for the insect orders Ephemeroptera, Plecoptera and Trichoptera, otherwise known as mayflies, stoneflies and caddisflies. These are small invertebrates that live in rivers and are the main food supply for our freshwater fish.

Report objectives

The Government is currently consulting on their *Action for Healthy Waterways* discussion document, which presents a range of new national policy and standards that seek to halt the decline in, and improve, freshwater health. One proposal is the introduction of a national bottom-line for dissolved inorganic nitrogen (DIN) at 1.0 mg/L in all rivers.

This [1]report seeks to:

a. Identify where the proposed DIN bottom-line would be exceeded;
b. Identify the proportions of dairy, other livestock land uses and cropping in catchments exceeding the proposed bottom-line by up to 20%, 20-40%, 40-60% and more than 60%.
c. Identify the proportions of nitrogen leaching from dairy, sheep, beef and deer in catchments exceeding the proposed bottom-line by up to 20%, 20-40%, 40-60% and more than 60%.

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[1] Recommended citation:
Canning, A. D. (2019) *Land use and the proposed nitrogen bottom-line.* (Report No. 01.1019). Palmerston North, New Zealand: Environmental Protection Trust

Ecosystem health and dissolved inorganic nitrogen (DIN)

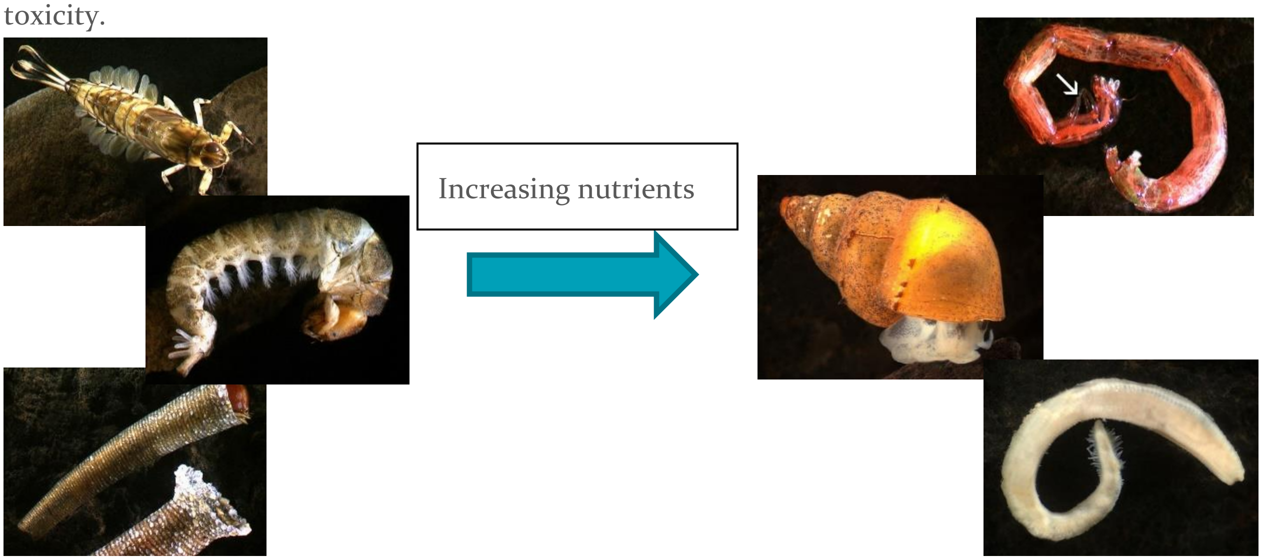
> *"A healthy ecosystem is one that is sustainable – that is, it has the ability to maintain its structure (organization) and function (vigor) over time in the face of external stress (resilience)."*[2]

For a freshwater ecosystem to be healthy, there are five core pillars that all need to be managed:

1. Aquatic life
2. Physical habitat
3. Water quality
4. Water quantity
5. Ecosystem processes

Dissolved inorganic nitrogen (DIN) is a critical part of the water quality pillar. It must be managed to achieve a healthy ecosystem but keeping DIN low is not the only water quality parameter that needs managing (such as phosphorus and heavy metals), nor will managing water quality alone be sufficient for a healthy ecosystem.

DIN can affect freshwater ecosystems in numerous ways including promoting algal growth (often seen as green slime); excessive microbial activity, in turn, affecting dissolved oxygen and organic matter breakdown; affecting invertebrate assimilation efficiency of organic matter; driving changes in the food web which can alter the diet of fish (typically grazing on macroinvertebrates – see contrasting bugs below); and at very high levels, invertebrates and fish can experience toxicity effects. A healthy ecosystem should not be experiencing toxicity.



[2] Costanza, R. & Mageau, M. 1999. What is a healthy ecosystem? *Aquatic Ecology,* 33 (1), 105-115. Available: DOI 10.1023/a:1009930313242

A snapshot of DIN exceedances

To gain insight into where exceedances of the proposed DIN bottom-line, and by how much, are likely to occur, both measured and modelled data are used. Modelled data is included because New Zealand's State of Environment (SOE) monitoring network is not representative of rivers by length. The SOE network sites are chosen for multiple reasons, including investigating localized impacts, assessing reference condition or calculating nutrient loads near river mouths. There are also substantial differences in monitoring intensity across the country, with Canterbury having 183 DIN monitoring sites on LAWA through to Taranaki with a very poor monitoring network of only 19 sites (Table 1).

According to the data held on LAWA (median of monthly samples collected between 2014-2018), 18% of SOE monitoring sites exceed the proposed DIN bottom-line of 1 mg/L (Table 1).

Table 1. The number and proportion of sites exceeding the proposed DIN bottom-line of 1 mg/L on a regional and national basis.

Region	# exceeding	Total	%
Northland	2	33	6
Auckland	5	37	14
Waikato	21	107	20
Bay of Plenty	4	40	10
Gisborne	1	38	3
Hawkes Bay	9	71	13
Taranaki	6	19	32
Manawatu-Whanganui	14	139	10
Wellington	7	43	16
Marlborough	2	32	6
Tasman	7	24	29
Canterbury	64	183	35
Otago	4	47	9
West Coast	1	29	3
Southland	15	63	24
Nationwide	**162**	**905**	**18**

Across all rivers, the modelled nitrate-nitrogen (≈ DIN in almost all rivers as nitrite-nitrogen and ammoniacal-nitrogen are typically very minute) concentrations suggest that approximately 6%, by length, exceed the proposed DIN bottom-line (Table 2; Larned, Snelder and Unwin, 2017) . When areas in native vegetation are excluded, the proportion in exceedance increases to approximately 10%. Approximately half of the river reaches in exceedance are greater than 2m wide.

In assessing the impact of the new proposal, the existing requirements to manage DIN for periphyton, as mandated under the NPS-FM 2017, need to be accounted for. To meet the existing periphyton requirements, a similar or more stringent DIN concentration than the proposed bottom-line is required (Matheson *et al.*, 2016; Snelder, Moore and Kilroy, 2019). Given that periphyton requires a hard substrate to grow, all rivers predicted to be largely composed of coarse gravels or larger (defined as FENZ ReachSed 3<; Leathwick *et al.*, 2010) are defined as capable of supporting high periphyton biomass. If it is assumed that the proposed DIN attribute is not more stringent than the existing requirement, then the proposed DIN bottom-line would require reductions in approximately 5% of rivers by length or 4% of rivers greater than 2m wide and outside native areas (Table 2). No discounting for the existing requirement to manage DIN for sensitive downstream environments has been applied.

Figures 1 and 2 show the modelled compliance against the proposed DIN attribute bands at the river reach draining the FENZ 5th order planning unit catchments for the North and South Islands respectively. Figures 3 and 4 show the same maps, except with only soft-bottomed catchments being coloured, the hard bottomed in white. Figures 5, 6 and 7 show gradings for rivers in Waikato, Canterbury and Southland respectively. Solid catchments represent catchments draining measured DIN (from LAWA), whilst the lines outside monitored areas represent modelled concentrations.

As with all modelling, there is uncertainty arising from measurement uncertainty, site selection, modelling technique and parameters, and chosen environmental factors. Results presented here should be considered as ‘ball-park’ figures, nonetheless they are useful at national and regional scales.

Table 2. The proportion (%) of rivers, by length, exceeding the proposed DIN bottom-line in each region and nationwide. Proportions are given for all rivers (regardless of size and location); all rivers greater than 2m wide at low flow; all rivers outside native areas; and all rivers greater than 2m wide and outside native areas. The same proportions are also given after discounting the existing DIN requirements for periphyton. Reductions required for sensitive downstream environments have not been accounted for.

	No discounting of existing policy				Discounting existing DIN requirements for periphyton			
Region	All rivers	Rivers >2m	Rivers outside native (any size)	Rivers >2m and outside native areas	All rivers	Rivers >2m	Rivers outside native (any size)	Rivers >2m and outside native areas
Northland	1.8	0.4	2.4	0.6	1.8	0.4	2.3	0.5
Auckland	7.5	8.7	9.0	9.9	7.2	6.6	8.6	7.5
Waikato	12.3	7.0	16.2	9.6	11.8	6.4	15.5	8.7
Bay of Plenty	1.0	0.2	2.1	0.4	1.0	0.2	2.0	0.4
Gisborne	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Taranaki	19.4	13.9	31.9	22.9	12.8	3.9	21.0	6.5
Horizons	6.2	2.9	8.9	4.4	5.5	1.7	7.8	2.5
Hawkes Bay	1.6	1.4	2.3	2.6	1.3	0.6	2.0	1.0
Greater Wellington	3.9	1.6	6.4	3.3	3.7	1.2	6.1	2.6
Nelson	0.8	0.0	2.4	0.3	0.5	0.0	1.6	0.2
Marlborough	1.5	0.4	3.0	1.1	1.4	0.4	3.0	1.1
West Coast	1.1	0.3	6.0	1.9	0.7	0.1	3.6	0.6
Canterbury	8.9	5.6	13.2	8.8	8.2	3.7	12.1	5.8
Otago	2.8	0.8	4.9	1.9	2.1	0.5	3.6	1.2
Southland	10.4	3.6	26.7	14.6	8.4	2.5	21.6	10.3
Nationwide	**5.9**	**2.9**	**10.2**	**6.3**	**5.0**	**1.9**	**8.8**	**4.1**

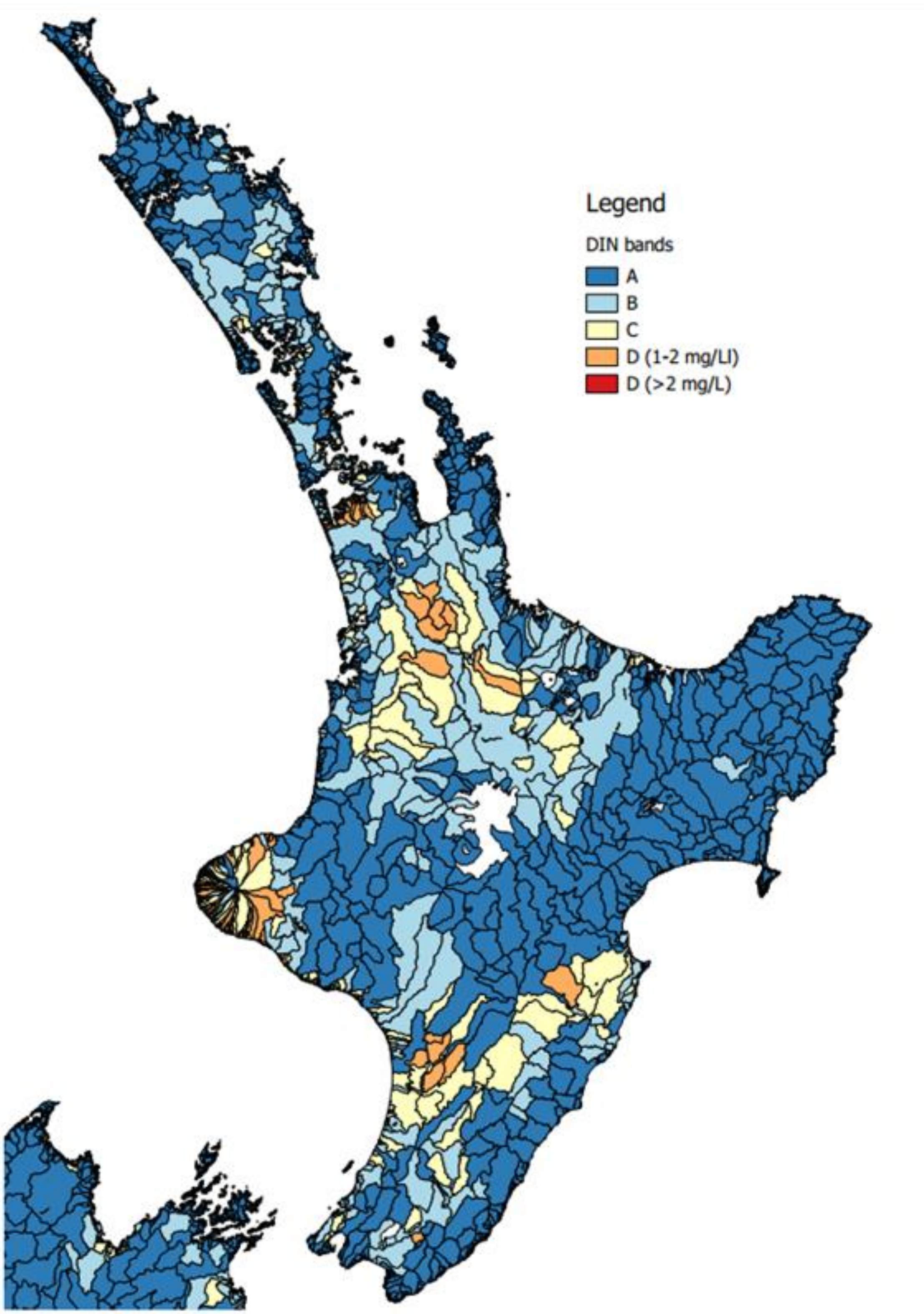


Figure 1. Modelled DIN attribute bands at the river reach draining the FENZ 5th order planning unit catchments throughout the North Island.

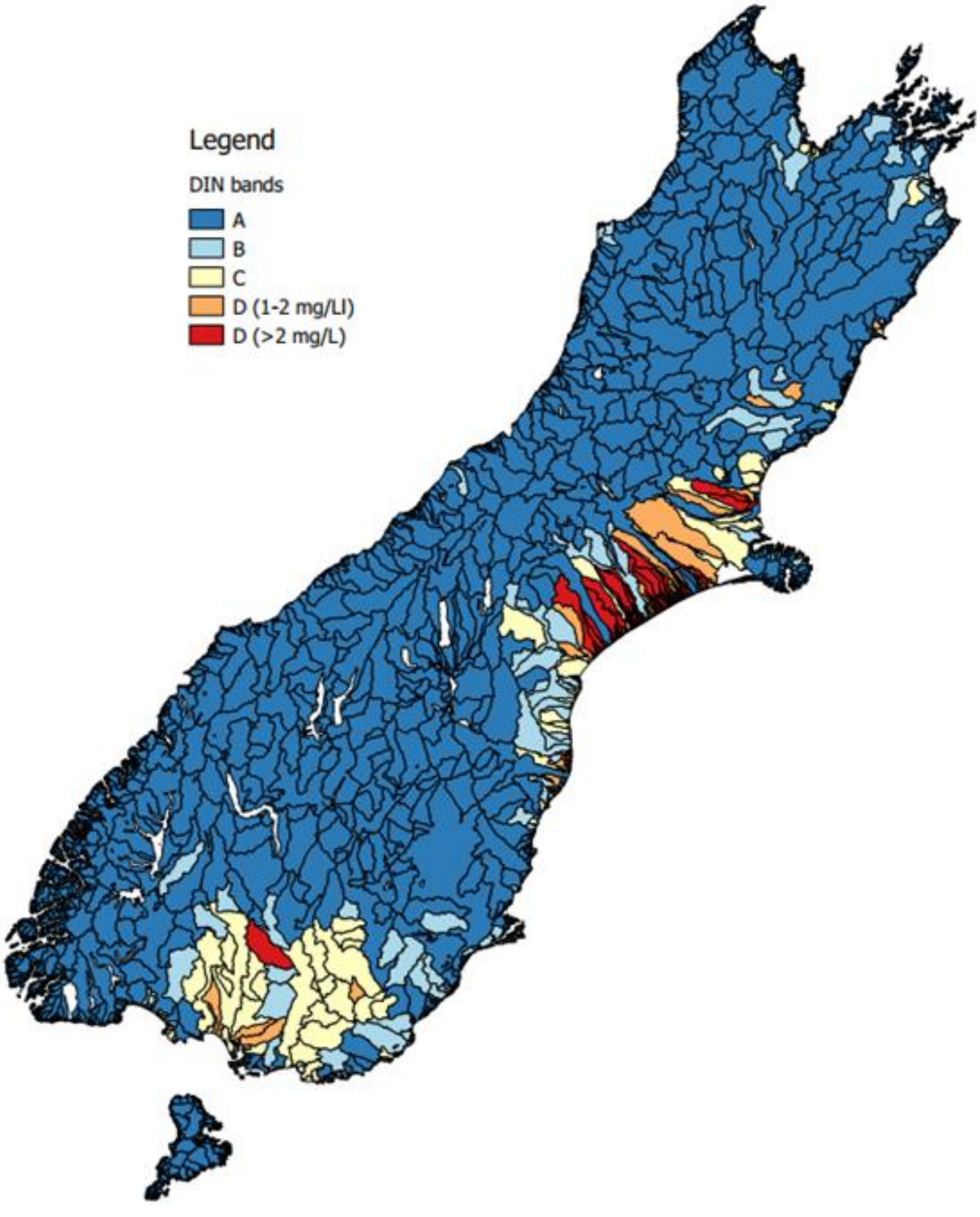


Figure 2. Modelled DIN attribute bands at the river reach draining the FENZ 5th order planning unit catchments throughout the South Island.

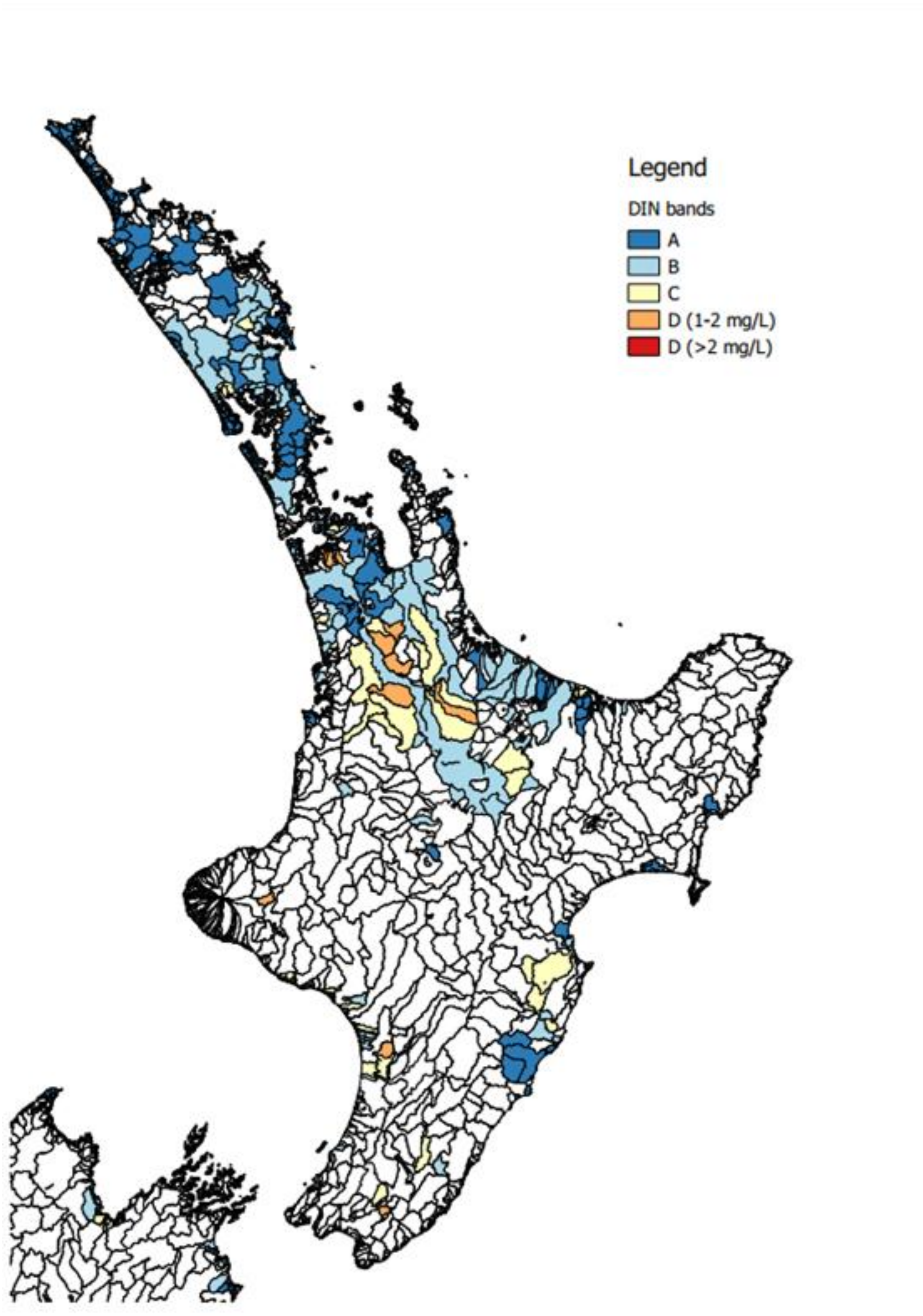


Figure 3. Modelled DIN attribute bands at the river reach draining the FENZ 5th order planning unit catchments throughout the North Island, except streams supporting periphyton in white.

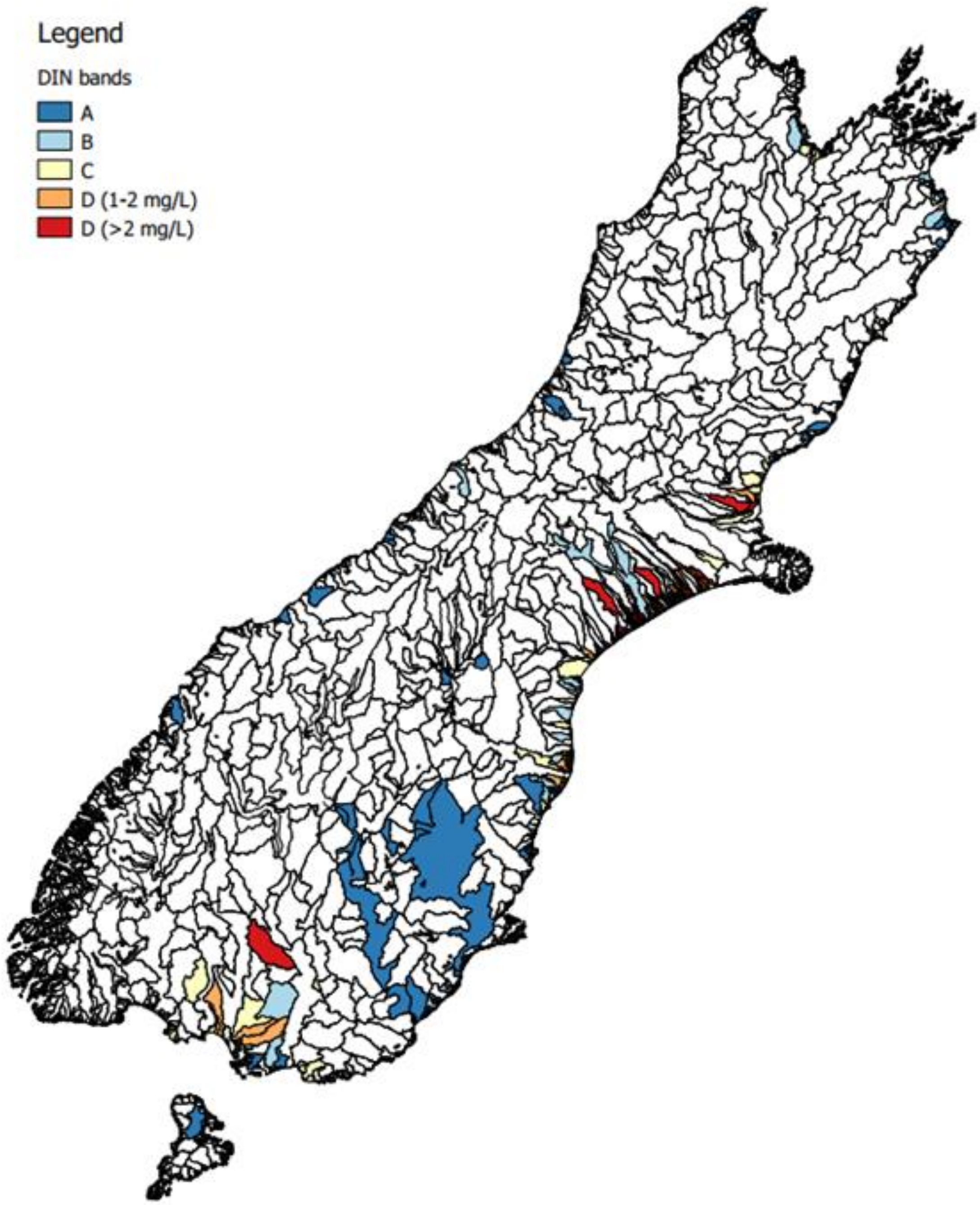


Figure 4. Modelled DIN attribute bands at the river reach draining the FENZ 5th order planning unit catchments throughout the South Island, except streams supporting periphyton in white.

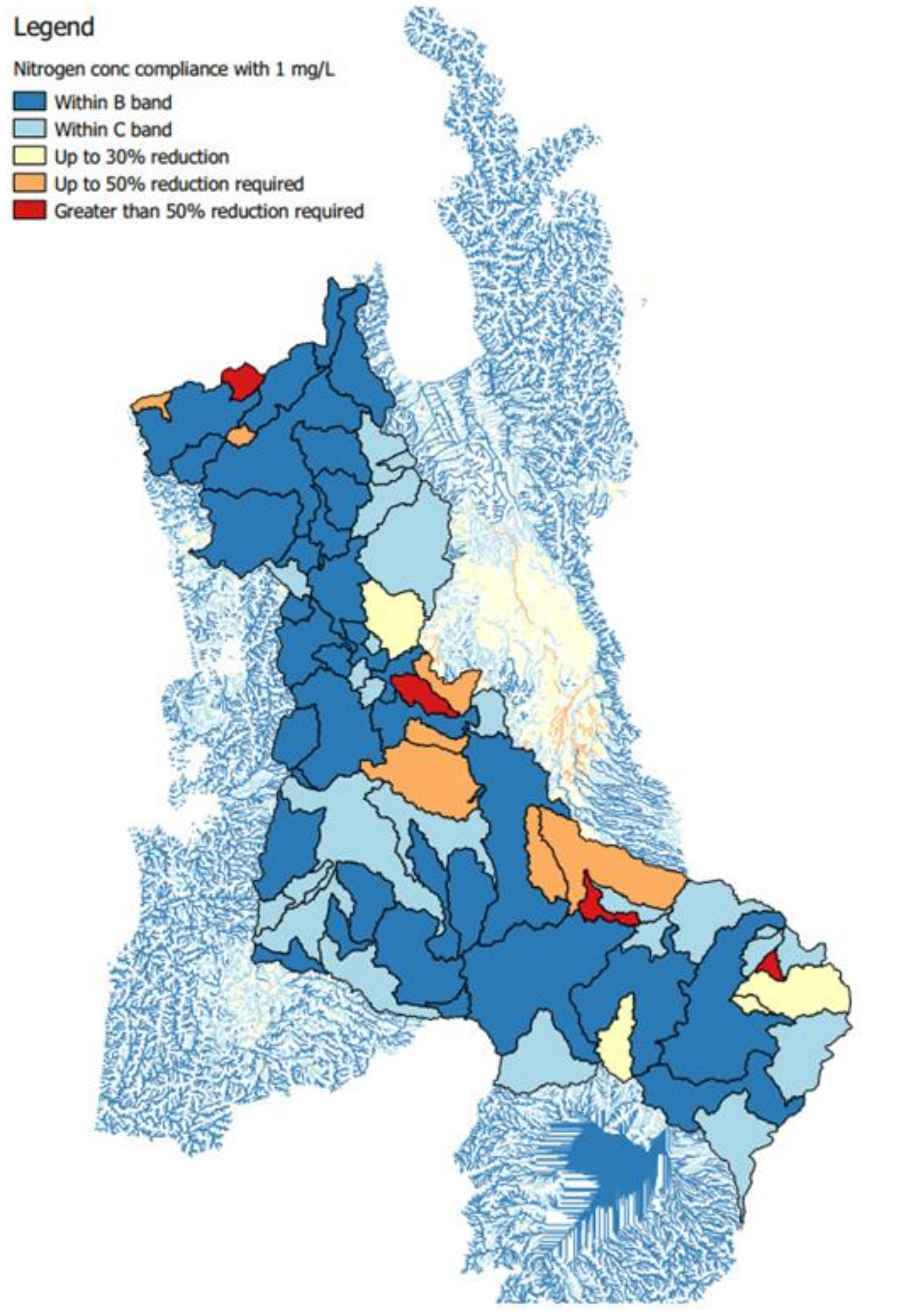


Figure 5. Compliance against the proposed DIN attribute in Waikato. Solid catchments (those used in Waikato Plan Change 1) represent measured concentrations; river lines represent modelled data.

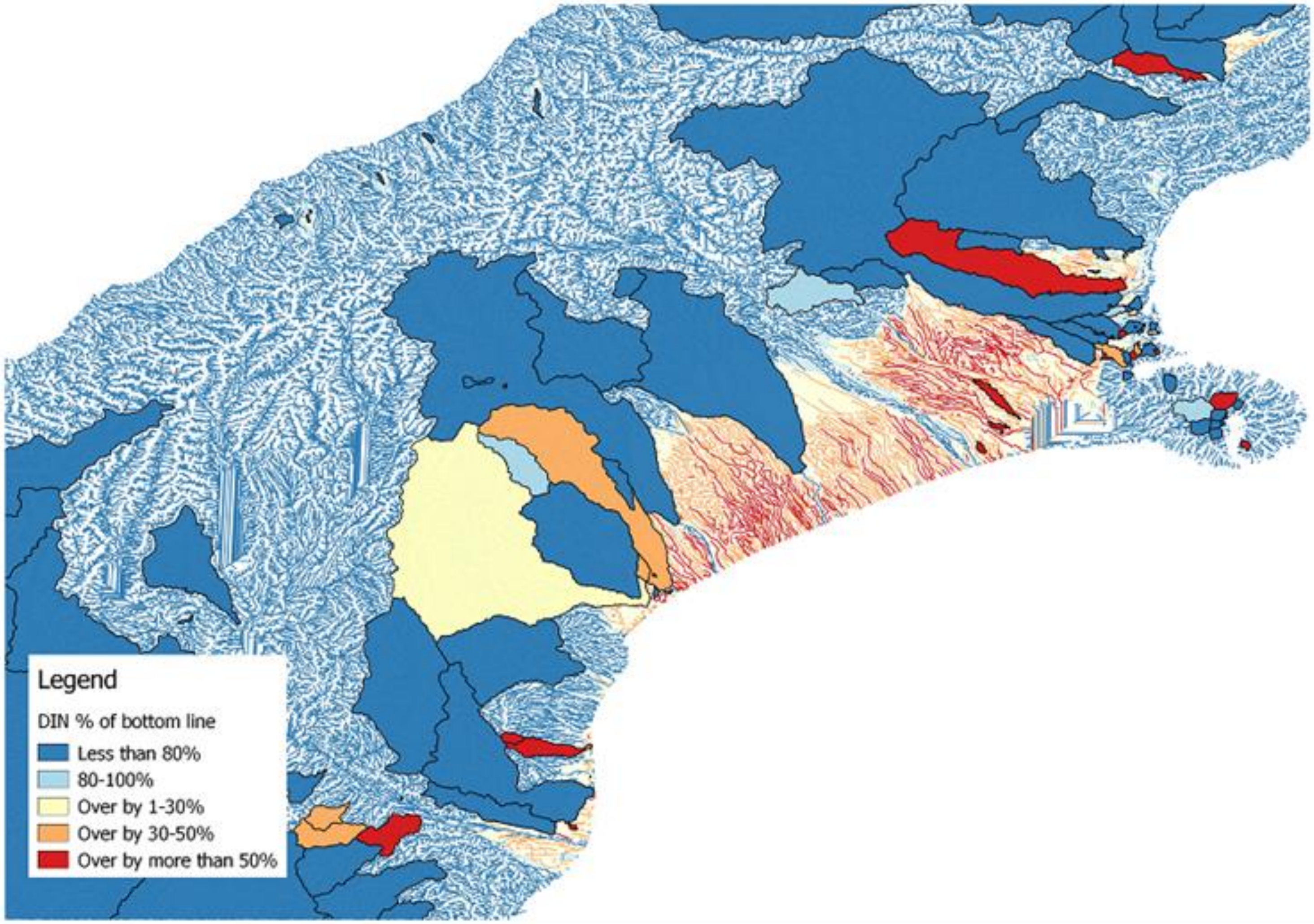


Figure 6. Compliance against the proposed DIN attribute in Canterbury. Solid catchments have measured concentrations; river lines represent modelled data.

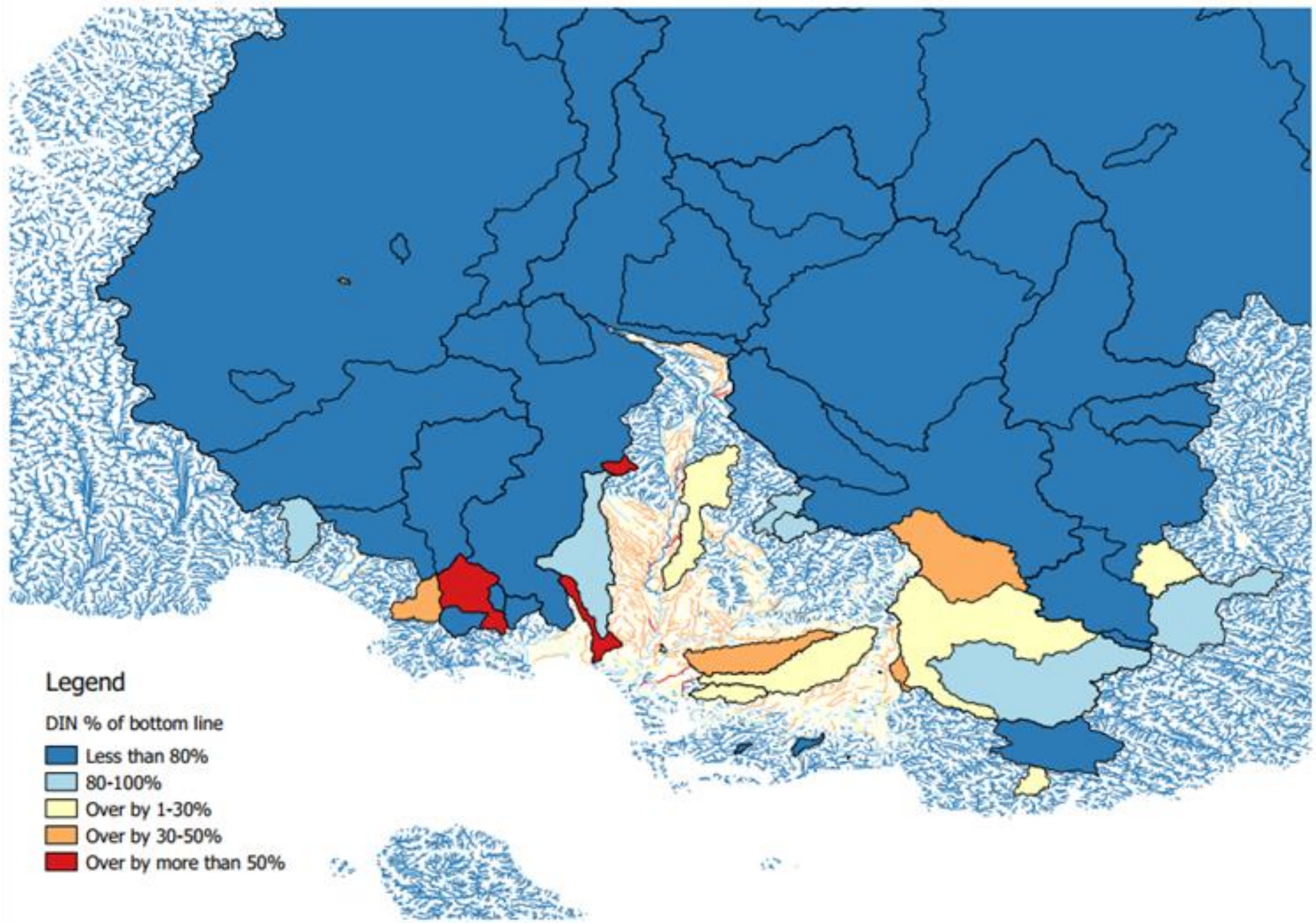


Figure 7. Compliance against the proposed DIN attribute in Southland. Solid catchments have measured concentrations; river lines represent modelled data.

Case studies where further nitrogen reductions might be required

Managing for ecosystem health of waterways requires considering multiple stressors. Managing only DIN and to the proposed bottom-line will be insufficient to ensure a healthy ecosystem. Good freshwater management will, by necessity, manage towards a wide array of standards. In many cases, DIN may need to be managed to a more stringent standard than the proposed bottom line of 1 mg/L. Furthermore, other actions beyond managing DIN will also be required for a healthy ecosystem, such as managing other contaminants, flow, riparian, habitat, sediment and migration pathways. The proposed NPS introduces a range of new standards to assist a more holistic management of waterway health. Limits to provide for all proposed attributes will be set on a river-specific basis, through the regional planning processes that are required, by law, to maintain or improve ecosystem health over time. As already discussed, in most catchments, DIN concentrations more stringent than the proposed 1 mg/L are likely required to comply with the existing periphyton attribute and the accompanying note on nutrient setting introduced in 2017. To illustrate how the full range of attributes may drive the need for more stringent standards on a case-by-case basis, two case studies are provided – one on the Horokiri Stream (Wellington) and another on the Manawatu River at Hopelands.

Case study one – Horokiri Stream

Horokiri (Horokiwi) Stream runs into the Pauatahanui Inlet, north of Porirua, Wellington. In the 1950s it was known as a very healthy stream with as was one of the world's most productive trout fisheries; however, by the mid-1960s the health of the stream and its fishery had collapsed severely. Table 3 provides a recent assessment of Horokiri Stream against the proposed ecosystem health attributes.

Table 3. A snapshot of likely grades for Horokiri Stream, Wellington assessed against the proposed ecosystem health attributes

Attribute	Grade
Periphyton	C
Macroinvertebrates (MCI & QMCI)	C
Macroinvertebrates (ASPM)	B
Fish IBI	D
Deposited sediment	B
Suspended sediment	B
Dissolved Inorganic Nitrogen	C
Dissolved Reactive Phosphorus	A
Dissolved Oxygen	ND
Ecosystem Metabolism	ND

Note: ND indicates no data available

Despite passing all other measured bottom-lines, Horokiri Stream falls below the bottom-line for Fish IBI attribute, suggesting there is little ecological integrity of the fish community remaining. Jellyman *et al.*, (2000) investigated the cause of decline in Horokiri Stream and concluded that extreme floods likely collapsed river banks, recently supported by Holmes *et al.*, (2018). The high sediment input made the stream shallower and wider, with a reduction in pools and riffles, reducing macroinvertebrate abundance. There was increased likely competition for macroinvertebrates and predation by eels. Furthermore, increased nutrients allowed greater macrophyte and algal growth – additional macrophytes could result in more sediment settling and infilling habitat. It is conceivable that the decline could have been prevented through controls on the vegetating high runoff areas (to regulate flows), vegetating highly erodible land, excluding stock to maintain bank stability, and having lower nutrient enrichment. That is, despite the sediment and nutrient attributes being above the bottom-line, they may require management to a more stringent standard to protect the ecosystem.

Case study two – Manawatu River at Hopelands

The Manawatu River at Hopelands drains the upper half of the Manawatu River catchment on the Eastern side of the Tararua and Ruahine ranges. It is notoriously infamous for being the site labelled as one of the worst rivers in the western world.[3] Whilst the validity of that claim is questionable, the Manawatu River still suffers from substantial degradation. Of the attributes assessed (Table 4), the site passes the periphyton, macroinvertebrate, sediment and DIN attributes, borderline passes the fish IBI, and scores fails phosphorus, dissolved oxygen and ecosystem metabolism. Graham and Franklin (2017) investigated the causes of low dissolved oxygen in the Manawatu and found water temperature and periphyton biomass were the key drivers. Improving water temperature and periphyton is likely to require a range of activities including further nutrient reductions (both nitrogen and phosphorus), managing low and high flows, and targeted restoration of riparian vegetation. Reducing the high phosphorus will likely increased sediment control and application reduction. Improving low oxygen and ecosystem metabolism may improve the borderline fish IBI score and the low macroinvertebrate scores.

Table 4. A snapshot of likely grades for the Manawatu River at Hopelands assessed against the proposed ecosystem health attributes

Attribute	Grade
Periphyton	C
Macroinvertebrates (MCI & QMCI)	C
Macroinvertebrates (ASPM)	C
Fish IBI	C/D (borderline)
Deposited sediment	ND
Suspended sediment	A
Dissolved Inorganic Nitrogen	C
Dissolved Reactive Phosphorus	D
Dissolved Oxygen	D
Ecosystem Metabolism	D

Note: ND indicates no data available

[3] http://www.stuff.co.nz/environment/3097651/Manawatu-River-among-worst-in-the-West

Land use in catchments exceeding the proposed DIN Bottom-line

Aim: To determine the areas and national proportions of dairy, other livestock or cropping in catchments modelled to require a 5-20% reduction, a 20-40% reduction, a 40-60% reduction and more than a 60% reduction in DIN concentration to meet the proposed 1 mg/L bottom-line. Data is also presented at the regional-level and for soft and hard bottomed rivers.

The Freshwater Environments New Zealand (FENZ; Leathwick *et al.*, 2010) fifth-order catchment-based planning units were used to define catchments across the country.

A catchment was determined to exceed the proposed DIN bottom-line when the modelled DIN at the catchments pour-point exceeds 1.0 mg/L (Larned, Snelder and Unwin, 2017). Whilst there is an extensive network of nutrient monitoring sites across the country, they are often not spatially representative, are selected for a range of purposes, and do not cover all catchments. To circumvent this, modelled DIN concentrations were used as these cover all river reaches across the country.

Land use information for each catchment was extracted from the LUCAS 2016 land use map, using ArcGIS Pro. Land uses are classified as either dairy, other livestock or cropping (includes all annual and perennial crops, all orchards and vineyards).

Given that the NPS-FM 2017 requirement to set DIN limits to achieve the periphyton objective, and that these limits are anticipated to be more stringent than the proposed DIN bottom-line, the area and proportion of affected land uses only in soft-bottomed rivers (unlikely to support periphyton) are also provided. A river was defined as soft-bottomed, when the predicted weighted average of proportional cover of bed sediment size at a given river reach is fine gravels or smaller (FENZ ReachSed ≤3; Leathwick *et al.*, 2010). No accommodation was made for the requirement to set instream DIN concentrations to provide for sensitive downstream environments, as a result, the land use areas modelled to be affected by the DIN at soft-bottomed rivers may be over-estimated.

Nationally, 20% of dairy (Table 5), 5% of other livestock (Table 6), and 32% of cropping (Table 7), occurs in catchments that exceed the proposed DIN bottom-line. However, when the existing periphyton requirements are accounted for (excluding the sensitive downstream environment requirement), then 9% of dairy, 2% of other livestock and 12% of cropping are affected. There is, however, substantial variation with Auckland, Waikato, Canterbury and Otago being most impacted.

Table 5. The area (ha) and proportion (%) of **dairy** in FENZ 5th order planning unit catchments in each region and nationally that have modelled DIN either with 5-20, 20-40, 40-60 and >60% above the proposed DIN bottom-line of 1.0 mg/L. Recognising that the existing periphyton attribute table should already be driving at least equally as stringent DIN limits, the data is shown with all rivers and only soft bottomed rivers.

Region	All rivers								Soft-bottomed rivers								Total area (ha)
	5-20%		20-40%		40-60%		>60%		5-20%		20-40%		40-60%		>60%		
	Area	%	Area	%	Area	%	Area	%	Area	%	Area	%	Area	%	Area	%	
Northland	1	0.0	0	0.0	0	0.0	0	0.0	1	0.0	0	0.0	0	0.0	0	0.0	154963
Auckland	4930	13.3	1011	2.7	0	0.0	0	0.0	3687	10.0	308	0.8	0	0.0	0	0.0	36969
Waikato	45025	8.4	25765	4.8	0	0.0	0	0.0	30992	5.8	25765	4.8	0	0.0	0	0.0	538988
Bay of Plenty	58	0.1	0	0.0	0	0.0	0	0.0	30	0.0	0	0.0	0	0.0	0	0.0	90297
Gisborne	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	371
Taranaki	33238	15.2	58555	26.7	0	0.0	0	0.0	11811	5.4	7755	3.5	0	0.0	0	0.0	219205
Horizons	8747	7.3	5860	4.9	0	0.0	0	0.0	3737	3.1	0	0.0	0	0.0	0	0.0	119149
Hawkes Bay	938	3.8	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	24468
Greater Wellington	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	28806
Nelson	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	18779
Marlborough	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	8046
West Coast	58	0.1	18	0.0	0	0.0	0	0.0	58	0.1	18	0.0	0	0.0	0	0.0	83429
Canterbury	13127	5.1	43415	16.9	65024	25.4	38269	14.9	6846	2.7	5931	2.3	9066	3.5	18787	7.3	256192
Otago	187	0.2	7778	8.9	0	0.0	0	0.0	144	0.2	5482	6.3	0	0.0	0	0.0	87045
Southland	9239	4.5	11620	5.7	1564	0.8	0	0.0	9167	4.5	11076	5.4	13869	6.8	0	0.0	205157
National	**115548**	**6.2**	**154021**	**8.2**	**66587**	**3.6**	**38269**	**2.0**	**66473**	**3.6**	**56334**	**3.0**	**22935**	**1.2**	**18787**	**1.0**	**1871862**

Table 6. The area (ha) and proportion (%) of **other livestock** in FENZ 5th order planning unit catchments in each region and nationally that have modelled DIN either with 5-20, 20-40, 40-60 and >60% above the proposed DIN bottom-line of 1.0 mg/L. Recognising that the existing periphyton attribute table should already be driving at least equally as stringent DIN limits, the data is shown with all rivers and only soft bottomed rivers.

Region	All rivers								Soft bottomed rivers								Total area (Ha)
	5-20%		20-40%		40-60%		>60%		5-20%		20-40%		40-60%		>60%		
	Area	%	Area	%	Area	%	Area	%	Area	%	Area	%	Area	%	Area	%	
Northland	36	0	0	0	0	0	0	0	36	0	0	0	0	0	0	0	394203
Auckland	7487	5	1278	1	0	0	0	0	5252	4	523	0	0	0	0	0	142293
Waikato	20067	3	15591	2	0	0	0	0	10915	2	15591	2	0	0	0	0	694519
Bay of Plenty	124	0	0	0	0	0	0	0	39	0	0	0	0	0	0	0	182032
Gisborne	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	240349
Taranaki	9553	6	7185	4	0	0	0	0	3508	2	402	0	0	0	0	0	165685
Horizons	34930	3	8258	1	0	0	0	0	5911	1	0	0	0	0	0	0	1022831
Hawkes Bay	27168	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	719379
Greater Wellington	3479	1	0	0	0	0	0	0	3479	1	0	0	0	0	0	0	307816
Nelson	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	75022
Marlborough	142	0	0	0	0	0	0	0	142	0	0	0	0	0	0	0	230437
West Coast	6	0	61	0	0	0	0	0	6	0	61	0	0	0	0	0	88305
Canterbury	10563	1	51336	3	113919	6	61328	3	3274	0	6854	0	10434	1	27829	1	1911536
Otago	383	0	7231	0	0	0	0	0	349	0	507	0	0	0	0	0	1670926
Southland	11440	1	10634	1	41931	5	0	0	11117	1	10308	1	41931	5	0	0	800730
National	**125378**	**1**	**101574**	**1**	**155850**	**2**	**61328**	**1**	**44027**	**2**	**34245**	**2**	**52365**	**3**	**27829**	**1**	**8646063**

Table 7. The area (ha) and proportion (%) of **cropping** in FENZ 5th order planning unit catchments in each region and nationally that have **modelled DIN** either with 5-20, 20-40, 40-60 and >60% above the proposed DIN bottom-line of 1.0 mg/L. Recognising that the existing periphyton attribute table should already be driving at least equally as stringent DIN limits, the data is shown with all rivers and only soft bottomed rivers.

Region	All rivers								Soft-bottomed rivers								Total area (Ha)
	5-20%		20-40%		40-60%		>60%		5-20%		20-40%		40-60%		>60%		
	Area	%	Area	%	Area	%	Area	%	Area	%	Area	%	Area	%	Area	%	
Northland	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9746
Auckland	3381	33	407	4	0	0	0	0	1839	18	138	1	0	0	0	0	10366
Waikato	647	3	1143	6	0	0	0	0	408	2	1143	6	0	0	0	0	18948
Bay of Plenty	162	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	29200
Gisborne	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16654
Taranaki	544	25	139	6	0	0	0	0	38	2	66	3	0	0	0	0	2146
Horizons	1124	7	804	5	0	0	0	0	153	1	0	0	0	0	0	0	15200
Hawkes Bay	409	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	35104
Greater Wellington	644	8	0	0	0	0	0	0	644	8	0	0	0	0	0	0	8317
Nelson	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9344
Marlborough	677	2	0	0	0	0	0	0	677	2	0	0	0	0	0	0	34831
West Coast	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	42
Canterbury	5668	2	19739	8	65024	27	38269	16	1458	1	5208	2	20463	9	20262	9	237171
Otago	0	0	447	3	0	0	0	0	0	0	447	3	0	0	0	0	15445
Southland	12	0	1101	15	1564	21	0	0	12	0	1101	15	1564	21	0	0	7427
National	**13269**	**3**	**23780**	**5**	**66587**	**15**	**38269**	**9**	**5230**	**1**	**8104**	**2**	**22027**	**5**	**20262**	**5**	**449941**

Pastoral nitrogen leaching in catchments exceeding the proposed DIN Bottom-line

Aim: To determine the proportions of nitrogen leaching from dairy, sheep, beef and deer in catchments modelled to require a 5-20% reduction, a 20-40% reduction, a 40-60% reduction and more than a 60% reduction in DIN concentration to meet the proposed 1 mg/L bottom-line. Data is presented as regional and national summaries for soft and hard bottomed rivers.

Consistent with above, the Freshwater Environments New Zealand (FENZ; Leathwick *et al.*, 2010) fifth-order catchment-based planning units were used to define catchments across the country and modelled DIN were applied at the pour-points (Larned, Snelder and Unwin, 2017). The same approach as above for determining soft-bottomed rivers was also used here.

The nitrogen leaching loads were extracted from Ausseil and Manderson (2018) GIS maps of nitrogen leaching in 2017, using ArcGIS Pro. Pastoral land uses assessed were dairy, sheep, beef and deer.

Nationally, for catchments exceeding a DIN of 1.0 mg/L, on average, 83% of the pastoral nitrogen leaching comes from dairy, 7% from beef, 8.7% from sheep and 0.3% from deer (Table 8). When the existing periphyton requirements are accounted for (excluding the sensitive downstream environment requirement), these proportions remain (Table 9). Whilst there is variation between catchments, in 80% of catchments in exceedance, the proportion of pastoral nitrogen leaching from dairy is between 80-100%.

When assessing the proportions for a region, it is important to consider the context provided in the previous section which accounts the total area of a land use affected, otherwise interpretation may be misleading. For example, 50% of the nitrogen load from one land use may be relatively insignificant if it only relates to a very small area of land affected.

Table 8. The proportion (%) of **pastoral nitrogen leaching** in FENZ 5th order planning unit catchments in each region and nationally that have **modelled DIN** either with 5-20, 20-40, 40-60 and >60% above the proposed DIN bottom-line of 1.0 mg/L, **for all rivers**.

Region	5-20%				20-40%				40-60%				>60%			
	Dairy	Sheep	Beef	Deer	Dairy	Sheep	Beef	Deer	Dairy	Sheep	Beef	Deer	Dairy	Sheep	Beef	Deer
Northland	8.3	-	91.7	-	-	-	-	-	-	-	-	-	-	-	-	-
Auckland	81.8	2	15.9	0.6	72.0	0.3	27.4	0.3	-	-	-	-	-	-	-	-
Waikato	62.8	2	35.2	-	91.7	1.7	6.4	0.2	-	-	-	-	-	-	-	-
Bay of Plenty	95.5	-	4.5	-	-	-	-	-	-	-	-	-	-	-	-	-
Gisborne	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Taranaki	98.2	-	1.4	-	97.6	0.5	1.9	-	-	-	-	-	-	-	-	-
Horizons	66.1	14	19.2	0.7	82.6	4.1	13.0	0.3	-	-	-	-	-	-	-	-
Hawkes Bay	24.9	32	40.9	2.1	-	-	-	-	-	-	-	-	-	-	-	-
Greater Wellington	22.0	35	43.2	-	-	-	-	-	-	-	-	-	-	-	-	-
Nelson	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Marlborough	-	97	3.1	-	-	-	-	-	-	-	-	-	-	-	-	-
West Coast	100.0	-	-	-	50.0	-	-	50.0	-	-	-	-	-	-	-	-
Canterbury	70.4	20	6.4	2.8	79.2	15.7	4.9	0.3	84.0	10.6	5.1	0.3	92.9	3.6	3.0	0.5
Otago	57.0	23	20.2	-	92.1	5.3	2.5	-	-	-	-	-	-	-	-	-
Southland	67.0	31	1.8	0.1	93.4	5.0	0.7	0.9	59.3	25.6	13.7	1.4	-	-	-	-
National	**81.1**	**8**	**10.2**	**0.6**	**88.7**	**6.2**	**3.8**	**1.2**	**82.8**	**11.3**	**5.5**	**0.3**	**92.9**	**3.6**	**3.0**	**0.5**

Table 9. The proportion (%) of **pastoral nitrogen leaching** in FENZ 5th order planning unit catchments in each region and nationally that have **modelled DIN** either with 5-20, 20-40, 40-60 and >60% above the proposed DIN bottom-line of 1.0 mg/L, **for soft-bottomed rivers only**.

Region	5-20%				20-40%				40-60%				>60%			
	Dairy	Sheep	Beef	Deer	Dairy	Sheep	Beef	Deer	Dairy	Sheep	Beef	Deer	Dairy	Sheep	Beef	Deer
Northland	8.3	-	91.7	-	-	-	-	-	-	-	-	-	-	-	-	-
Auckland	81.6	1.7	16.1	0.6	67.8	0.2	32.0	-	-	-	-	-	-	-	-	-
Waikato	55.3	2.1	42.5	0.1	91.7	1.7	6.4	0.2	-	-	-	-	-	-	-	-
Bay of Plenty	100.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Gisborne	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Taranaki	98.5	0.3	1.1	-	97.3	0.5	2.2	-	-	-	-	-	-	-	-	-
Horizons	86.8	5.8	7.1	0.3	-	-	-	-	-	-	-	-	-	-	-	-
Hawkes Bay	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Greater Wellington	22.0	34.7	43.2	-	-	-	-	-	-	-	-	-	-	-	-	-
Nelson	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Marlborough	0.0	96.9	3.1	-	-	-	-	-	-	-	-	-	-	-	-	-
West Coast	100.0	-	-	-	50.0	-	-	50.0	-	-	-	-	-	-	-	-
Canterbury	67.9	23.6	7.0	1.5	77.2	17.8	4.8	0.2	85.7	10.4	3.7	0.2	93.4	3.1	2.9	0.6
Otago	60.6	34.1	5.3	-	99.8	0.2	-	-	-	-	-	-	-	-	-	-
Southland	68.8	28.7	2.3	0.1	90.1	8.3	1.3	0.4	59.3	25.6	13.7	1.4	-	-	-	-
National	**81.1**	**8.5**	**10.0**	**0.4**	**87.2**	**7.4**	**3.9**	**1.5**	**84.2**	**11.2**	**4.3**	**0.2**	**93.4**	**3.1**	**2.9**	**0.6**

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