Action for Healthy Waterways

DairyNZ Submission

31 October 2019

DairyNZ

This submission was authorised by:

Dr Tim Mackle
Chief Executive
DairyNZ
tim.mackle@ceo.dairynz.co.nz

About DairyNZ

DairyNZ is the industry good organisation representing New Zealand's dairy farmers. Funded by a levy on milk solids and through Government investment, our purpose is to secure and enhance the profitability, sustainability and competitiveness of New Zealand dairy farming.

We deliver value to farmers through leadership, influencing, investing, partnering with other organisations and through our own strategic capability. Our work includes research and development to create practical on-farm tools, leading on-farm adoption of best practice farming, promoting careers in dairying and advocating for farmers with central and regional government. For more information visit www.dairynz.co.nz

For further information regarding this submission contact:
Dr David Burger
Strategy Investment Leader
DairyNZ
Private Bag 3221
Hamilton 3240
Phone 0800 4 DairyNZ (0800 4 324 7969)

Table of Contents

Preface

This submission is the culmination of eight weeks of intensive engagement with our farmers, involving 19 national workshops, drop-in events and webinars that attracted a record turn-out of over 2,100 attendees. It also includes input from our Dairy Environment Leaders Group, colleagues across dairy processing and many more.

Our work has also been shaped by many farmers who contacted us directly to share their vision for their local catchments, and help us identify which of the Government's proposals have the strongest potential to stop any further degradation of our waterways and wetlands, and start the process of reversing past damage.

We all have a shared vision. As New Zealanders we all want improved waterways, for today and for tomorrow. In reality, dairy has been on this journey for many years, with significant changes undertaken on farm already delivering improved environmental outcomes. We know this work must continue.

This submission contains over 120 pages of technical commentary on the Essential Freshwater proposals. Firstly, we want to share with you some of the unanimous feedback that we have received from our farmers over the past two months.

Overwhelmingly at every workshop we heard about our farmers' passion for their land, their herds, their on-farm teams and their local communities. This passion is often dismissed by others and always under-estimated. However, it's this passion that funds, through DairyNZ and other groups, leading-edge research into projects aimed at improving water quality and ecosystem health outcomes; drives continuous improvements in farm management practices; and helps maintain the economic and social wellbeing of most of regional New Zealand.

But don't just take our word for it, let's take you through some of what has been achieved so far.

As part of the Sustainable Dairying Water Accord process our farmers made a collective, voluntary commitment to implement a series of good management practices to lift the environmental performance of dairy farmers. By entering into the Accord, dairy farmers demonstrated their determination to take ownership of the environmental challenges created by existing farm systems. They also committed to implementing a series of practical changes to improve the environmental footprint of their farm businesses, and to have their results subject to an independent audit process.

Over the past five-years, our farmers have:

- Excluded dairy cattle from 24,744km of New Zealand's waterways.
- Ensured that 100% of stock crossing points on New Zealand dairy farms have bridges or culverts to prevent stock entry into waterways.
- Ensured that 100% of dairy farms have their effluent management practices systematically assessed.
- Developed Riparian Management Plans for 52% of all New Zealand dairy farms.

In 2018 we launched the Good Farming Practice Water Quality Action Plan in partnership with primary sector stakeholders, regional councils and central Government, representing our collective commitment to further improve on-farm practices to improve our waterways.

At DairyNZ we have also been investing in new science and tools to better understand our footprint and how best to reduce it – for example, our work on constructed wetlands, bioreactors, farm system options and catchment modelling.

Although our farmers recognise that improving their environmental performance is an ongoing process, it is important to acknowledge that the changes our farmers have already delivered are world-leading. The work started through the Accord process has now also been translated into our *Dairy Tomorrow* Strategy which strengthens famers' commitment to:

- Protecting and nurturing the environment for future generations.
- Building the world's most competitive and resilient dairy farming businesses.
- Producing the highest quality and most valued dairy nutrition.
- Becoming world leaders in animal care.
- Building great workplaces for New Zealand's most talented workforce.
- Growing vibrant and prosperous communities.

Against this background, we also heard that our farmers are deeply concerned about the tight timeframes for delivering the Government's political agenda ahead of the 2020 election, and these timeframes have hampered meaningful efforts to harness their experience and expertise during the development of the Essential Freshwater package.

Consequently, our farmers have registered significant concerns regarding the technical feasibility of many of the proposals as well as the reliability of the underlying cost/benefit analysis. We know thousands of farmers have provided feedback through the submission process, and we applaud the effort, care and passion they have had in finding practical and appropriate on-farm options for positive environmental outcomes.

We also heard their widespread disappointment that the discussion document has not developed a more extensive range of regulatory and voluntary measures and co-management approaches.

The following sections of this document outline our farmers' concerns in more detail and, provide responses to MfE's specific consultation questions.

Thank you for taking the time to review our submission. We look forward to discussing it with you in more detail over the coming weeks.

Dr Tim Mackle
Chief Executive

Jim van der Poel
Chairman

Executive Summary

Freshwater is essential to our lives and the ecosystems we rely on. In addition to sustaining our health and wellbeing, our freshwater resources shape New Zealand's cultural identity, provide important recreation opportunities, and drive our economic performance. Although some of our freshwater bodies surpass current minimum requirements for safeguarding the life-supporting capacity of our water resources, we recognise that in some parts of New Zealand freshwater quality does not always meet community needs or expectations. This is due to a broad range of factors including agricultural intensification, urban expansion, industrial pollution and, hydroelectric power generation, as well as natural processes. Over the coming decades, predicted patterns of climate change will further influence the availability and quality of our freshwater resources.

The release of the Essential Freshwater Discussion Document provides an important opportunity to undertake a more detailed assessment of the current state, trends and drivers of freshwater quality, and to identify the most efficient and effective means of delivering durable improvements over the short, medium and long term. Against this background **DairyNZ supports** the implementation of more targeted efforts to immediately halt any further degradation of our freshwater resources. We agree that the following proposals represent a good starting point towards achieving this:

- Sharpening the focus of the current NPS-FM.
- Introducing interim controls on land use intensification.
- Developing a new freshwater planning process.
- Requiring stock exclusion of significant waterways.
- Introducing mandatory requirements for farmers and growers to develop farm environment plans and set minimum expectations regarding certain on-farm management practices.
- Setting clear interim standards for swimming in summer, pending the completion of the Microbiological Water Quality Guidelines for Marine and Freshwater Recreational Areas review.

These proposals will build on the momentum generated by current primary sector initiatives such as the Good Farming Practice: Action Plan for Water Quality that aim to embed and continuously improve management practices across every farm system in New Zealand, and reflect the most effective approach for improving water quality outcomes quickly for all contaminants. The proposals are also broadly aligned with the dairy sector's *Dairy Tomorrow* strategy and, have the potential to accelerate the delivery of our farmers' environmental management commitments.

At the same time there are a number of policies which **DairyNZ does not support** because we believe the Government's water quality and broader emissions reductions objectives can be achieved with less stringent reforms, and at a minimal cost to the New Zealand economy. For example, the economic modelling conducted by DairyNZ (outlined in Appendix 4) indicates that the Essential Freshwater package could reduce the Government's Gross Domestic Product forecasts by $6 billion by 2050. The resulting economic effects will be felt by all New Zealanders. The proposed nutrient limits, which include the broadscale introduction of phosphorous and nitrogen leaching reductions in monitored catchments, are based on overly simplistic causal relationships and are not supported by robust science as demonstrated by our technical analysis located at Appendices 1, 2 and 3.

Dairy farmers are understandably concerned at the prospect of being required to invest in mitigations that will impose significant, additional costs without assurance around corresponding environmental gains.

Some proposals will require further refinement if the Government's objectives of achieving material water quality improvements within five years and reversing past damage within a generation are to be met. We strongly encourage Government to work in partnership with DairyNZ to ensure farmers are provided with clear, relevant and trusted advice regarding their new regulatory obligations and adaption pathways and, that farmers have access to reliable and affordable tools to support decision-making on-farm.

DairyNZ broadly welcomes the proposals to raise the bar on ecosystem health by developing a broader range of integrated ecosystem health attributes, and developing Action Plans to prioritise effort where it is needed most. However, we have recommended refinements to the proposed attributes, thresholds and/or standards for addressing sediment, nitrogen toxicity and the macroinvertebrate community index. Our recommendations are designed to ensure that any new attributes incorporate the best available scientific data and will deliver measurable and sustainable improvements in ecosystem health. We have also registered concerns regarding proposals to develop multiple measures that assess the same dimensions of ecosystem health – for example the three proposed macroinvertebrate indices – as we believe this approach will increase complexity without necessarily delivering any ecosystem health gains.

As is inevitably the case with such a far-reaching policy development process, there are several instances where we disagree with the underlying policy and scientific analysis. We would have liked to have seen a stronger emphasis on the role of adaptive management approaches in developing specific solutions at the catchment scale. There is also a fundamental analytical gap in relation to the significant socio-economic impacts the proposals will have on the dairy sector and wider economy, and the support mechanisms that will need to be developed to assist the transition process. Finally, we are concerned that several proposals cannot be implemented in an efficient or effective manner at this point because of the Government's decision to defer detailed consideration of water allocation issues, and the failure to address longstanding capacity constraints in the local government sector.

The following table summarises DairyNZ's position on the key proposals with the remaining sections of this submission providing extensive analysis and commentary on those that we support, either in full or conditionally, and those which should not proceed. These positions have been informed by our conversations with farmers and milk companies. We firmly believe that by acting on our recommendations, Government and dairy farmers can work together to deliver lasting water quality gains at a more rapid pace, and significantly less socio-economic cost, than the current proposals.

Summary of DairyNZ positions

DairyNZ positions as summarised are supported in-principle by Fonterra, Miraka, Oceania Dairy, Tatua and Westland Milk Products.

Support | **Support with amendment** | **Do not support**

Policy	Proposal	Implications for Dairy farmers	DairyNZ position	DairyNZ Recommendation
Improving farm practices				
Freshwater Farm Plans (FW-FP)	• All farmers and growers to have a FW-FP to manage risks to waterways by 2025	• Generally aligns with Dairy Tomorrow sector strategy • Builds off industry and farmer efforts so far • Approximately 3000 dairy farms already have an environment plan • Existing plans may not align or meet all new NPS/NES criteria • Robust plans for all 12,000 dairy farms will require time and capability to deliver	• Support mandatory and audited FW-FPs prepared by certified advisors • This is the best way to manage environmental risk on-farm and to start improving water quality outcomes quickly for contaminants • Support national certification scheme similar to the approach proposed by Waikato PC1 and currently being developed under the Integrated Farm Planning process led by MPI/MfE • Support proposed timeframes and content but require clarity on drafting • Plans need to be adaptable and allow for innovation	• Avoid penalising early adopters; those with current, robust Farm Environment Plans shouldn't need to have them redone • That Government works with the sector on integrated farm planning, certification and implementation to ensure practicality for farmers and policy achieves intended outcomes • Government needs to invest in infrastructure (certification and auditing schemes) and capability to support delivery within the proposed timeframes
Immediate action on N loss	• Reduce N-loss through interim measures in proposed high-N catchments • Three options being considered: N-cap, fertiliser-cap and FW-FPs	• Targets allocation ahead of improving farm practices • Implementation requires robust Overseer files and supporting data for current and historical years for 21% of all dairy farms; this data is not currently available and will take several years to achieve	• Support the need to manage nitrogen in priority catchments where the science linking nitrogen to impact is clear • Do not support thresholds based on N loss as there is insufficient information or systems to deliver immediate action • Support modified options 1 and 3 (reducing N surplus through a FW-FP) as an interim approach	• Focus on improving N-use efficiency and practices as an interim measure before completion of limit setting and allocation (Option 3 of RIS) • Target highest N surplus farms (90th percentile) in each catchment; this will lead to immediate action in the short term and still drive reductions in N loss • Farms under threshold need to remain at current N surplus or below
Restricting further intensification	• No further intensification from June 2020 • Applies in catchments where limit-setting process not fully implemented	• Any increases in contaminant loading in these areas risks requiring all farmers to make greater reductions to their footprint in future • Intensification already prohibited for many dairy regions	• Broadly support no further intensification in over-allocated catchments until the limit-setting process is implemented • Require further clarity around the allocation status of many catchments	• Regional councils define allocation status for N, P, sediment and bacteria for all catchments within 12 months • Provide clarity on how the proposal would quantify sediment and bacteria discharges; this cannot be achieved with existing tools

Policy	Proposal	Implications for Dairy farmers	DairyNZ position	DairyNZ Recommendation
Stock exclusion	• Regulations for stock exclusions and buffer widths on permanent waterways • Some moving of fences will be required • Timeframes for moving fences based on minimum setback	• Dairy farmers have already made significant voluntary investments to exclude large (>1m) waterways • Existing fence lines not meeting the new criteria would need to be moved; this penalises early adopters for marginal environmental gain	• Support current fencing to remain in place if minimum setbacks are achieved • Support 1m minimum setback • Support capturing smaller streams and critical sources through FEPs • Support an average setback approach but not 5m • Stock exclusion will only be effective if all land users exclude significant waterways	• For this policy to be effective it needs to capture more rivers on steeper slopes. Our modelling suggests load reductions are nearly doubled if stock exclusion is extended from 5 degrees to 15 degrees • Average setback is 3m, in line with many regional council plans • Existing fence lines not meeting the required setbacks are replaced at the end of the service life of the fence • Flood control restrictions and requirements should take precedent (as set by regional councils) • Government needs to clarify where the setback starts and finishes
Intensive winter grazing	• Standards for wintering of forage crops within 6 months of policy coming into effect • Two options proposed: regulation or sector standards	• Most practices proposed are considered good practice by the primary sector	• Support mandatory wintering plan in an FW-FP as a standard for a permitted activity • Support a mix of proposed 'national' and sector standards • Do not support pugging rules and these cannot be implemented or assessed on-farm	• Permitted Activity status up to a slope of 15 degrees and wintering area of 15% or 100ha, based on the Southland Land and Water Plan • Use of an interim winter grazing plan if a FW-FP has not yet been developed • Protocols and tools needed to measure and define slope • Support minimum standards and GMPs, according to individual farm risk • Remove the pugging rules
Stock holding areas	• Consented standards for stock-holding areas, including feed, wintering, stand-off and loafing pads	• An additional resource consent would be required for stock holding areas including feed pads • Sacrifice paddocks permitted activity if criteria met	• Support measures to manage environmental effects of stock- holding areas as permitted activities through FW-FPs • Oppose requiring a consent	• Clear, defined set of requirements are best managed through FW-FPs • Need further clarity on whether calf sheds and wintering barns included as both trigger rule thresholds

Policy	Proposal	Implications for Dairy farmers	DairyNZ position	DairyNZ Recommendation
Improving Ecosystem Health				
New attributes & management approach	• 15 additional attributes proposed for inclusion in the NOF	• Implications vary as managing ecosystem health is complex and involves managing a multitude of stressors on freshwater systems	• Support the need for additional attributes, particularly inclusion of integrated, holistic measures (dissolved oxygen, *E. coli*) • Support MCI as per existing MfE guideline, but not the proposed changes to the thresholds (no scientific basis) • Do not support multiple metrics for the same measure, as this results in confusion around assessment of state, where actions plans are triggered, and how success is monitored and reported	• Place emphasis on measuring ecological outcomes through regional councils customising catchment-specific management responses via Action Plans based on what's driving the problem • Require national guidance on criteria and content of Action Plans for the attributes identified in appendix 2B • Apply the MCI metric as the best integrated ecosystem health measure, as based on robust science and testing for over 30 years
New bottom lines for nutrients	• New bottom line for instream nitrogen (DIN) and phosphorus (DRP) for ecosystem health • Where instream concentrations exceed proposed values reductions needed over a generation	• These limits increase the annual cost of EFW package from $1 to $6 billion (reduced GDP) and reduce average dairy farm profit by 46% in 2050 • Approximately 22% of all dairy farms for DIN and 31% for DRP are in catchments exceeding the proposed limit • Limits may not drive ecosystem health sought by communities or the policy	• Support policies that protect ecosystem health alongside swimmability • Proposed nutrient limits are based on overly simplistic relationships and not supported by robust science • Ecosystem health reporting should focus on ecological responses such as nitrate toxicity, macroinvertebrate community health and dissolved oxygen	• Reduce the existing nitrate toxicity standard from 6.9 to 3.8 g/m3, providing for even the most sensitive native fish and invertebrates • Reduce the bottom-line for ammonia toxicity from 1.3 to 0.54 g/m^3 • Implement the 2017 NPS periphyton attribute to address trophic level nutrient concerns relevant to both *hard*- and *soft*-bottom streams for both N and P • No standard for DRP • Regional variability needs to be considered • Change SoE reporting for nutrients so that toxicity attributes are not used to infer 'ecosystem health status'

Policy	Proposal	Implications for Dairy farmers	DairyNZ position	DairyNZ Recommendation
Reducing sediment	• New limit-setting attribute for managing suspended sediment (SS) • New 'Action Plan' attribute for managing effects of deposited sediment	• SS bottom lines may be overly stringent in some areas and potentially too permissive in others, with high variability across small spatial scales • Many classes have turbidity bottom-lines that are lower than published effect-based literature thresholds (some catchments may be subject to limit setting despite having relatively low SS concentrations)	• Support managing SS through a bottom line and deposited sediment through adaptive management, to reflect the importance of sediment in degradation of water and habitat quality • The method used to derive the proposed SS thresholds is untested, does not account for variation in fine sediment at reference state, defines thresholds that are inconsistent with existing NOF attributes and will result in unworkable management outcomes	• Base SS classifications on the natural state of the river • Use a simpler system for managing 'bottom-line' adverse effects of suspended sediment. • Propose two alternative options for consideration: 1) using the values derived from the macroinvertebrates extirpation analysis (Appendix Hf) which produced thresholds of between approximately 5 and 8 NTU and corresponding to loss of 1% to 10% of macroinvertebrate species, or 2) bottom line thresholds based on an increase of 5 NTU relative to reference state
A higher standard for swimming	• Clear standards for water quality at swimming sites during the swimming season • Councils to prepare Action Plans to address risks	• Many pastoral catchments fail existing E. coli standards	• Support these proposals	• Undertake further work to understand how sources of bacteria are best mitigated
No further loss of wetlands	• Protect remaining existing wetlands and put tighter controls on certain activities that damage wetlands	• Would require councils to identify and develop monitoring to accurately determine the condition of the region's wetlands • Would put restrictions on activities considered most destructive to wetlands • Creating stronger incentives for farmers to identify, protect and enhance wetland areas through FW-FPs will deliver increased protection	• Support policies that recognise the importance of wetlands for improving water quality and biodiversity outcomes • Do not support monitoring requirements by farmers • Support measures which credit reductions in contaminant losses provided • Activities to maintain or restore natural wetlands should be a permitted activity • Hydrological monitoring requirements in a highly modified landscape is unclear	• NES should not put up barriers for farmers who seek to protect or restore wetlands • Developing inventories and monitoring wetland health on private land should be borne by Government • Further incentive mechanisms to accelerate wetland protection (i.e. improvements to modelling tools to recognise reductions in contaminant losses, and tax breaks) • The wetland area protected should contribute to the average farm riparian set-back width through the stock exclusion NES • Support the recognition of constructed wetlands as a distinct category

Policy	Proposal	Implications for Dairy farmers	DairyNZ position	DairyNZ Recommendation
Setting and clarifying policy direction				
Te Mana o Te Wai & mahinga kai	• Putting Te Mana o Te Wai as the foremost objective of water policy • Introducing a new compulsory value for mahinga kai	• Implications not able to be fully assessed	• Support inclusion of Te Mana o Te Wai and mahinga kai as a compulsory value	• Government develop a range of tangata whenua/mahinga kai values which local iwi/hapū can then select those that apply at a catchment level • Government clearly exclude allocation issues from any development of mahinga kai or tangata whenua values, to prevent these attributes being litigated in every region as iwi/hapū seek to reserve those rights in any regional plans now • Funding to the regions is required to facilitate this process • Need to address all wellbeing's over time
New planning process for freshwater	• Fast track process with expert, independent panel to advise councils on their plans	• Should enable regional councils to get rules in place sooner, thereby providing certainty and clarity sooner about what's required	• Support these proposals in-principle • Limited confidence that fast-tracked policy process will deliver on community aspirations (risk of implementation failure, farmers losing confidence in process)	• Government and regional councils work with the Sector over the coming months to develop a workable solution

Introduction

The New Zealand dairy sector is a critical part of the New Zealand economy, generating $18.1 billion in export revenue in the year to June 2019[1], supporting 46,000 jobs and, sustaining the social, economic, and environmental wellbeing of our regional communities. Our sector is comprised of 11,950 dairy herds which occupy approximately 1.75 million hectares of land[2]. Over 59% of these herds are owned by farmers who own and operate their own farms, with the balance managed by share or contract milkers. All the people working in our sector share several things in common – a passion for their land, pride in their herds, and a genuine desire to safeguard our unique environment for the next generation of New Zealanders.

DairyNZ therefore welcomes the opportunity to provide this submission on *Action for healthy waterways: A discussion document on national direction for our essential freshwater.* We recognise the important role the dairy sector will play in improving New Zealand's freshwater quality outcomes both now and into the future.

Safeguarding the environment and maintaining a sustainable and competitive dairy sector is at the core of the Dairy Tomorrow sector strategy. It also shapes every aspect of the management and investment decisions our farmers make each day, and underscores their commitment to continuously improve their farm systems to enhance the rivers, lakes, aquifers, soils and ecosystems on which their farm businesses, local communities and consumers depend.

DairyNZ welcomes the Government's decision to start a far-reaching, national conversation on options for maintaining and improving New Zealand's waterways. We also appreciate the comments made by Joint Ministers that, while it is necessary to increase the scale, pace and consistency of the improvements being delivered by current freshwater management approaches, maintaining primary sector viability remains a key concern.

Overarching principles

Our starting point for any national policy conversation is that the discussion must be evidence-based, using the best available scientific data to build a complete understanding of water quality states, trends and drivers at the national and catchment scales. Any proposed solutions must:

- Strike the right balance when addressing short and long-term freshwater management goals
- Undertake a phased approach to implementation that is tailored to the specific challenges within each catchment
- Allow flexibility for implementation methods, while setting clear and realistic timelines for delivering water quality improvements
- Focus on delivering measurable and durable water quality improvements
- Build on existing community and sector-led initiatives
- Provide business certainty, promote investment confidence and support the sustainable growth of our regional economies and local communities
- Be well-resourced and capable of practical implementation on the ground

[1] Situation and Outlook for Primary Industries (September 2019), Ministry for Primary Industries
[2] New Zealand Dairy Statistics 2017-18, Livestock Investment Corporation and DairyNZ

- Allow for a fair and just transition

The following diagram brings our thinking together and outlines our framework for meeting New Zealand’s freshwater management challenges.

Overview

Submission guide

Our submission is comprised of four key parts.

- **Executive Summary**: outlining our key findings and recommendations
- **Introduction:** explaining our analytical approach together with the aims, objectives and principles that have informed our thinking
- **General Comments:** identifying the areas and issues that require further national policy development
- **Technical Submission Points:** exploring the robustness of the Government's underlying policy approach, including our detailed responses on the consultation questions that are of key concern to dairy farmers

The **Appendices** to this submission contain the technical background papers and reports that have informed our analysis and supported the development of our recommendations

General comments

We would like to make some overarching comments about the Essential Freshwater Package before outlining our technical comments and recommendations.

Lack of Economic Impact Analysis

We are deeply concerned that the Essential Freshwater Package is not underpinned by a comprehensive economic assessment of its potential impacts on the dairy sector or the broader economy. This is a significant oversight given that nearly one-third of New Zealand's exported goods and 46,000 jobs are reliant on dairy sector production. DairyNZ has worked with Infometrics and Sense Partners to plug this analytical gap, culminating in the development of the technical reports examining economic impacts at the farm, regional and economy-wide scale. The reports, which are located at Appendices 1-3, are as follows:

- *Economic impacts of the Essential Freshwater proposals on New Zealand dairy farms* (Dr Graeme Doole, 24 October 2019).
- *Regional and National Impacts of Proposed Environmental Policies on the New Zealand Dairy Sector* (Infometrics, October 2019).
- T*he Economywide Effects of Proposed Environmental Policies* (Sense Partners, 29 October 2019).

In addition to examining three potential Essential Freshwater implementation scenarios, the Sense Partners Report also models one of these scenarios alongside the estimated effects associated with Zero Carbon Bill implementation. The results are sobering.

The analysis confirms that the Essential Freshwater Package presents one of the largest economic challenges that the dairy sector has faced in over a generation and, is forecast to:

- Reduce milk output by 30%.
- Reduce the number of full-time equivalent positions across the dairy sector by 15-20%.
- Reduce the tax take from the dairy sector by 50%.
- Increase the number of insolvent farms from 2% to 11%.
- Reduce long-term, economy wide Gross Domestic Product by $6 billion on an annual basis.

The scale of these impacts is significant, with the analysis indicating that the Northland, Taranaki, Waikato, Canterbury and Southland regional economies would shoulder most of the costs.

As noted in our recent submission on the Zero Carbon Bill, it is essential that Government develops a deeper understanding of the impact its environment reform agenda will have on farming communities and New Zealanders more broadly. The lack of any integrated analysis examining the potentially cumulative and compounding effects of recent water quality, greenhouse gas emissions and afforestation policies is extremely worrying. Our concerns are compounded by the fact that the Government's current *Just Transition* workstream remains heavily focused on managing the impacts that the decision to ban future oil and gas exploration permits will have on the Taranaki region. Policy work analysing the adaptative capacity and future transition pathways of key industry sectors, such as dairy, is barely out of the starting blocks.

To be clear, DairyNZ is not advocating for a continuation of the status quo. Our point is that any policy proposals that have the potential to deliver such profound impacts must be evidence-based, require more than eight weeks public consultation, and should be part of a coherent and integrated strategy to safeguard New Zealand's social, economic and environmental wellbeing.

A significant component of the modelled economic impact is driven by the proposed national bottom lines for dissolved inorganic nitrogen and dissolved reactive phosphorus. We believe that these nutrient limits are based on overly simplistic relationships and not supported by robust science. Instead we propose an alternative approach to manage ecosystem health and more effectively achieve the desired policy outcomes, based on strengthening existing standards for nitrate and ammonium toxicity. Economic modelling of this scenario indicates this is a more pragmatic policy mechanism to achieve similar environmental outcomes at less cost to the dairy sector and the communities which it supports.

Finalising a plan for progressing the allocation discussion

Since early 2004 MfE has released successive technical reports outlining the systemic failings in New Zealand's current water allocation and use systems. These failings have included the need to develop more robust and dynamic processes to:

- Deliver more coherent strategic planning at the national and regional scales
- Overcome process and data uncertainties
- Consider opportunities to allocate water to the highest environmental, social, cultural and economic values
- Create incentives for technical efficiency
- Enhance opportunities for iwi and hapū to participate in allocation processes
- Enhance organisational capacity, experience and skills in freshwater management across the central and local government systems

These challenges have been highlighted in other reports by bodies such as the Land and Water Forum over the last past decades. Against this background, the decision to start a national policy conversation that only responds to water quality challenges is unusual. This decision will inevitably increase the complexity of the policy challenges that lie ahead, and until allocation issues are resolved, will significantly increase uncertainty for farmers and their local communities. A plan is urgently needed to progress the nutrient and water allocation discussion. To address this, we recommend that Government work with the primary sector, regional councils, iwi and other interested agencies on the development of a potential framework to resolve the challenge of allocation, and provide for a fair and just transition.

DairyNZ recommends that any nation water allocation should be informed by the following considerations:

1. Recognise the importance of focusing on all key contaminants impacting water quality decline (e.g. nitrogen, phosphorous, sediment, and pathogens).

2. Reflect that the environmental priorities for all catchments should be clearly defined, and the principal drivers of deteriorating water quality should be well-understood.

3. Acknowledge that catchment contaminant loads should be quantified based on all land users and sources.

4. Confirm that all farms must have and be implementing an on-farm plan that identifies and prioritises environmental risks and opportunities in accordance with the good farming practice principles set out in the Good Farming Practice Action Plan for Water Quality (2018) and any relevant GFP practices prioritised for each region or catchment.

5. Recognise that options for improving environmental outcomes should consider actions at both the farm and catchment scale.

6. Clarify that allocation should be based on net environmental outcomes, not inputs, and provide for environmental improvements over time.

7. Acknowledge that allocation decisions must be supported by a robust, technical evidence base for each catchment.

8. Reflect that future land use and activity may look very different than today.

9. Recognise that a long-term allocation framework should be linked to the natural attributes and assimilative capacity of each land unit in its catchment context, and broader environmental, social, economic and cultural values.

10. Reflect that the time for transition to a final allocation mechanism must consider existing land-owner investment and policy frameworks, to maintain farm business viability and maximise possible adaptation pathways.

11. Ensure that allocation and transfer mechanisms allow for land use flexibility, and enable farmers to respond to threats and opportunities.

All have a part to play in improving water quality

DairyNZ recognises that the current state of water quality of freshwater across New Zealand does not meet community expectations or aspirations. However, the water quality of freshwater in some catchments more than exceeds the proposed national bottom lines. While it is difficult to directly attribute land use pressures to water quality outcomes given the complexity of the problem, it is generally accepted that water quality is highest in catchments dominated by native bush, followed by pastoral agriculture and then by urban areas.

Addressing New Zealand's water quality challenges requires a collaborative approach, that goes beyond simply focusing on nutrients such as nitrogen. Other contaminants driving water quality issues include sediment, phosphorus and microbes such as *E.coli*, which are mostly associated with overland flow pathways and also have significant implications for ecosystem health and swimmability. One recent study estimated that while yields of N and P loss re greatest for dairy land (on a per ha basis), the total load of N, P and sediment from pastoral land use across New Zealand is dominated by sheep and beef (57, 79, 91% of the total pastoral load, respectively) owing to its' greater share of land area (McDowell et al. 2019).

The dairy industry has already voluntarily implemented programmes such as the Sustainable Dairying: Water Accord that have resulted in the adoption of a range of mitigations across dairy farms, including stock exclusion and improved effluent management practices.

DairyNZ believes that expanding the scope and scale of existing mitigation adoption and Good Farming Practice initiatives, combined with prioritised and targeted catchment-scale approaches, will reduce contaminant losses and improve biodiversity, ecosystem health outcomes and water quality throughout New Zealand.

Harnessing the potential of adaptive management approaches

One of the key themes emerging across many aspects of this consultation process relates to the inherent challenges associated with delivering consistent and predictable water quality outcomes at both the national and local scales. This is a challenge that New Zealand shares in common with a number of international jurisdictions. Looking overseas, several countries are developing national policy frameworks that allow for the emergence of adaptive co-management approaches which enable local communities to take a lead role in developing rules, systems and resources to sustainably manage their freshwater resources. These approaches harness local knowledge regarding the drivers and indicators of ecosystem health and, recognise the critical role that local communities can play in delivering fast, measurable and lasting improvements on the ground. These approaches also have the potential to help offset the implementation risks that we have highlighted elsewhere in this submission.

We think the timing is right for a deeper discussion about the potential role of adaptive management approaches, and we strongly recommend the Government considers opportunities to facilitate this national conversation when developing its final policy solutions.

Resolving regional government capacity constraints

In its recent draft report, *Local Government Funding and Financing*, the Productivity Commission ('the Commission') determined that one of the key drivers of regional Government debt levels was:

> *'The continued accumulation of functions and responsibilities that central Government has passed to councils over the years.'*[3]

This '*accumulation'* included the imposition of higher regulatory standards as a consequence of new National Policy Statements, National Environment Standards and higher standards for drinking water and wastewater. The Commission commented that:

> *'The increasing tasks and responsibilities being placed on local government have now reached a point where the cumulative burden is difficult for many local authorities to manage. A risk is that some councils, particularly small ones, may be unable to continue to comply with all the new responsibilities passed to them. This risk could mean that the policy objectives of central Government are not achieved.'*[4]

The Commission suggested that:

- A significant shift in the current state of central and local government relationships was needed in order to address the risk of implementation failure, including a stronger emphasis on co-designed regulatory approaches and extending the range of council funding tools.

[3] New Zealand Productivity Commission. (2019). Local Government funding and financing: Draft report. Available from www.productivity.govt.nz Page 9
[4] New Zealand Productivity Commission. (2019). Local Government funding and financing: Draft report. Available from www.productivity.govt.nz Page 9

- Central Government should take a lead role in providing local Government with high-quality and consistent science and data, as well as guidance on standard setting, legal and other decision-making processes.

Although the Commission made these latter comments in the context of climate change adaptation, we think they apply equally to the development and implementation of freshwater management policy.

The Auditor-General expressed similar concerns regarding local Government capacity constraints in his recent report *Managing freshwater quality: Challenges and opportunities* which noted, '*there is not enough information about freshwater at a national level to prioritise efforts on a national basis.'*[5] Consequently decision-makers at the national level do not have the information they need to prepare a national approach or long-term strategy to respond to New Zealand's freshwater management challenges. By extension, decision-makers at the local Government level are unable to comprehensively identify and assess the factors that are driving freshwater quality outcomes in their catchments.

The Auditor-General went on to comment that there were *'significant gaps in knowledge about the effects of poor freshwater quality, including the effects of pollution on te ao Māori and human health.'*[6]. Although he acknowledged the work that has previously been undertaken to improve the processes through which freshwater management information is reported and used, he emphasised the need for MfE and Statistics New Zealand to step up and take on a more proactive leadership role, in order to make meaningful progress towards improving water quality outcomes.

It is not surprising that the Regional Sector Commentary Report, *He Pito Korero e pa ana ki Nga Tutohu Mo te Waimaori,* makes broadly identical observations and recommendations to those made by the Productivity Commission and Auditor-General. In particular, the Regional Sector Group (RSG) expressed concern regarding the '*limited human and financial resources that are available across the local government system'* to be deployed on the implementation of the Essential Freshwater reform package[7]. The RSG recommended that central Government must develop an implementation package that '*corresponds to the scale and complexity'* of the implementation challenges that councils will face nationwide[8]. The RSG goes on to note that the implementation package should,

> *'Include a commitment to align science funding to assist councils to, for example, set robust freshwater limits and targets. It should also include policy guidance on difficult and contentious matters such as limit setting and/or allocation methodologies'*[9]

[5] Office of the Auditor-General. (2019). Managing freshwater quality: Challenges and opportunities. ISBN 978-0-9951185-5-3. Page 4

[6] Office of the Auditor-General. (2019). Managing freshwater quality: Challenges and opportunities. ISBN 978-0-9951185-5-3. Page 4

[7] Regional Sector Water Subgroup. (2019). Regional sector commentary on essential freshwater proposals; *He Pito Korero e pa ana ki Nga Tutohu Mo te Waimaori.* CR 374. Page 6

[8] Regional Sector Water Subgroup. (2019). Regional sector commentary on essential freshwater proposals; *He Pito Korero e pa ana ki Nga Tutohu Mo te Waimaori.* CR 374. Page 6

[9] Regional Sector Water Subgroup. (2019). Regional sector commentary on essential freshwater proposals; *He Pito Korero e pa ana ki Nga Tutohu Mo te Waimaori.* CR 374. Page 6

The RSG Report makes is clear that, in the absence of additional implementation and technical support, some aspects of the Essential Freshwater Package cannot be implemented. In particular, local Government bodies may need to reduce the level and intensity of their community engagement activities, and reduce the evidential rigour of the technical, policy and impact analysis that underpins their planning processes. It may also result in some local bodies re-prioritising current budget lines, diverting funds previously earmarked for environmental improvement initiatives - e.g. riparian fencing and planting - into compliance. Both outcomes are likely to undermine public trust and confidence in the Essential Freshwater process, and result in the proposed timeframes for delivering durable improvements in water and ecosystem health outcomes becoming largely unachievable.

Setting and Clarifying National Policy Direction

Our overarching comments

DairyNZ broadly welcomes efforts to strengthen national policy direction regarding the vital importance of restoring the mana and health of New Zealand's waterways, and setting nationally consistent rules to shape how particular activities and resource uses are carried out in future. We also support proposals to introduce better, faster freshwater planning processes to accelerate the pace at which NPS-FM requirements are implemented.

However, many of the proposals are contingent on Government's ability to resolve fundamental questions regarding the future direction of water allocation policy and, longstanding local Government capacity and capability constraints. Significant progress must be made on these issues if the proposed 2025 deadline for activating a new suite of freshwater management plans is to be met.

Independent national oversight

Question 7

Do you think it would be a good idea to have an independent national body to provide oversight of freshwater management implementation, as recommended by KWM and FLG?

At this stage the discussion document provides limited guidance on the jurisdiction and role of the proposed national body. Consequently, it is difficult to assess whether this proposal will add significant value to existing regulatory arrangements.

Te Mana o te Wai

Question 9

Do you support the Te Mana o te Wai hierarchy of obligations, that the first priority is the health of the water, the second priority is providing for essential human health needs, such as drinking water, and the third is other consumptive use?

We think the key questions are:

- Will the concept of Te Mana o te Wai advance our existing regulatory arrangements?
- Does it deliver the paradigm shift signalled in the discussion document?
- Will it make the process of allocating and managing the assimilative capacity of water resources any easier?

Te Mana o te Wai, as expressed in the discussion document, provides an extremely helpful articulation of the intrinsic health and wellbeing values that all New Zealanders place in our freshwater resources. Te Mana o te Wai also resonates strongly with the environmental stewardship principles that our farmers apply to their farm businesses. However, in and of itself, the range of values and priorities embedded within Te Mana o te Wai are already provided for in the Resource Management Act.

For example, it has always been recognised that:

- Water bodies must retain certain minimum flows in order to protect in-stream values (both cultural and ecological).
- Takes for domestic supply or community potable supplies should be prioritised (and most existing regional plans already provide for this).
- Other uses, including productive ones, are of a lesser order of priority.

Although the discussion document understandably focusses on the shortcomings of our current arrangements, there are some success stories. The Waitaki Catchment Water Allocation Regional Plan[10] is an excellent example of a water planning process that expressly sought to identify and allocate in-stream and out-of-stream uses, including a specific allocation for town and country water supplies, and a comprehensive range of additional uses including industrial, commercial, tourism, recreation, agriculture, horticulture, mahinga kai, and hydro-generation.

There is also the fundamental question as to how Te Mana o te Wai will be applied in practice. Will it be applied in an absolute of qualified sense?

At face value the Te Mana o te Wai conceptual framework prevents the health and mauri of water from being traded off for economic or other benefits arising from the consumptive use of water. However, the taking of any water from, or discharge of contaminants into, a water body will ***always*** have some impact on the health and mauri of the water. Consequently, we do not think Te Mana o te Wai can be applied in absolute sense as meaning there can ***never*** be any effects on the mauri or health of water because this is simply not realistic or possible. The questions that inevitably follow from this are:

- What is the most effective approach for determining the appropriate reference point(s) for the establishment of tangata whenua values and attributes?

- At what level is the mauri of the water appropriately safeguarded in terms of the quantum of in-stream flows and/or nutrient impacts?

- Who determines what the appropriate quantum or degree of impact is?

To this extent, Te Mana o te Wai helps re-frame our national water management challenges in way that resonates with a wider number of New Zealanders, but it does not resolve the challenges.

Question 10

Do you think the proposals will have the desired effect of putting the health of the water first?

As mentioned in Question 9 above, we doubt that the further elevation of Te Mana o te Wai within the new NPS-FM will fundamentally change the outcome of regional land and freshwater management processes.

---

[10] Waitaki catchment water allocation board. (2019). Waitaki catchment water allocation regional plan; Revision 05-Feb-2019. Available at: https://eplan.ecan.govt.nz/eplan/#Rules/0/97/1/9021

The discussion document also recognises the importance of Ki uta ki tai, which provides a useful and timely reminder of the need for integrated management approaches, especially in the freshwater management context where there are some interconnectivities and interdependencies that must be taken into account. However, this concept is already a core component of the Resource Management Act, and regional councils regularly have regard to the impacts that their decisions may have on connected or downstream water bodies when developing their policies and plans, and making resource consent decisions.

Question 11

Is it clear what regional councils have to do to manage freshwater in a way consistent with Te Mana o te Wai?

No – as previously noted, the Te Mana o te Wai proposals outlined in the discussion document cannot be implemented in an absolute sense. Evidence-based decisions will still need to be made by local communities at the Freshwater Management Unit (FMU) level regarding how and at what level the mauri of water is appropriately safeguarded.

The discussion document provides little guidance on how this will occur other than recognising that councils will need to provide local iwi and hapū with the support and resourcing necessary to develop tangata whenua values and attributes. It is also unclear whether iwi and hapū engagement should occur in parallel with the FMU process. We recommend that these processes must run in parallel given that the outputs of both processes will need to be integrated and then converted into planning provisions for notification as regional plans.

Question 12

Will creating a long-term vision change how councils and communities manage freshwater and contribute to upholding Te Mana o te Wai?

As previously noted, the proposals outlined in the discussion document re-frame rather than re-set existing management approaches. We note that one of the strengths of our current arrangement is that it enables debate, at the FMU level, regarding the values each local community believes it should provide for and how that should occur. In addition, local communities will also continue debating the quantum of water quality protection and enhancement that their catchment requires and how this should be ascribed to each in-stream value.

This community-led process is the one of the cornerstones of our current system, and is something that must continue beyond the implementation of the current proposals.

New Māori Value

Question 13

Do you think either or both of these proposals will be effective in improving the incorporation of Māori values in regional freshwater planning?

The discussion document outlines two proposals that are intended to reframe the description and application of Te Mana o te Wai within the NPS-FM as follows:

Proposal 1: Elevate the status of mahinga kai to a compulsory national value

The key objective is to require regional councils to:

- Enable and support tangata whenua locally to develop attributes that represent the specific mahinga kai values in their local catchments.
- Provide for the new value in identified sites or waterbodies, in all freshwater management units including enabling and supporting tangata whenua to identify attributes, target attribute state and management requirements.

Proposal 2: Strengthen the priority given to tangata whenua values in freshwater values

This would be achieved by creating a new tangata whenua freshwater values category in the NPS-FM with the intention of providing regional councils with stronger and clearer direction on:

- The requirement to incorporate tangata whenua freshwater values into regional freshwater planning processes where these values have been identified by iwi and hapū for the purposes of freshwater management within a freshwater management unit.
- How regional councils should work with hapū and iwi on freshwater management issues in future.

The question regarding the extent to which these proposals are likely to be effective in improving the incorporation of Māori values in regional freshwater planning is difficult to answer because neither proposal is fully formed. On balance, we consider that Proposal 1 has the strongest potential to fulfil Government policy objectives because:

- Mahinga kai is a multi-faceted concept that is of universal value to all New Zealanders.
- Since mahinga kai is already included in the NPS-FM as an 'other national value' it is familiar to regional councils and stakeholders.
- We are aware from our engagement in regional planning processes that a number of iwi and hapū have already identified mahinga kai values and attributes in iwi management plans, regional planning documents, and kaupapa Māori assessment frameworks. Regional planning processes are becoming richer for this experience, and the proposed requirements for councils to identify, monitor and report on mahinga kai values is a logical next step.

However, our regional planning experience also highlights that an increasingly large number of regional councils are grappling with important implementation questions such as:

- What is the best approach for nesting broader kaupapa Māori assessment matters for mahinga kai to sit alongside conventional western attribute states? Which takes priority or should equal weighting be given to both? Is it possible to assess them together?

- Should mahinga kai values remain qualitative, or will they be converted in quantitative form?

- Should there be separate consent requirements for mahinga kai values, <u>or</u> is it the expectation that one of the key areas of focus for Māori Commissioners on hearing panels is to ensure these values are fully expressed, <u>or</u> will this be the responsibility of the co-governance entities involved in plan development processes?

- Is there scope for the development of some core, nationally consistent mahinga kai attributes and target states?

- How should/could mahinga kai be encapsulated within a Farm Environment Plan (FEP), and who will monitor and report on progress? Will it be kaitiaki, farmers or both?

We need to receive further guidance on how the MfE intends to resolve these issues before we are in position to fully endorse either of these proposals.

Question 14

Do you foresee any implementation issues associated with either approach?

We think these proposals will quickly confront fundamental implementation challenges which we have summarised below:

Recognising the new interests and values

We are struggling to understand how different interests and values in water bodies can be recognised without understanding what quantum of water (or assimilative capacity) is to be set aside for iwi and hapū interests. We agree that water for marae and traditional practises, and for cultural values relating to the intrinsic health and wellbeing of a water body can be reasonably identified and provided for. However, setting aside more substantive volumes (e.g. irrigation to enhance the productive capacity of landholdings) will be extremely problematic until the broader issues associated with the proper recognition of iwi and hapū interests are resolved. Also, as previously noted, this problem is likely to become intractable if the mauri of water (as the primary consideration under the proposed Te Mana o te Wai framework) is determined to be affected by the ability of an iwi or hapū to use that water for broader economic development purposes.

In view of this, we recommend Government explicitly excludes allocation issues from the development of the proposed mahinga kai or tangata whenua values at this stage.

Harmonising western environmental management approaches with tikana and matauranga Māori

As mentioned previously, the current expectation is that mahinga kai attributes and states will be developed locally. While we obviously recognise the critical importance of these processes being championed at the local level, we are concerned about the additional demands this will place on regional council resources, and the delivery of broader FMU outputs given the need to progress existing FMU and new mahinga kai attributes in parallel.

Consequently, **we recommend** Government:

- Urgently reconsiders its leadership role and investment responsibilities in relation to the successful implementation of its proposals to strengthen Māori values.

- Develops further guidance regarding the purpose of these values and attributes, how they are to be developed, and how they will be incorporated into decision-making processes.

- Considers developing a table, for inclusion in the NPS-FM, that outlines the key elements and issues that iwi and hapū populate at a regional level. This will ensure councils, iwi and hapū are not required to spend valuable time and resources starting from scratch at the commencement of each process.

- Considers making specific 'placeholder' provision within the table for an iwi/ hapū allocation of both assimilative water capacity and quantum, with a direction that this element will be populated once broader national policy discussion have been completed. This will help sharpen the focus of regional processes while Government addresses the fundamental allocation issues outlined in this submission.

Managing the transition from the current to the new NPS-FM

The NPS-FM requirement to maintain existing state means that New Zealand's freshwater quality will effectively be fully allocated as at the date the new NPS-FM becomes operative. Put simply, this could mean that no further resource consents to discharge contaminants should be granted unless an equivalent offset can be obtained. Consequently, we recommend that:

- MfE (and other key stakeholders) rigorously examine how regional plans give effect to the NPS-FM and both reflect and implement any mahinga kai and/or tangata whenua values.

- Government provides further, explicit guidance on what new uses are to be enabled within the period between the NPS-FM becoming operative (in 2020) and any regional plans becoming operative in 2024/2025.

Question 15

What are the benefits and impacts of either of these approaches?

Please see response to question 14 above.

Question 16

What implementation support will need to be provided?

As noted elsewhere in this submission, the local government system has not been appropriately resourced to undertake its current land and water planning functions. We therefore doubt that many regional councils will have either the capability or capacity to assist local iwi and hapū in the manner suggested in the discussion document.

We are not in a position to estimate the scope or scale of additional assistance that regional councils will require, other than that it is likely to be substantial given the level of granularity that is likely to be required when identifying mahinga kai values on a catchment by catchment basis.

We also consider it is essential that iwi and hapū engagement should occur in parallel with the FMU process (noting that the participants in the FMU mahinga kai process will be limited to those with relevant expertise – i.e. local iwi and hapū members). This is because the outputs of both processes will need to be integrated and converted into planning provisions for inclusion in the notified versions of regional plans.

New planning process for freshwater

Question 17

Do you support the proposal for a faster freshwater planning process? Note that there will be an opportunity to comment on this proposal in details through the select committee process on the Resource Management Amendment Bill later this year.

We note that the Resource Management Amendment Act (RMAA) Bill was introduced on 27 September 2019 and was referred to the Environment Select Committee for consideration. Since we will be developing a separate select committee submission, we have focussed our current efforts on providing some high-level commentary on the proposals contained in the discussion document.

Sir Geoffrey Palmer, one of the architects of the RMA, when reflecting on the key lessons arising from 25 years of the Act's post-implementation experience commented that,

> *'There are simply too many plans. They are too diverse, and they are too complicated. This has involved local authorities in considerable duplication of effort, and there has been a proliferation of planning documents.'*[11]

Although these comments were made in 2015, we think the problem definition remains accurate and is consistent with our own, direct experience of regional planning processes. We continue to see first-hand that regional councils are implementing varied planning responses to the same issues across regions. This creates considerable uncertainty, produces significant process delays, and escalates the likelihood of Environment Court appeals. We also receive regular, unsolicited feedback from our farmers regarding the escalating cost, complexity and unpredictable nature of resource consent processes. The perceived inability of local decision-makers to provide clear and timely advice on what needs to be done on farm and by what date is a source of growing concern.

There have been several attempts to streamline RMA planning processes in recent years which have paradoxically added further layers of complexity. We therefore support the proposal to introduce a new, faster freshwater planning process and remain hopeful that it will deliver more efficient, technically robust and inclusive outcomes. We believe the drafting of the proposed RMAA Bill's provisions is appropriate, and that enabling cross-examination (albeit in a limited form) provides an important procedural safeguard.

[11] Sir Geoffrey Palmer. (2015). "Ruminations on the problems with the Resource Management Act". Keynote address to the Local Government Environmental Compliance Conference, 2-3 November 2015. Page 17.

More integrated management of freshwater

Question 18

Does the proposal make the roles and responsibilities between regional councils and territorial authorities sufficiently clear?

Yes, this is an improvement on what is in the current NPS-FM. **DairyNZ supports** the integrated management of the impacts of urban development on freshwater.

However, clarifying the roles and responsibilities of regional councils and territorial authorities is only part of the equation. The recent Productivity Commission[12] and Auditor-General[13] reports clearly demonstrate the urgent need for MfE to expand its national leadership and coordination role.

Exceptions for major hydro schemes

Question 19

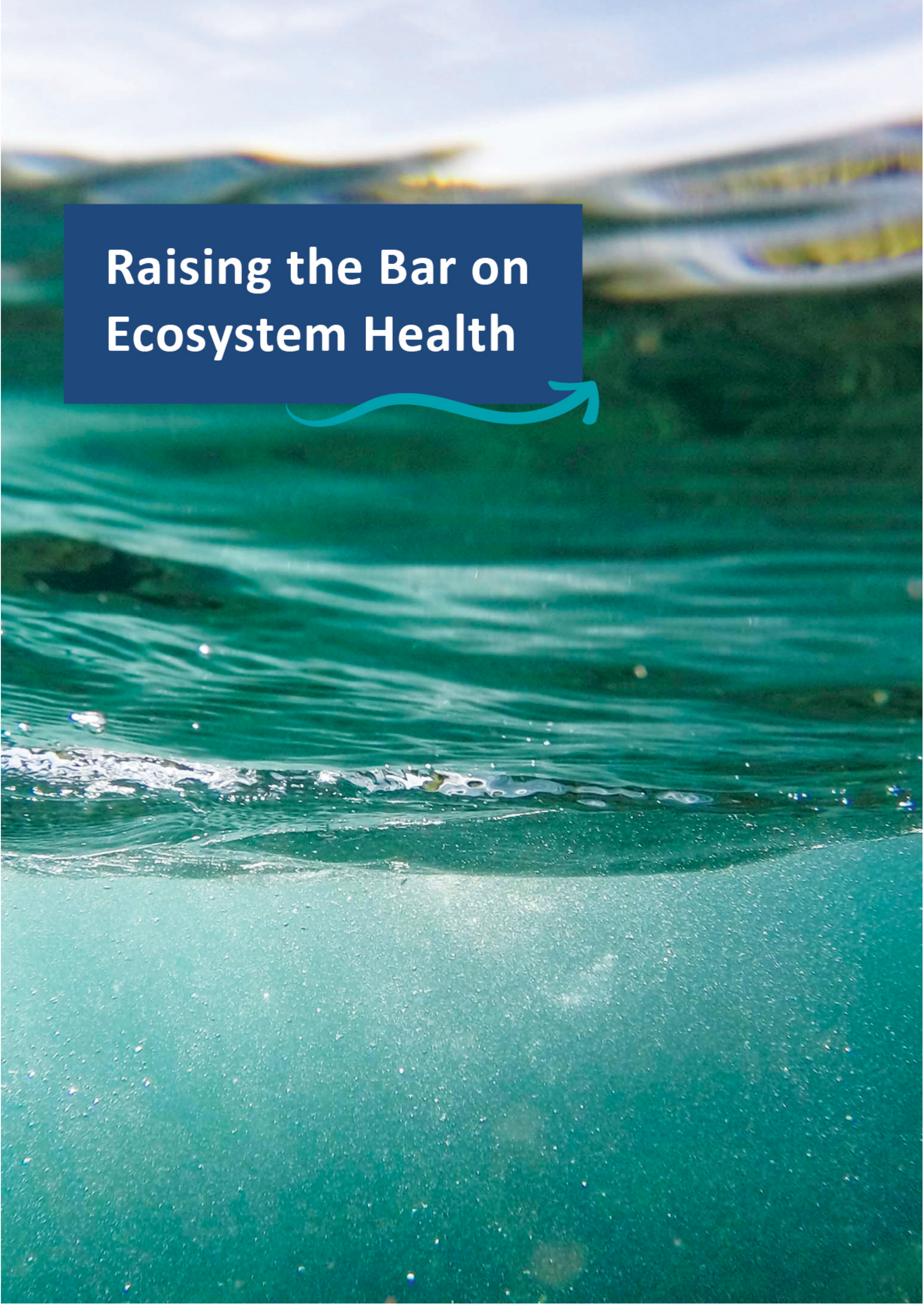
Does the proposal to allow exceptions for the six largest hydro-electricity schemes effectively balance New Zealand's freshwater health needs and climate change obligations, as well as ensuring a secure supply of affordable electricity?

DairyNZ agrees that the inter-relationship between the National Policy Statement for Renewable Electricity Generation (NPS- REG) and the NPS-FM is unclear, and this creates regulatory risk and uncertainty when the resource consents of hydro-electricity schemes are initially granted and/or come up for renewal. However, the proposed exception constitutes a blunt means of achieving Government's water quality and renewable energy policy goals. In particular, we think it is important that all major water resource users are under a continuing obligation to reduce the impact of their activities on water quality outcomes. Consequently, **DairyNZ does not support** the proposed exception for the six largest hydro-electricity schemes.

[12] New Zealand Productivity Commission. (2019). Local Government funding and financing: Draft report. Available from www.productivity.govt.nz

[13] Office of the Auditor-General. (2019). Managing freshwater quality: Challenges and opportunities. ISBN 978-0-9951185-5-3.

Raising the Bar on Ecosystem Health



Our overarching comments

DairyNZ supports policies that protect ecosystem health alongside swimmability. We support taking a scientifically robust and holistic approach to the management of our waterways. This includes setting targets and attributes, developing adaptive management approaches to prioritise effort where it is needed most, and catchment-scale solutions where everyone plays their role in improving the health of our waterways. The technical analysis shaping our approach to the Government's ecosystem health proposals and our associated recommendations is outlined at Appendices 1, 2 and 3.

DairyNZ supports:

- Meaningful limits that will deliver the instream ecosystem health outcomes being sought. We do not support our farmers working to achieve a bottom line that is overly simplistic and focusses just on nutrient concentrations, which will, in many instances, not result in improved ecological health – a position which is consistent with what the science is telling us.
- Science driven processes to inform policy decisions. The national attributes for nutrients (the basis of the proposed dissolved inorganic nitrogen [DIN] and dissolved reactive phosphorus [DRP]) do not account for 85-90% of the band placement in the biological metric they are being implemented to control[14]. Based on LAWA data from 2013-18, one-third of sites in the worst band for MCI (D band) are in the best A band for nitrogen. Or to frame it another way, if we examine all sites that have an A band nitrogen concentration, only 10% of these sites corresponds to A band macroinvertebrate health. Somewhat surprisingly, a greater proportion (16%) of these sites with A band nitrogen actually have D band macroinvertebrate health.

DairyNZ does not support the proposed nitrogen and phosphorus bottom lines as the most effective way to achieve this. The new ecosystem health nutrient thresholds are not scientifically robust, nor supported by current scientific literature (e.g. Pingram et al 2019[15]). The proposed bottom lines are therefore unlikely to achieve the improvements in waterway health as sought by the community for many catchments. Figures 1 & 2 indicates the catchments currently not meeting the proposed DIN and DRP limits.

DairyNZ recommends that a combination of the proposed (new NPS), existing (2014 NPS or existing policy guidelines) and modified (DairyNZ proposed) attributes will provide a scientifically robust and implementable framework to fully protect and monitor ecosystem and recreational health across all waterways. We suggest adoption of the following approach:

- Proposed MCI as the best integrated ecosystem health measure, based on the existing bottom-line of 80 (Policy CB3 of NPS-FM 2017), which is supported by previous MfE

[14] Using measured data, DIN concentration explains approximately 16% of the observed variation in macroinvertebrate health. This is even lower for DRP, at around 11%.
[15] Pingram, M., K. Collier, M. Hamer, B. David, A. Catlin, & J. Smith. (2019). Improving region-wide ecological conditions of wadeable streams: Risk analyses highlight key stressors for policy and management. *Environmental Science and Policy.* 92: 170-181.

guidance on state of the environment monitoring for macroinvertebrates[16], and the 2014 proposed NOF attribute band thresholds[17].

- Proposed DO attribute as a broad indicator to manage the effects of eutrophication, and impaired ecosystem functioning/metabolism.

- Existing NPS-FM (2014, amended 2017) periphyton attribute and nutrient note that requires councils to set meaningful instream nutrient criteria to protect hard-bottom streams, soft-bottom streams and sensitive downstream environments from adverse trophic effects from anthropogenic nutrient enrichment. This attribute, combined supporting guidance material[16], and other key ecosystem health attributes (namely lake trophic state and macroinvertebrates) address the potential for adverse 'trophic' effects of nutrients in freshwater receiving environments.

- Strengthened existing national bottom line for nitrate toxicity from 6.9 to 3.8 g/m^3 (see Figure 3) and ammonium toxicity from 1.3 to 0.54 g/m^3, to provide a higher (and more suitable) level of protection (i.e. increase from 80 to 90%) for potentially sensitive native aquatic species.

- Modified suspended sediment attribute that is more consistent with effects-based bottom-line thresholds reported in national and international literature, and the principle/limitations discussed in other MfE-commissioned reports[18]. The proposed fine sediment attributes suffer from several technical deficiencies that make them unworkable. These include: a classification system that does not account for natural state variation in fine sediment, entirely new methods that have not been peer-reviewed or validated, reliance on modelled data, and derivation of bottom-line thresholds that approximate to near reference conditions in several sediment classes.

  This highlights the concern that the technical work underpinning the proposed attributes has not been adequately 'sense-checked'. To address the many limitations, we recommend:

  - Suspended sediment: Attributes only define bottom-lines that represent turbidity values most likely to result in significant adverse effects. There are two potential

---

[16] Stark, J.D. & J.R. Maxted. (2007). A user guide for the Macroinvertebrate Community Index. Prepared for the Ministry for the Environment. Cawthron Report No. 1166.

[17] Pingram M, Collier K, Hamer, M, David B, Catlin A, Smith J. 2019. Improving region-wide ecological condition of wadeable streams: Risk analyses highlight key stressors for policy and management. *Environmental Science and Policy,* 92, 170-181

[18] Depree, C., Clapcott, J., Booker, D., Franklin, P., Hickey, C., Wagenhoff, A., Matheson, F., Shelley, J., Unwin, M., Wadhwa, S., Goodwin, E., Mackman, J., Rabel, H. (2018). Development of ecosystem health bottom-line thresholds for suspended and deposited sediment in New Zealand rivers and streams: NIWA Client Report prepared for the Ministry for the Environment 190 p (plus appendices). Clapcott J. & J. Goodwin. (2014). Relationships between MCI and environmental drivers. Prepared for Ministry for the Environment. Cawthron Report No. 2507. Davies-Colley, R., Hicks, M., Hughes, A., Clapcott, J., Kelly, D. and Wagenhoff, A. (2015). Fine sediment effects on freshwaters, and the relationship of environmental state to sediment load: A literature review. Prepared for Ministry for the Environment.

approaches (or a hybrid of the two): (1) increase in of 5 NTU relative to reference state (i.e. 0.5 to 2.5 NTU)[19]. This would equate to absolute turbidity bottom-lines of between around 5.5 and 7.5 NTU, which are consistent with the global average extirpation thresholds derived in (Appendix H)[20].

- Deposited sediment: recommend only bottom-lines, and simple classification that accounts for three broad deposited categories/scenarios[21] – for example:
  - i) *naturally low deposited fine sediment* (e.g. <20%) then bottom-line either absolute value of 30% or <15% increase on background.
  - ii) *naturally moderate levels of deposited fine sediment* (e.g. 20-50%) then bottom line of 60% deposited fine sediment.
  - iii) *naturally high levels of deposited fine* (i.e. >50%, or soft-bottom), excluded from attribute.

- Improved *E.coli* standard for recreational health (swimmability), based on the outcomes of the proposed review.

- Existing lake eutrophication and recreational health attributes (total nitrogen, total phosphorus, cyanobacteria).

Based on this framework DairyNZ does not support:

- A national bottom line for DIN or DRP (managed through nitrate toxicity or periphyton attribute table for both soft and hard bottomed streams) as these are based on overly simplistic, and weak relationships. Setting instream nutrient limits to achieve ecosystem health outcomes is inconsistent with scientists' conceptual understanding of key drivers of ecosystem health, and key findings from several recent national studies/analyses.
- Multiple attributes nor multiple metrics for measuring macroinvertebrate community health. Multiple metrics are not justified and will result in ambiguous ecosystem health outcomes (as assessed by macroinvertebrates). We do not support QMCI and ASPM. Macroinvertebrate community health, for state of the environment reporting, is best measured via MCI[22].

[19] McDowell RW, Snelder TH, Cox N (2013). Establishment of reference conditions and trigger values for of chemical, physical and micro-biological indicators in New Zealand streams and rivers. AgResearch report prepared for Ministry for the Environment. 70 p.

[20] Franklin, P. Stoffells, R. Clapcott, J. Booker, D., Hickey, C., Wagenhoff A. (2019) Deriving potential fine sediment attribute thresholds for the National Objective Framework: NIWA Client Report prepared for the Ministry for the Environment 105 p (plus appendices).

[21] As recommended by Cawthron in Depree, C., Clapcott, J., Booker, D., Franklin, P., Hickey, C., Wagenhoff, A., Matheson, F., Shelley, J., Unwin, M., Wadhwa, S., Goodwin, E., Mackman, J., Rabel, H. (2018). Development of ecosystem health bottom-line thresholds for suspended and deposited sediment in New Zealand rivers and streams: NIWA Client Report prepared for the Ministry for the Environment 190 p (plus appendices).

[22] This was strongly recommended in the 2007 MfE Guidance Document. Stark, J.D. & J.R. Maxted. (2007). A user guide for the Macroinvertebrate Community Index. Prepared for the Ministry for the Environment. Cawthron Report No. 1166. Page 58.

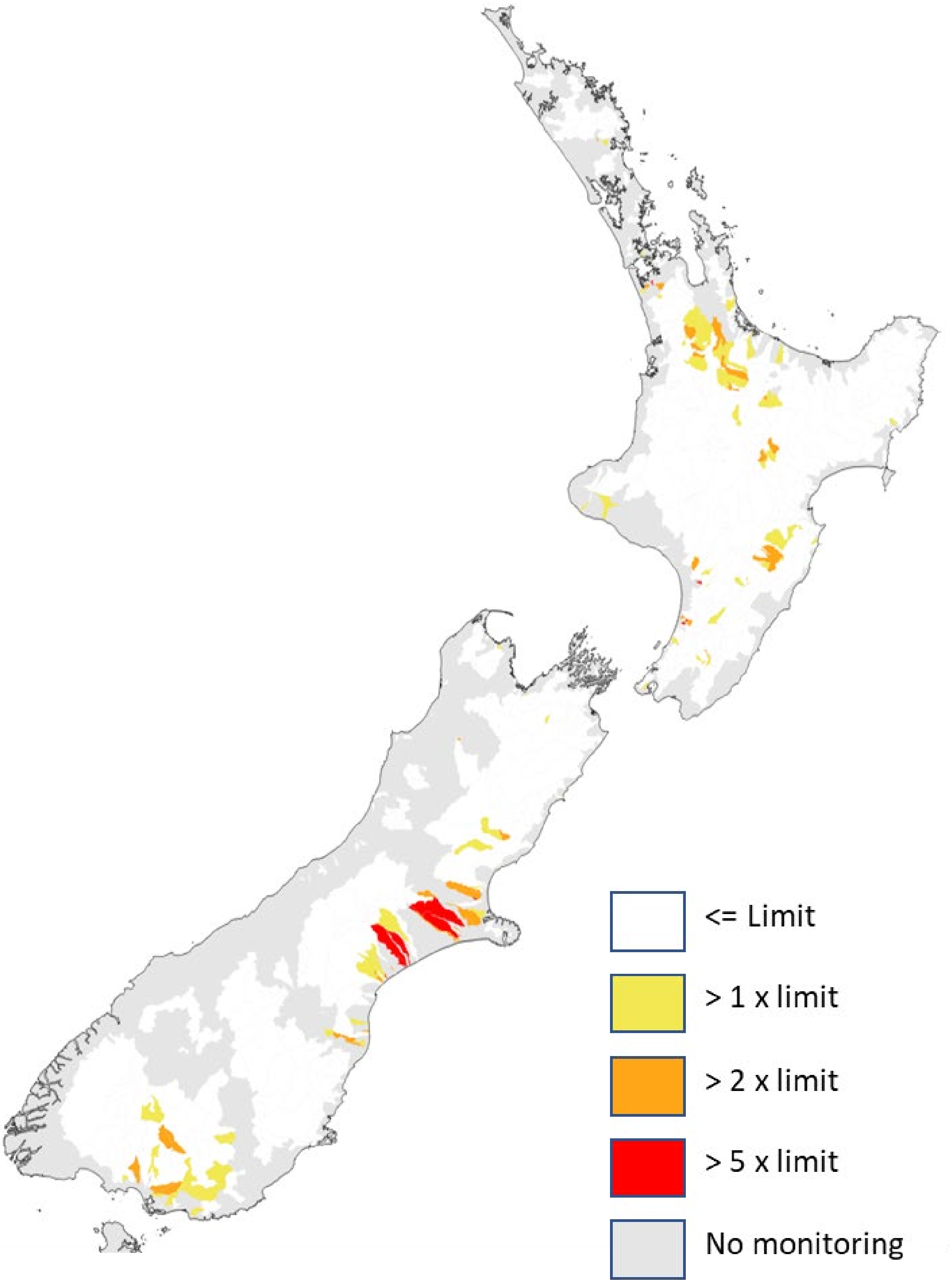


Figure 1: Catchments impacted by proposed DIN Limit (1 g/m^3).

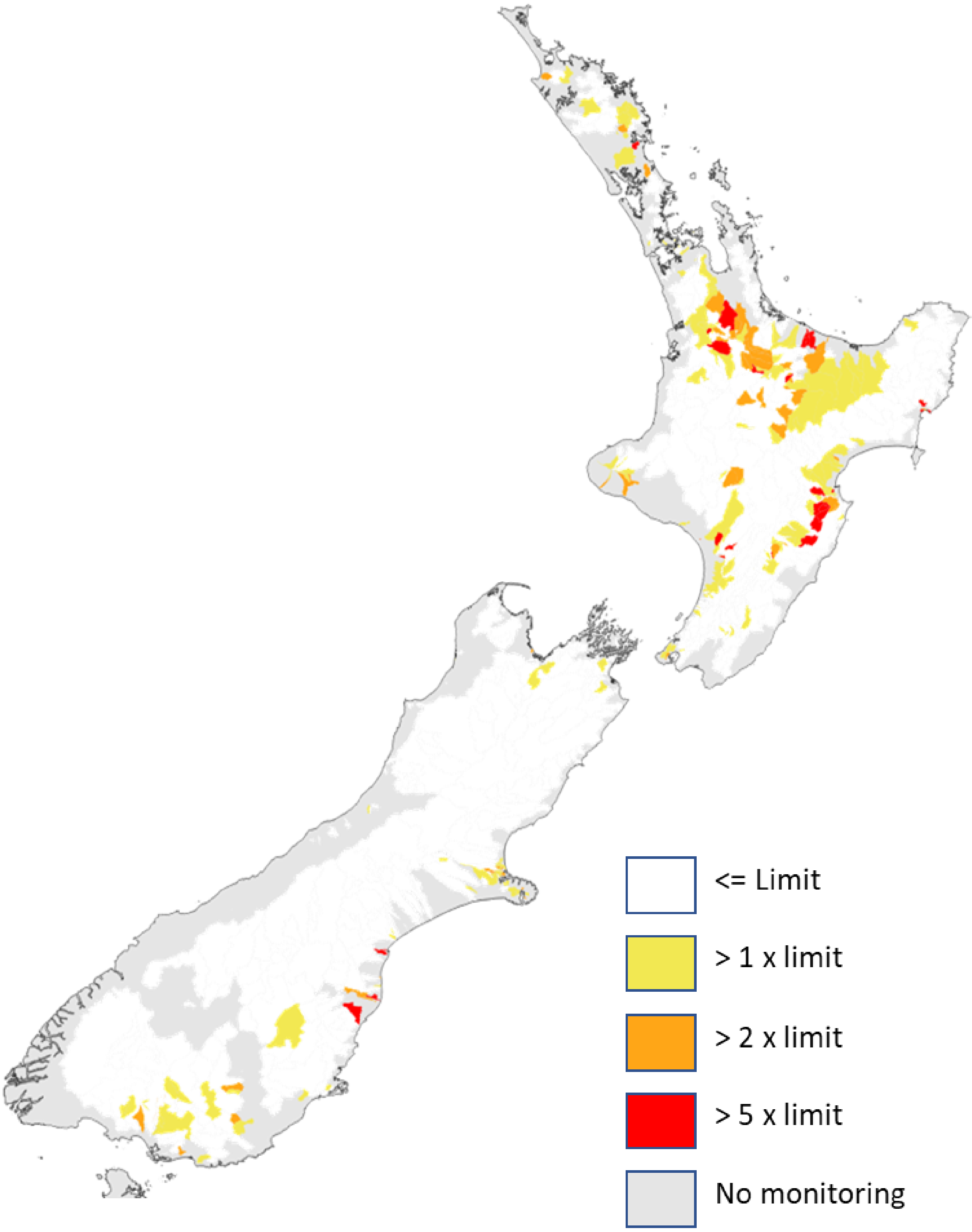


Figure 2: Catchments impacted by proposed DRP Limit (0.018 g/m^3).

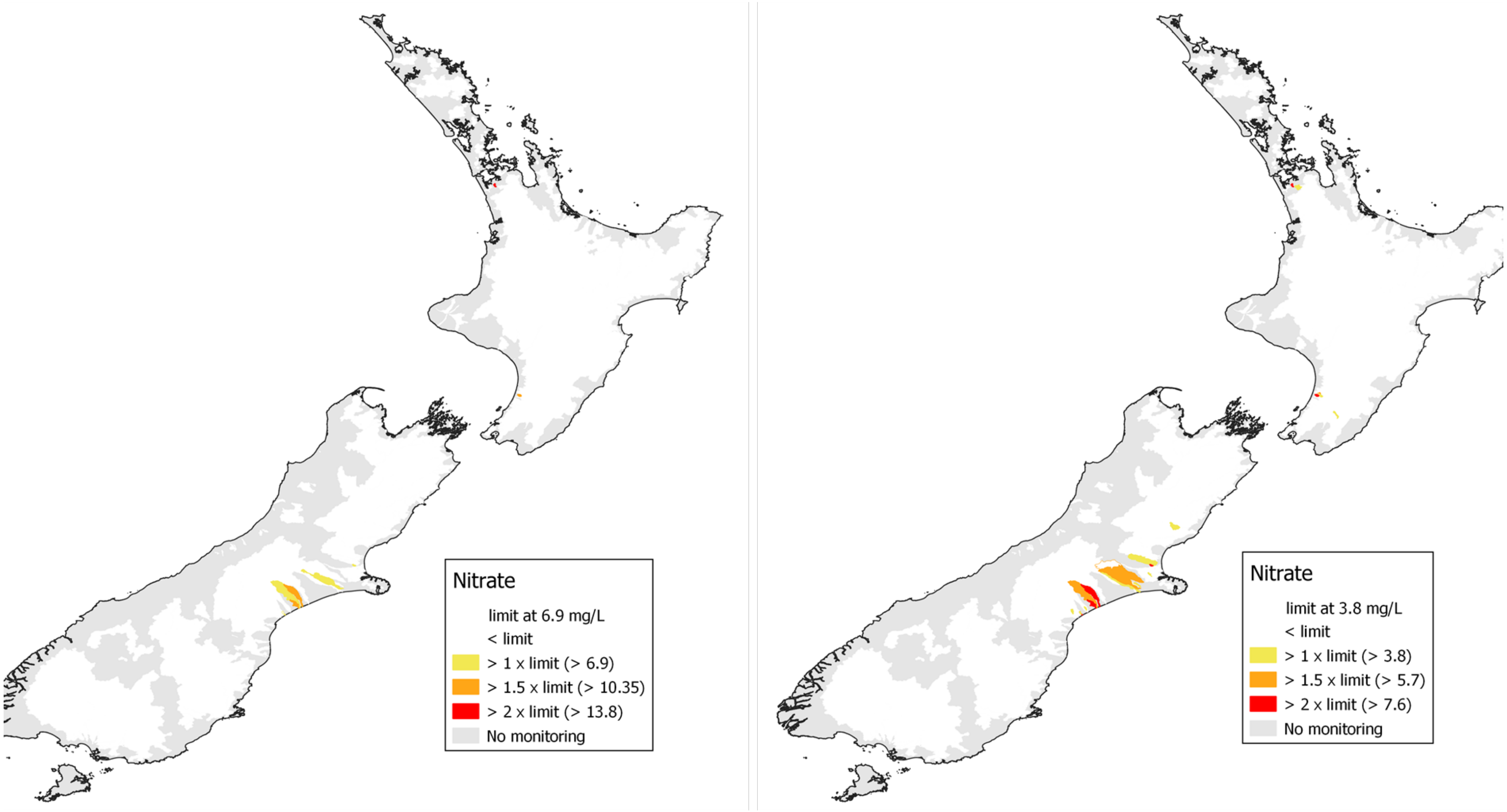


Figure 3: Catchments impacted by existing limit (6.8 g/m^3) and DairyNZ recommended (3.8 g/m^3) nitrate toxicity limit.

Attributes

Question 20

Do you think the proposed attributes and management approach will contribute to improving ecosystem health? Why/Why not?

DairyNZ supports the proposed approach of having some attributes managed via limits, and others via an action plan (i.e. attributes in Appendix 2A and 2B, respectively). DairyNZ agrees that in many cases an action plan, or adaptive management approach, will achieve better ecosystem outcomes than attempting to set contaminant limits that may explain <10-15% of the observed variation in ecosystem health measure being managed. We note, and fully support, the following statement in the discussion document:

> '*This approach reflects that there may be a wide range of reasons for a deterioration, a variety of actions that might be taken, and the specific actions might depend on the catchment and situation*.'

Importantly, having attributes where bottom-line exceedance triggers an action plan (as opposed to direct limit setting) allows for decision-making in the face of uncertainty.

Ecosystem health is complex. Therefore, having bottom-lines to trigger action plans for those attributes that relate to more integrated measures of ecosystem health is well suited for managing the multitude of stressors and associated uncertainty driving ecosystem health at each site. This also allows the number and extent to which different policy levers are pulled to be tailored to the specific challenges in each catchment, freshwater management unit or site. We suggest that this hierarchical approach across limits, action plans and monitoring is likely to achieve better water quality outcomes over the long term.

DairyNZ can see value in considering some of the five proposed components of ecosystem health:

- **Water quality** - strengthened by including sediment and dissolved oxygen.
- **Biology** - strengthened by inclusion of macroinvertebrates, fish, lake native macrophytes.
- **Habitat** - unsure of the added value. Value will depend on quality of action plans.
- **Water quantity** - strengthened by including flow requirements.
- **Ecosystem metabolism** - no value. Management approaches already include higher indicators of stream biological health such as macroinvertebrate indices that integrate lower level processes through inclusion of dissolved oxygen monitoring, which we support. The proposal presented is very unclear and does not contain any proposed values.

However, we do not believe that being a component of ecosystem health should be a default for attribute development. Of fundamental importance is the inclusion of a minimum set of attributes to cover-off contaminants that can be key drivers of degraded ecosystem health (e.g. fine sediment), and integrated measures of ecosystem health, which includes a sensitive, widely applicable, biological indicator of stream health (i.e. macroinvertebrate community health), and dissolved oxygen (essential for life-supporting capacity of freshwater ecosystems; integrating both biotic [ecosystem metabolism] and abiotic [reaeration] oxygen dynamics).

DairyNZ believes the NPS-FM has been complicated by a large number of attributes. It appears efforts to address limitations (actual and perceived) of the current NPS-FM have resulted in the inclusion of a significant number of additional attributes of ecosystem health to ensure everything is covered.

What is lacking, however, is a logical framework for these attributes. On one hand there is a need for integrated (i.e. holistic), biological measures, because measuring conventional water quality variables alone is not sufficient for managing (i.e. maintaining/improving) aquatic ecosystem health. On the other hand, STAG is recommending reductionist water quality nutrient limits that are, at best, poorly related to the complex ecosystem health measures with which they are intended to harmonise.

For example, DairyNZ struggles to reconcile how limits can be set for ecosystem health based on an indirect driver like nutrients (see Figure 4), which are assumed to correspond to an ecosystem health outcome (i.e. macroinvertebrate box in Figure 4) via an unsatisfactory harmonisation process. Such a simplistic reductionist relationship is completely counter-intuitive to MfE including macroinvertebrates as an action plan attribute (i.e. 2B).

DairyNZ believes an opportunity has been missed to have a much clearer framework on how freshwater management could be managed through the introduction of attributes that involve integrated measures of stream biological health. These holistic measures (attributes) of ecosystem health will have greater weight or importance with communities, given that they measure ecosystem health directly.

Achieving instream objectives for ecosystem health via monitoring and reporting of a robust, integrated measure of ecosystem health (which we assert is MCI) will almost certainly be the more important outcome (i.e. we can measure and report on what is important - an integrated, biological measure of ecosystem health).

DairyNZ has assessed the full suite of proposed attributes. Tables 1 and 2 provide a summary of our position on each.

Question 21

If we are managing for macroinvertebrates, fish and periphyton, do we also need to have attributes for nutrients that have been developed based on relationships with aquatic life?

No. Setting limits for nutrients will not deliver, in and of themselves, the ecosystem health outcomes being sought.

This is because there is a non-causal and very weak relationship between nutrients and ecosystem health attributes. The national attributes for nutrients (which are the basis of national bottom-lines for DIN and DRP) cannot explain 85-90% of the variation in the biological metric they are being implemented to control[23].

[23] Using measured data, DIN concentration explains approximately 16% of the observed variation in macroinvertebrate health. This is even lower for DRP, at around 11%.

This implies that there is limited scientific rigor to support the setting of nutrient limits to achieve a corresponding state of ecosystem health (e.g. macroinvertebrates), highlighting that nutrients are just one of many indirect drivers and pressures determining the state of an integrated ecosystem health measure such as macroinvertebrate community health. This is highlighted in Figure 4 (Collier et al 2014).

However, current science does support MCI as being one of the best indicators of holistic ecosystem health. Given this is a direct measure of stream biological health, we consider a poorly related and indirect proxy measure based on nutrients to be inferior and redundant. These simply do not work, and are also inconsistent with macroinvertebrates being action plan attributes (i.e. Appendix 2B) and justification for these attributes, namely it '…*reflects that there may be a wide range of reasons for a deterioration, a variety of actions that might be taken, and the specific actions might depend on the catchment and situation'*, and importantly it *'allows for decision-making in the face of uncertainty'.*

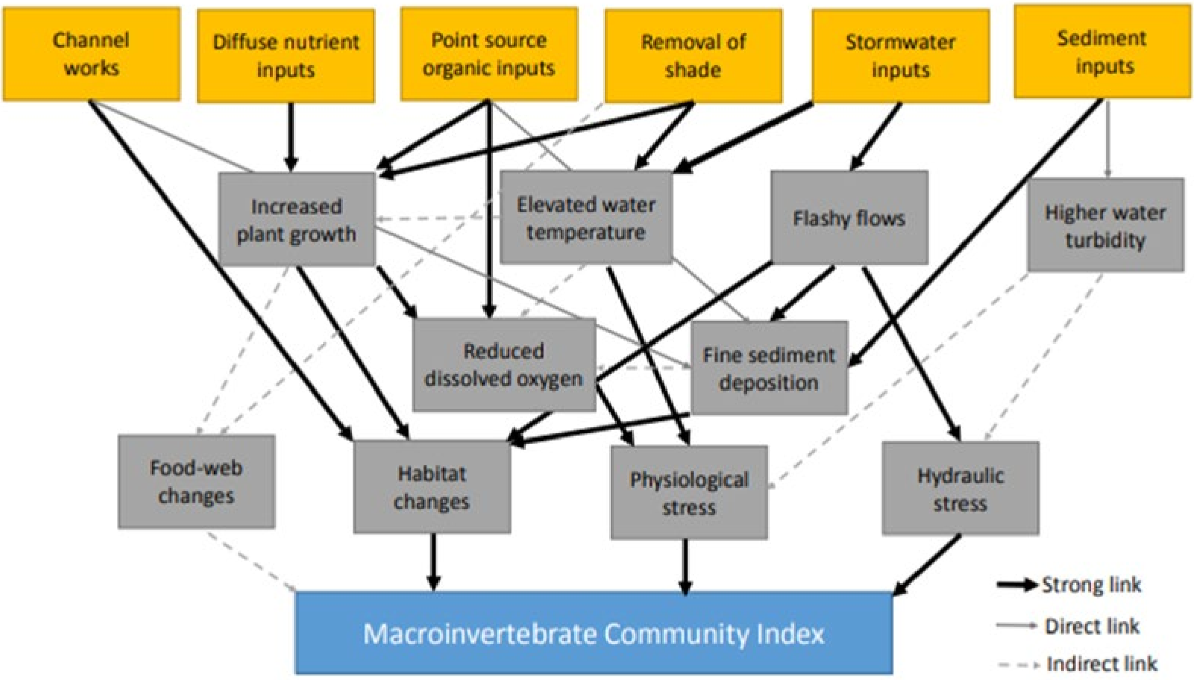


Figure 4: Diagram showing the relationship between human pressures on waterways and MCI. From Clapcott and Goodwin (2014)[24].

[24] Clapcott J. & J. Goodwin. (2014). Relationships between MCI and environmental drivers. Prepared for Ministry for the Environment. Cawthron Report No. 2507. 21p.

Table 1: DairyNZ positions on proposed attributes – Appendix 2A NPS-FM, limit setting required.

Attribute table	Attribute name	DairyNZ position
1	Plankton (trophic state)	**Support.**
2	Periphyton (trophic state)	**Strongly support** national monitoring and reporting. This attribute incorporates trophic state and therefore impacts on ecosystem health. **Support** STAG recommendation to remove the productive classes. However, councils should be able to justify higher frequency exceedance criterion where justifiable on account of natural conditions (e.g. climate, hydrology, nutrients). **Do not support** STAG periphyton default instream nutrient criteria being included in the attribute. We support MfE's suggestion that these could be made available as guidance tables for councils.
3	Total nitrogen (trophic state)	**Support** – we recommend excluding from overall trophic grading if councils can show lake is strongly P-limited.
4	Total phosphorus (trophic state)	**Support** – we recommend excluding from overall lake trophic grading if councils can show lake is strongly N-limited.
5	Dissolved inorganic nitrogen (DIN)	**Do not support as attribute.** **Propose** that the combined measures will provide for ecosystem health outcomes, and in doing so address the perceived need for nutrient attributes that address trophic level effects of nutrients (especially in soft-bottom streams): 1. Correct implementation of the periphyton attribute as notified in the 2017 amended version of the NPS-FM (2014). 2. Raising the bar on nitrate and ammonia toxicity by increasing the level of protection to 90% (from 80%). 3. The introduction of new attributes that incorporate integrated measures of ecosystem health and processes (i.e. macroinvertebrates and dissolved oxygen) that apply in both hard and soft-bottom streams. 4. Recommend councils not report on nitrogen status of a waterway using the nitrate toxicity attribute as a measure of ecosystem health. Alone, nitrate toxicity is not reflective of ecosystem health. **Support** nutrient thresholds being made available as guidance table for councils (where required/applicable) in developing action plans for biological ecosystem measures/attributes - like macroinvertebrate health. This would be analogous to MfE's recommendation/proposal to make periphyton nutrient criteria available as guidance tables.
6	Dissolved reactive phosphorus (DRP)	**Do not support** (same reasons as DIN attribute).
7	Ammonia (toxicity)	**Support** with the recommendation to adopt 90% protection level of bottom-line, which increase the level of protection for aquatic organisms to 90%; reporting of ecosystem health, focused on biological measures of stream health, such as macroinvertebrate indices. **Recommend** changes to how councils report on nitrogen status of a waterway using the ammonia toxicity attribute. Ammonia toxicity should not be used to report/infer ecosystem health status (with respect to nutrient enrichment). Reporting should be aligned/structured with the higher prominence of integrated ecosystem health measures. For example, if macroinvertebrate objectives are not being met, reporting on whether ammonia concentrations are potential limiting ecosystem health (i.e. above/near national bottom-line) would be more informative and address concerns about toxicity reporting used to incorrectly infer nutrient pressures to ecosystem health.
8	Nitrate (toxicity)	**Support** with the recommendation to adopt 90% protection level of bottom-line. **Recommend** - same comment as for ammonia.
9	Dissolved oxygen	**Support.**

10	Suspended fine sediment	**Support** the need for a suspended fine sediment attribute - but we have **serious concerns** about the methods used and thresholds derived. **Propose** revised suspended fine sediment attribute based on a more workable attribute that is based on bottom-line of 5 NTU increase relative to reference. This approach is similar to that recommended in MfE's Stage 2 report, and the thresholds would be consistent with (and supported by) reported effect-based suspended sediment thresholds. **Concerned** that while reports do link catchment loads to median concentrations of suspended sediment (i.e. turbidity) there is considerable uncertainty, which may have implications for setting catchment load limits to meet instream suspended sediment concentrations/turbidity values.
11	*E.coli*	**Support.**
12	Cyanobacteria (planktonic)	**Support.**

Table 2: DairyNZ positions on proposed attributes – Appendix 2B NPS-FM, action plan required.

Attribute table	Attribute name	DairyNZ position
13	Macroinvertebrates (MCI & QMCI)	**Support** proposed attribute as integrated measure of biological stream health. **Do not support** multiple measures on the basis this will create confusion as different measures will produce different band grades for the same ecosystem health measure. It is also unlikely that regional councils have the capacity to undertake quantitative monitoring (for QMCI), and we do not consider that this additional resourcing is justified given that the non-quantitative measure of MCI is fit-for-purpose, and represents the recommended approach (in MfE documents) for undertaken State of the Environment Monitoring. **Propose** only using MCI as this is the recommended metric for SoE monitoring (Stark and Maxted, 2007).[25] Comprehensive MfE-commissioned reports concluded that MCI is one of the most sensitive indicators of stressor effects on macroinvertebrates and can be used to distinguish the ecosystem health of streams at a national scale.
14	Macroinvertebrates (ASPM)	**Do not support** this metric. Includes MCI and EPT, the latter of which is strongly correlated to the former, and therefore a superfluous attribute. Justification for needing an addition attribute measure due to it being more sensitive is inconsistent with comprehensive reports commissioned by MfE (refer to comments above for MCI/QMCI). **Propose** using MCI as this is recommended metric for SoE monitoring (as above).
15	Fish	**Support as a monitoring requirement not as an attribute.** Monitoring fish is important but we have concerns about the appropriateness of using this as a national attribute for freshwater management, given that fish community metrics are generally not good indicators of habitat or water quality pressure. If the intent of the draft NPS-FM is to have the best (i.e. most sensitive, most widely applicable and understood) integrated measure of biological stream health, then this is achieved via a macroinvertebrate attribute. **Need clarification** from Government on how reference states would be set, especially for a national bottom line. **Support** STAG view that exceptions will be needed where a site naturally departs from the IBI bottom line (i.e. geothermal/natural barriers to migration). These could be identified by regional councils.
16	Submerged plants (natives)	**Support** as a monitoring requirement in representative lakes, not as an attribute, and an important measure of lake habitat that is not currently assessed by existing freshwater attributes. However, submerged native plants are impacted by invasive plants (and fish) as well as water quality meaning that their management may require biosecurity approaches (as opposed to land use and catchment management approaches). Water quality limitations of native submerged plants are adequately addressed via the existing three lake trophic attributes (phytoplankton, total nitrogen and phosphorus). **Propose** this indicator is incorporated into the NPS-FM framework as a monitoring requirement, with the caveat that action plans may not be related to resource use limits in an FMU/sub-catchment.
17	Submerged plants (invasive species)	**Do not support as an attribute.** Action plans to improve this measure would be limited to weed spraying/harvesting and not related to setting resource use limits in an FMU. Accordingly, it should be a supporting measurement only in assisting to understand invasive plant pressures on native macrophyte biodiversity.
18	Deposited fine sediment	**Support in principle**. However, we are concerned about the lack of information on current state and also about potential national variability. We are neutral as to whether deposited sediment is best managed as an *Action Plan attribute* (i.e. Appendix 2B) or a *monitoring requirement*, although we understand the perceived importance of this attribute status. The classification system and thresholds are overly complicated.

[25] Stark, J.D. & J.R. Maxted. (2007). A user guide for the Macroinvertebrate Community Index. Prepared for the Ministry for the Environment. Cawthron Report No. 1166. Page 58.

		Thresholds proposed are unworkable in that the difference between classes and bands within classes are typically less than the accuracy with which visual assessments of deposited sediment can be made. **Propose** sediment classification be revised and implemented in the NPS-FM using an approach more in line with what was proposed in the Stage 2 report, which involved setting national bottom-lines to manage for significant adverse effects in stream/river that contain naturally low, moderate or high levels of deposited fine sediment.
19	Dissolved oxygen	**Support.**
20	Lake bottom dissolved oxygen	**Support in principle.** But given the uncertainty expressed in STAG documents, we are concerned that science is not yet robust enough for this to be a national attribute. We suggest it would be better implemented as a monitoring requirement. If adopted, we support the need for section 3.23 exclusions, where there is uncertainty about natural state. **Propose** making this a monitoring requirement, rather than a national attribute.
21	Mid-hypolimnetic dissolved oxygen	**Support in principle,** but we are concerned that this ecosystem health attribute has been driven by salmonids. That is, their requirement to seek out cooler lake water, and hence the requirement to ensure this cooler water has sufficient oxygen. **Propose** the MfE reconsiders whether salmonids should solely drive the requirement for a national attribute, given that these fishes are generally detrimental to native fish (particularly in lakes) and are explicitly excluded from the proposed fish IBI attribute metric.
22	Ecosystem metabolism	**Do not support**. We have significant concerns about what this means. STAG was unable to define a bottom line, or other attribute states (numeric or narrative). This metric is achieved through a combination of biological (MCI) and physio-chemical (dissolved oxygen) attributes. These attributes have high certainty and well defined, accepted bottom-lines. While an ecosystem metabolism attribute *could* have some value, it will not work as a national attribute.
23	*E.coli* – primary contact sites	**Support in principle,** although there is confusion about how the same measure can be both a limiting setting (2A) and action plan (2B) attribute within the same framework. **Propose** a consistent approach is taken for *E.coli* attributes: If management of *E.coli* needs to *reflect that there is a range of reasons for a deterioration, a variety of actions that might be taken, and the specific actions might depend on the catchment and situation* then logically both *E.coli* attributes should require action plans (i.e. be in Appendix 2B).

Threatened indigenous species

Question 22

Do you support the new compulsory national value?

Yes. This policy will promote the protection of ecological processes (e.g. habitat and flows) to support the survival of threatened indigenous species. We note this approach is consistent with the proposals outlined in Te Koiroa o Te Koiora[26] (the NZ Biodiversity Strategy discussion document) and the NPS for Indigenous biodiversity recommendations of the Biodiversity Collaborative Group[27]. This strong degree of alignment is to be welcomed.

We request clarification as to how the value for threatened indigenous species would be achieved alongside the management of undesirable fish species, but we are supportive of the approach to manage fish passage to protect threatened species. We support the protection of ecosystem health provisions to enhance the environment of native freshwater species as recommended by the advisory group, but not the inclusion of trout and salmon.

Fish passage

Question 23

Do you support the proposed fish passage requirements? Why/why not?

Yes, in principle. It is proposed to take management measures to allow native freshwater fish species, trout, and salmon access to the sea.

However, clause 19(2) of the NES, specifically states that fish passage regarding culverts and weirs does not apply in any river identified by the council where passage of undesirable fish species is to be impeded.

As indicated above, we would appreciate additional guidance from MfE as to how the value for threatened indigenous species will be achieved in conjunction with the need to manage undesirable fish species. For example, where undesirable fish species and threatened indigenous species utilise the same water way (including sea access) in their life cycles (diadromous species).

Question 24

Should fish passage requirements also apply to existing instream structures that are potentially barriers to fish passage, and if so, how long would it take for these structures to be modified and/or consented?

We **support in principle** the identification and prioritisation of fish passage as per section 3.17(4) of the NPS-FM, fish passage requirements as outlined in Part 2, and agree that as proposed, subpart 3 of the NES should apply to new instream structures only. Remediation of existing structures will represent a significant cost (both in terms of time and resources) and while remediation is an

[26] Department of Conservation. (2019). Te Koiroa o Te Koiora; Our shared vision for living with nature. A discussion document on proposals for a biodiversity strategy for Aotearoa New Zealand.
[27] Biodiversity Collaborative Group. (2018). Report on the Biodiversity Collaborative Group. http://www.biodiversitynz.org/

important long-term goal, this should be approached as a separate initiative in the most efficient manner possible.

DairyNZ recommends:

- Existing stock crossings be identified through the proposed farm plan freshwater module planning process.

- Undesirable fish species GIS layers are developed by all regional councils, and that these should be freely available for upload to farm plans to help farmers identify where issues with pest fish exist.

- Significant natural impediments, including hydro schemes, that impact fish passage should also be identified and available for upload to farm plans. In addition, any subsequent fish passage requirements should reflect the presence of these natural hazards.

- Remediation of existing structures to provide for fish passage should ordinarily occur when those structures require upgrade and/or replacement provided that:
    - Managing the passage of undesirable species is not a clear and present environmental requirement.
    - There are no other significant natural impediments affect the passage of indigenous fish species.

We have some concerns on the resources required from regional councils to identify all existing fish passage structures and suggest that councils utilise the work being undertaken by the dairy sector in their development of FW-FPs as the most effective way for their identification. We suggest, however, that farmers not be required to replace existing stock-crossings that were installed to meet Sustainable Dairying: Water Accord targets (to have 100% of stock crossings bridged or culverted to exclude dairy cows) until those structures require upgrade and/or replacement.

We agree that the Fish Passage Guidelines provide a pragmatic way to guide the installation and monitoring and maintenance of instream structures and support the use of this document as a guideline. We do not, however, support monitoring requirements for stock crossing structures, suggesting instead that installation standards should safeguard the protection of fish passage.

Wetlands

DairyNZ recognises the important role wetlands have on dairy farms for achieving both biodiversity and water quality outcomes:

- As one of the most biologically diverse ecosystems, wetlands provide a valuable home for native plants and animals.

- Wetlands help protect land from flood damage by slowing or holding surface water and releasing it slowly over time.

- Wetlands also contribute to carbon sequestration and store, assimilate and transform contaminants (especially nitrogen but also phosphorus, sediment and bacteria) lost from farmland before they reach waterways (McKergow et al. 2017)[28]. Research indicates seepage wetlands remove between 75% and 98% of nitrate from water (Rutherford 2017)[29]. They also trap sediment and phosphorus and reduce faecal bacteria.

- Due to their small size (10 to 5,000m^2) seepage wetlands are rarely identified in regional wetland inventories and despite a wetland module in the OVERSEER® model, regional councils do not support the outputs. Consequently, farmers do not receive credit for contaminants removed through the protection of their wetlands. DairyNZ, along with other sectors and NIWA, is working with Overseer® to update the module and strongly encourage central Government to recognise reductions in farm contaminant losses made through wetland protection and creation as another mechanism for incentivising the protection of wetlands.

This is why wetlands feature as a key aspect of our commitment to protect and enhance biodiversity under Dairy Tomorrow. Specifically, DairyNZ will actively promote the protection of wetlands on dairy farms for both biodiversity and water quality outcomes.

Question 25

Do you support the proposal to protect remaining wetlands? Why/why not?

Yes, **DairyNZ supports** the intent to protect remaining natural wetlands and wishes to see the proposals incentivise wetland management on dairy farms.

We support the recognition of **constructed wetlands** as being a distinct category of wetland that is created to reduce nutrients and sediment entering streams, rivers and lakes. Stronger recognition in regional plans and the Overseer® model of the ability of constructed wetlands and protected natural wetlands to reduce contaminants will assist to promote their development, protection and enhancement.

The NES should not create new barriers in the form of onerous consenting and monitoring requirements for farmers who seek to use a constructed wetland to reduce diffuse contaminants leaving their farm, or when protecting natural wetlands.

Restoring wetlands on private land should be enabled and encouraged. We wish to see changes in the proposed NES standards that currently act as a disincentive to their protection and restoration. Some activities related to restoring wetlands should be permitted, subject to conditions to prevent inadvertent damage during works to restore their condition.

[28] McKergow, L.A., Hughes, A., Rutherford, J.C. (2017). Seepage wetland protection review. NIWA Client Report 2016048HN.
[29] Rutherford, J.C. (2017). Review of nitrogen attenuation in New Zealand seepage wetlands. NIWA Client Report 2017241HN.

While we support the proposal to protect remaining wetlands, DairyNZ recommends:

- The definition of constructed wetland and any reference in the NES and NPS should recognise wetlands created for the specific purpose of reducing contaminants and/or enhancing biodiversity. Their continued effectiveness for this purpose must be enabled, recognising that intervention including earthworks, will be an ongoing task and should not be subject to resource consent where certain conditions are met. Two changes to definitions are requested.

- The definitions in clause 4 should be amended so constructed wetland means a wetland constructed by artificial means that:
  a) Supports an ecosystem of plants suited to wet conditions.
  b) Is constructed for a specific purpose, which includes, but is not limited to, reduction of nitrogen, phosphorus, sediment and microbial contaminants, or enhancing biodiversity entering the wetland.

- The definition of earth disturbance in clause 9 should be amended to clarify its application to clauses 9 to 14 so that earth disturbance means the disturbance of earth (including soil, clay, sand, rock and peat):
  a) Including by moving, removing, placing, blading, cutting, excavating, cultivating, filling, excavating, or maintaining it.
  b) But not including disturbance in the course of:
     i. Planting indigenous plants for restoration purposes.
     ii. Installing fencepost.
     iii. Removing pest or weed vegetation using hand-held tools.
     iv. Routine maintenance of a constructed wetland to enable it to continue to function according to its purpose and design.

- Where a FW-FP or other tailored farm environment plan exists, activities to maintain or restore natural wetlands should be a permitted activity. Changes requested to the wetlands standards 4-17 are to include a new permitted activity for wetland restoration and drain maintenance near wetlands that would otherwise require a discretionary activity consent. For instance, restoration activities may require earthworks to remove accumulated material that has slumped and infilled a natural wetland.

- The result of the change is that a discretionary consent is the default situation for farmers, unless they have been through a risk assessment and have a certified farm plan that has specifically listed actions for the wetlands on their farm, including details such as when and to what depth drains near wetlands will be cleaned. **DairyNZ recommends** the permitted activity rule should read:

  New clause 10A general earth disturbance and earth disturbance for drainage – permitted activity

(1) Engaging in earth disturbance and earth disturbance for drainage in, or within, 10m of any part of a natural wetland or constructed wetland is a permitted activity if it is undertaken:

a. For the purpose of restoring or maintaining a natural wetland or for creating or maintaining a constructed wetland.
b. The farm has a certified FW-FP that has mapped the location of all constructed and natural wetlands.
c. The FW-FP has identified actions with timeframes for restoration of any natural wetlands or creation and maintenance of any constructed wetlands.

- The responsibility for developing inventories and monitoring the continuing health of significant wetlands on private land should be borne by Government and carried out as part of a national level framework, which would also provide consistency and oversight at national level.

- Further incentive mechanisms be considered, including Government contribution to Overseer® model improvement measures to recognise reductions in contaminant losses provided by seepage and constructed wetlands[30], and in rates reductions and tax breaks.

- Wetland areas protected and excluded from stock should contribute to the average farm area riparian set-back width as currently proposed through the stock exclusion NES[31].

- Farmers undertaking routine drain maintenance within 100 metres of a wetland there is high uncertainty in drainage provisions in the NES (Clause 12 and 13), because of the requirement for knowing the annual median water level in the wetland before the work occurred and whether a 10cm change has occurred.

- Once consents are granted, there will be significant ongoing costs from monitoring wetlands. NES standard monitoring will require specialists and new technology on farm to assess some of the more technical aspects such as hydrology and nutrients (Clause 5).

Question 26

If this proposal was implemented, what would you have to do differently?

The increased emphasis on the importance of wetlands is likely to raise awareness of their benefit at a farm and catchment scale. This will assist DairyNZ in its work promoting the positive environmental

[30] DairyNZ presumes this will result in less conservative nitrate reductions currently calculated by the module as shown in a recent OVERSEER® wetland module sensitivity analysis (Rutherford 2017b). OVERSEER® assumes an average rate of 250 mg $m^{-2}d^{-1}$(at 20°C) which is adjusted by wetland condition and temperature. Compared to four studies with measured removal rates (Collins (two wetlands), Burns & Nguyen in Rutherford 2017a, Rutherford & Nguyen 2004), OVERSEER® predicted only 36-67% of the measured NO3 removal rates indicating that OVERSEER® predictions were underestimated.
Rutherford, J.C. (2017b) Natural Wetlands in OVERSEER®. Sensitivity to input parameters. NIWA Client Report 2017 2017045HN.
[31] Ministry for the Environment. 2019. Action for healthy waterways – A discussion document on national direction for our essential freshwater. Wellington: Ministry for the Environment. - See appendix 5.4, page 75.

benefits associated with having wetlands on farms, particularly small and highly modified ones that are not currently listed in an inventory.

The proposed approach to protecting and enhancing the wetland condition on farms through consenting and monitoring obligations seeks to ensure no further loss of wetlands. We believe that creating stronger incentives for farmers to identify, protect and enhance wetland areas on their farms through FW-FPs will deliver increased protection. The identification of existing wetlands through FW-FPs is already well underway, and tools such as the Riparian Planner[32] (which identifies wetlands) are being used to guide restoration efforts.

The following approach reflects the sector's commitment and ongoing work to protect and increase the extent of natural and constructed wetlands on dairy farms, an approach we believe will achieve the wetland outcomes sought through MfE's proposals:

- Identification of all on-farm wetlands through FW-FPs (underway).
- Commissioned literature reviews to summarise the current understanding of seepage and constructed wetland efficacy (McKergow et al. 2017[33], Rutherford 2017[34]).
- With regional councils and MfE, develop agreed performance estimates for constructed wetlands (underway).
- With regional councils, develop agreed guidelines for the construction of wetlands to minimise the consenting obligations for both councils and farmers (underway).
- With rural professionals, increase the focus of training modules on identification and importance of wetlands for water quality and biodiversity outcomes (underway).
- With OVERSEER®, regional councils, other sectors and central Government, update the wetland modules to ensure farmers are recognised through nutrient budgets for protecting and increasing the extent of wetlands on-farm.

The proposed changes to the NPS and NES would impose significant administrative, compliance and monitoring burden on both councils and landowners, delivering potentially perverse outcomes.

DairyNZ recommends:

- The NES should be amended to clarify that a constructed wetland should have different regulatory oversight. This will enable farmers to investigate constructed wetlands as an effective mitigation option to reduce nutrients, sediment and faecal bacteria.
- The numerical condition should be retained but onerous consenting requirements should be removed to incentivise farmers to restore natural wetlands on their farm.

[32] DairyNZ riparian planner. Available at: https://www.dairynz.co.nz/environment/waterways/riparian-planner/
[33] McKergow, L.A., Hughes, A., Rutherford, J.C. (2017) Seepage wetland protection review. NIWA Client Report 2016048HN.
[34] Rutherford, J.C. (2017). Review of nitrogen attenuation in New Zealand seepage wetlands. NIWA Client Report 2017241HN.

Streams

Question 27

Do you support the proposal to limit stream loss? Why/why not?

DairyNZ supports all land and water users playing their part to protect the ecosystem health of our waterways. We therefore support the proposed mitigation hierarchy to prevent further loss of streams in urban environments.

Question 28

If this proposal was implemented, what would you have to do differently?

Not applicable to DairyNZ as an industry good organisation.

Question 29

Do the 'offsetting' components adequately make up for habitat loss?

Not applicable to DairyNZ as an industry good organisation.

New bottom line for nutrient pollution

Question 30

Do you support introducing new bottom lines for nitrogen and phosphorous? Why/why not?

DairyNZ does not support the proposed national attributes for DIN and DRP. The proposed thresholds are inconsistent with current scientific understanding of drivers of ecosystem health, and do not adequately address the issue of what is required to improve the biological health outcomes of streams (see DairyNZ response to Question 20).

This attribute has been proposed based on the need to develop nutrient thresholds that protect streams (mainly soft-bottom) from the trophic level effects of nutrients. Importantly, these trophic level effects occur at nitrogen concentrations that are lower than toxicity thresholds. Below we list issues with the logic and technical robustness of the proposed DIN and DRP bottom-line thresholds:

- Ecosystem health, which is best measured by an integrated measure like macroinvertebrates, is complicated. Nutrients are only one of many indirect stressors that interact with and drive an ecosystem health response.

- DIN and DRP concentrations generally vary longitudinally within a catchment in response to the intensity of land use upstream. However, many other variables also vary longitudinally (e.g. local habitat, flow regimes and light and temperature). There are many correlative relationships between ecological health variables and environmental variables, and there are likely to be multiple causal variables among the environmental variables. Death *et al.'s* (2018) analysis provides no evidence that DIN and DRP are the sole causal variables and it is reasonable to expect other environmental variables are among the causative agents. If variables other than DIN and DRP are among the causative agents, then actions to manage these nutrients will not produce the desired change in ecological health.

This is perhaps best exemplified in Pingram *et al*. (2019)[35] where the authors concluded:

> *'These analyses identify that management actions targeted at improving instream habitat quality, particularly reducing fine sediment deposition, when applied across the entire stream network are likely to yield the most widespread improvement in biological condition indices. Our findings also highlight the importance of extending policy development beyond a singular focus on water quality if ecosystem health objectives are to be met.'*

The authors further emphasised that the attributable risks to stream biological health from nutrients were relatively low compared to other stressors (e.g. fine sediment and habitat diversity and quality). They concluded that sole management of nutrients, such as DIN and DRP, may not lead to an improvement ecosystem health. The proposed ecosystem health nutrient attributes assume that nutrient concentrations are a key driver of instream ecosystem health (e.g. MCI score/band). This over-simplification risks prioritising a singular focus on nutrients, at the expense of addressing key drivers such as habitat, flow and fine sediment.

The proposed DIN and DRP attribute thresholds lack a robust technical and peer reviewed explanation expected for setting a national bottom-line. The values used to derive the recommended thresholds for DIN and DRP were extrapolated from an unpublished manuscript (Death *et al.*)[36]. The values derived from this manuscript were different, notably the bottom-lines for nitrate (>95% of DIN at most sites) and DRP were larger than the proposed NPS-FM attribute, 1.32 and 0.057 g/m^3, respectively. For DRP this is three times higher than the proposed NPS-FM attribute. A one-page explanation of the values used to derive the recommended thresholds is summarised in the STAG report[37].

DairyNZ agrees that ecosystem health needs to be managed. We are aware there are indirect and complex relationships to ensure biological health outcomes for streams are meet.

We support the proposed inclusion of the other proposed ecosystem health attributes (with caveats).

DairyNZ disagrees with the national bottom-line for nutrients (DRP and DIN) being used as the main lever to address ecosystem health, which is contrary to published science (e.g. Pingram et al 2019[38]).

---

[35] Pingram M, Collier K, Hamer, M, David B, Catlin A, Smith J. 2019. Improving region-wide ecological condition of wadeable streams: Risk analyses highlight key stressors for policy and management. *Environmental Science and Policy,* 92, 170-181

[36] Death, R. G., Magierowski, R., Tonkin, J. & Canning, A. D. Submitted. Clean but not green: a weight-of-evidence approach for setting nutrient criteria in New Zealand rivers. *Marine and Freshwater Research*

[37] Freshwater Science and Technical Advisory Group. (2019). Freshwater science and technical advisory group; Report to the Minister for the Environment. Publication Reference Number: CR 372. Page 54.

[38] Pingram M, Collier K, Hamer, M, David B, Catlin A, Smith J. 2019. Improving region-wide ecological condition of wadeable streams: Risk analyses highlight key stressors for policy and management. *Environmental Science and Policy,* 92, 170-181

Figure 4 demonstrates the relationship between human pressures on waterways on MCI, and the relatively limited impact that nutrients have.

DairyNZ recommends the following four measures be adopted as an **alternative** to the Government's proposal.

1) **Use DIN/DRP values as guidance:** Adopt the MfE recommended approach for addressing periphyton nutrients; also recommended by STAG as one of original recommendations (Recommendation 2)[39]. That is to make the nutrient thresholds (national and/or by regional grouping) available as a guidance table to assist regional councils (where needed) in either limiting setting (i.e. periphyton) or setting nutrient criteria as part of action plans (e.g. macroinvertebrates). Following this recommendation would eliminate the attribute, and the DIN/DRP values provided as guidance tables to support councils where they are not able to derive regional or site-specific values.

2) **Increase protection level for nitrate from 6.9 g/m^3 to 3.8-3.2 g/m^3**: Raise the bar of ecosystem health to reflect best science and a more conservative approach to protecting native aquatic species. This would entail defining the bottom-line thresholds using a 90% protection level, instead of the current 80% in the NPS-FM. For nitrate this would reduce the current 6.9 g/m^3 value for nitrate down to 3.8 g/m^3.

3) **Be explicit about how they will be applied:** Structure the nutrient table more explicitly for the requirements for nutrient criteria in soft-bottom streams to consider any other relevant freshwater objectives. This will address the current assumption in the technical documents that defaults to toxicity for soft-bottom streams. Restructuring the table could include that:

    a. Explicitly defining streams that do not support conspicuous growths including 'soft bottom' streams.

    b. Instream nutrient criteria set for these streams must consider sensitive downstream receiving environments.

    c. Instream nutrient criteria set for these streams must consider any other freshwater water objective – these could include:

        i. Compulsory attributes such as:

            1. dissolved oxygen.
            2. Macroinvertebrates.
            3. toxicity (lower bottom line).

        ii. Non-compulsory attributes such as stream macrophytes.

4) **Require reporting of holistic attributes:** Alter the method used by councils to report on nitrate toxicity so that reporting on this measure cannot be used to infer nutrient status of water ways. Nutrient status must be explicitly reported on. One possible method to address this would be to allow reporting only of toxicity sites that exceed the D-band. Given that the NPS-FM is moving to a focus on holistic measures of ecosystem health (i.e. biological and ecological responses), for example periphyton biomass, macroinvertebrate health attributes, it is logical that there should be increased requirements for councils to focus on these

[39] Freshwater Science and Technical Advisory Group. (2019). Freshwater Science and Technical Advisory Group: 16 April – priority paper compilation. Page 30.

attributes, plus the drivers and action plans initiated to improve these attributes where community expectations are not being meet. The inclusion of these holistic attributes is the first step to enable councils to address and report on effects of nutrients at trophic or ecosystem health scale.

Question 31

If this proposal was implemented, what would you have to do differently?

DairyNZ commissioned Sense Partners to consider the cost impact of the proposed DIN and DRP limits. Their analysis estimates the annual cost of the Essential Freshwater package increases from $1 billion to $6 billion when these limits are considered (measured in terms of decreases in national GDP).

Sense Partners predict the proposed DIN and DRP limits would reduce dairy hectares, jobs, production, and profit by 15, 23, 29 and 46% respectively, relative to business-as-usual in 2050.

The scientific evidence that underlies these limits is contentious and based on overly simplistic empirical modelling. DairyNZ's proposal is more scientifically robust. We propose to strengthen the nitrate toxicity bottom-line so that it is protective (with respect to chronic, non-lethal effects) of 90% of aquatic species. This corresponds to a median nitrate concentration of 3.8 g/m^3 instead of the current 6.9 g/m^3. This would provide for even the most-sensitive native fish and invertebrates.

This proposal was found to have muted economic impacts. Losses in hectares, jobs, production, and profit relative to the business-as-usual are expected to be around 2, 2, 5, and 10%, respectively, in 2050.

This policy proposal is more robust from a scientific viewpoint and has a much-reduced economic impact on the dairy sector, and therefore the economic impact on the country as a whole. This is important given the significance of dairy farming to income and jobs in regional areas, where alternative employment options are limited.

Question 32

Do you have a view on STAG's recommendation to remove the productive class definition for the periphyton attribute?

DairyNZ supports STAG's recommendation to remove the productive class. Our support is conditional on councils being able to make a case for exceptions in streams that were previously not considered productive class.

Reducing Sediment

Question 33

For deposited sediment, should there be a rule that if, after a period (say five years), the amount of sediment being deposited in an estuary is not significantly reducing, the regional council must implement further measures in each and every year? If so, what should the rule say?

DairyNZ does not support the inclusion of a rule that explicitly sets out a need to reduce the deposit of sediment in estuaries within certain timeframes if there is not significant progress in reducing sediment deposit in estuaries. The limit-setting process under the proposed 2019 NPS-FM will ensure the effect of sediment on each estuary will be identified and provisions to address it in regional plans.

Estuaries naturally accumulate sediment; they are depositional areas. The proposed rule assumes that councils have good information on current depositional rates (measured by plates). Currently there is no standard method for measuring deposition rates, and there is a lack of consistency in sampling design (for both frequency and site selection), as well as analytical methods, preventing comparison between results. In addition, the deposit of sediment in estuaries is naturally variable, both within and between an annual period, due to seasonal and climate variation. This means deposits within an estuary do not follow a strong predictive pattern. Hydrodynamic and morphological processes such as mixing and flushing dynamics also have a string influence on depositional zones and rates. For example:

- In evaluating deposited sediment as a potential estuary attribute, Zaikao *et al.* (2018)[40] concluded that there were no consistent or technically robust methods available for: 1. *sample design, 2. Sampling, 3. lab analysis, 4. computation* for assessing sediment deposition. The lack of consistent and comparable methods for measuring deposited sediment in estuaries means there is, at present, no technically robust foundation to establish what level of deposited sediment is acceptable and what level will trigger the rule.

- Some estuaries such as Avon-Heathcote and Aparima are largely full of sediment, yet there is no net increase in sediment deposition, meaning even if large sediment loads are delivered to these estuaries, the deposited sediment is not retained permanently in the estuary. Any proposed rule would need to explicitly account for this.

- The majority of sediment delivered to estuaries occurs during storm events, whereas freshwater limits for turbidity are based on baseflow (non-stormflow) conditions. Requiring a rule to reduce sediment deposited in an estuary may diminish the importance of the suspended sediment attribute focusing on managing for ecosystem health.

Question 34

Do you have any comments on the proposed sediment attribute?

DairyNZ supports:

- The inclusion of the deposited and suspended fine sediment attributes in the NPS-FM **but we are concerned** about the proposed implementation structure. The proposed sediment

[40] Zaiko A. Berthelsen A. Cornelisen C. Clark D. Bulmer R. Hewitt J. Stevens L. Stott R. McBride G. Hickey C. Banks J., Hudson N. (2018). Managing upstream: estuaries state and values – Methods and data review stage 1B report. *Prepared for The Ministry for the Environment March 2018*

attributes include a total of 24 classes and 96 thresholds that councils and communities will be required to integrate into their existing frameworks.

- The introduction of a limit for suspended fine sediment.

However, **DairyNZ does not support** the proposed classification systems for fine sediment because they:

- Are not based on New Zealand rivers, which have naturally high sediment rates. For example, the current bottom-line thresholds are not met in many sub-catchments dominated by natural landcover (including DOC conservation estate land).

- Do not differentiate rivers according to variation in reference state measures. This means a community may have to manage to a threshold that is naturally unobtainable.

- Are complex, unclear and highly variable within the same waterways. For example, just above the cursor in Figure 5 below the same stream appears to change from green (below the threshold) to purple (above) and back to green in less than five kilometres.

- Will be unnecessarily complex and challenging for implementing catchment load reductions during limit setting in overallocated catchments.

- Will be difficult to communicate to communities and translate to action plans, due to their complexity.

DairyNZ does not support the use of the untested and bespoke fish community index method as the basis for deriving thresholds for a limiting setting attribute in the NPS-FM. DairyNZ is not satisfied with the technical foundations and lack of peer review of the proposed fish community index method. We note that the Stage 2 report did not support using this newly developed, non-validated model as the basis for setting national bottom-lines for suspended sediment (Depree et al. 2018)[41].

[41] Depree, C., Clapcott, J., Booker, D., Franklin, P., Hickey, C., Wagenhoff, A., Matheson, F., Shelley, J., Unwin, M., Wadhwa, S., Goodwin, E., Mackman, J., Rabel, H. (2018). Development of ecosystem health bottom-line thresholds for suspended and deposited sediment in New Zealand rivers and streams: NIWA Client Report prepared for the Ministry for the Environment 190 p (plus appendices). See Section 7.3.2

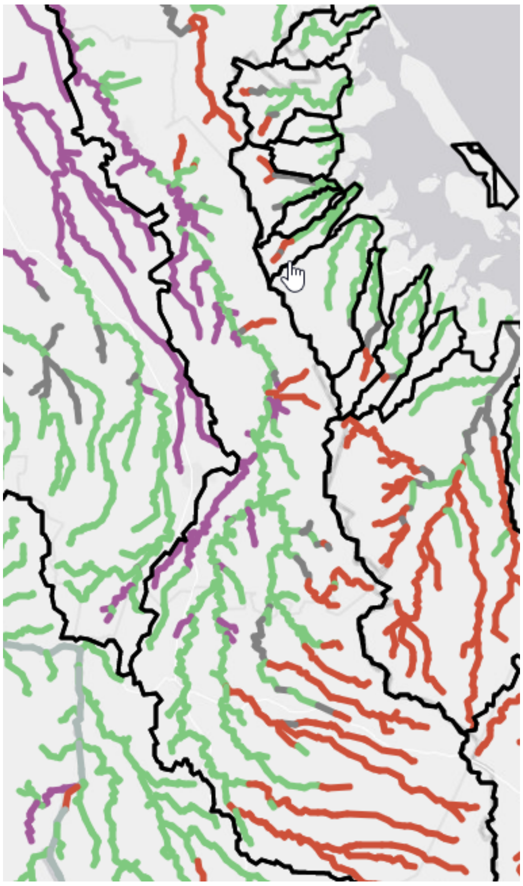


Figure 5: Map snippet with classification of national bottom-lines for sediment applied (example from the Hauraki catchment)

DairyNZ strongly supports the inclusion of deposited sediment in the NPS-FM as either an action plan attribute or monitoring requirement (which would trigger a requirement for a similar action plan).

DairyNZ is concerned the methods would require a more precise measurement of deposited sediment than is possible using instream or bankside assessment methods. Deposited sediment can only be determined (at best) to +/-5% fine cover. Accordingly, classes that differ by 5-10% deposited fine sediment are not able to be differentiated using either instream or bankside assessment methods (ibid). As indicated, the uncertainty in the measurement is likely to be greater than the band gap. This is problematic for reporting and meeting instream objectives.

DairyNZ recommends an approach that focusses on setting bottom lines for fine sediment that are consistent with effects-based thresholds as published in international and national studies.

DairyNZ emphasises the importance of having confidence in the thresholds, particularly bottom-line values which will drive limit setting. It is concerning that current bottom-line thresholds are not met in sub-catchments dominated by natural landcover (including DOC conservation estate land). This indicates that either the classification system and/or bottom-line thresholds are not robust. It also highlights the challenges of using an untested, newly developed method.

If Government concludes the proposed classification approach (i.e. using impact sites) is suitable, **DairyNZ recommends:**

- Sense checking the tables and aggregating classes that have similar values, or revising the table to adopt a higher level classification to address superfluous classes (i.e. classes with overlapping or similar reference states and/or thresholds).

- Government considers using an indicator measure other than the change in fish community index for defining suspended sediment thresholds.

- Any proposed guidelines are consistent with current scientific knowledge about the adverse effects of fine sediment, and that the results based on macroinvertebrate extirpation are:
    - More understandable, and translatable with respect to effects-based attribute states.
    - Based on measured data and rely on technically robust and peer-reviewed methods.
    - Consistent with literature on effects-based thresholds for suspended sediment.

DairyNZ does not support suspended sediment thresholds based on the untested fish community index for the following reasons:

- The fish community index is based on a bespoke and unpublished method that has not been critically reviewed, nor have the outputs of the model been validated or calibrated.

- The fish community index is based on modelled turbidity data, modelled reference state and modelled relationships to explain the relationship between fish presence and absence and a modelled sediment gradient. The methodology's reliance on modelled data and relationships to underpin the derivation of thresholds results in the promulgation of significant uncertainty which has not been addressed. The possible errors and uncertainty in the thresholds derived from this heavily modelled approach have not been quantified, or at least reported. In addition, the arbitrary deviations from reference (modelled) do not translate well to clear effects-based attribute states. Note that DairyNZ has not received the information requested of MfE to better understand how this method was established.

- The method results in national bottom-line values for some classes that correspond to clear water (e.g. 1.5 NTU), and much lower than published thresholds for suspended sediment.

If Government continues to support thresholds based on the fish community index for suspended sediment, **DairyNZ recommends** the following work be undertaken to address some of the method's limitations:

- Clear articulation and definition of what the bottom-line means: as it is currently proposed, the bottom-lines are defined by a modelled value that represents, on average, a 20% decrease in probability of capturing the same group of fish (between 3 and 7 fish species) at a site relative to a modelled reference site. DairyNZ is concerned as to how this can be clearly communicated to the public when explaining the need to set limits.

- Peer review of the method by technically qualified experts, including estimates of uncertainty that are known to propagate through the steps of a model-heavy method.

- Validation of the model output, such as the suitability of a 20% decrease in probability for bottom-line, and full transparency on how final numbers are derived. For example, it would be valuable to know the number of fish included in the index for each class, to be able to view the modelled probability of capture curves that show fit to measured presence and absence data, and normalised probabilities values for reference and impact conditions.

- Sensitivity analysis and recalculation of the thresholds where brown trout are removed (1 of 7 fish species used in the index). The removal of brown trout (or understanding the impact of its inclusion) is consistent with the draft NPS-FM Fish IBI attribute that excludes salmonids.

We provide a more comprehensive review of the sediment attribute in Appendix 4

Question 35

If this proposal was implemented, what would you have to do differently?

Some communities would be required to manage their rivers to meet bottom lines that will be difficult – or in some cases impossible – to meet, because of their natural state. We therefore support implementation based on our recommendations for a revised methodology as outlined under Question 34 above.

Higher standard for swimming

Question 36

Do you agree with the recommended approach to improving water quality at swimming sites using action plans that can be targeted at specific sources of faecal contamination? Why/why not?

DairyNZ supports the proposed approach. The preparation of action plans to help safeguard human health during the swimming season is a sensible approach.

DairyNZ also supports Government's proposal to review guidelines for swimming standards. The need for this review has been signalled by leading freshwater scientists for some time.

Minimum flows

Question 37

Is any further direction, information or support needed for regional council management of ecological flows and levels?

DairyNZ supports Government's goal of linking minimum flows to safeguard ecosystem health and a collaborative community approach to set minimum flows based on the values of the waterbody.

However, we are concerned about the implementation burden this may place on regional councils, relative to the potential gains.

We question whether the full extent of what is proposed in the NPS is needed to achieve the desired outcomes. For example, including all tributaries with the flow at nodes being considered at upstream tributaries.

DairyNZ proposes a risk-based approach that could achieve similar outcomes, but with less burden for regional councils. For example, in locations where pressure from consented takes was found to putting pressure on the system, make decisions to:

- Collect more data, i.e. add flow monitoring stations.
- Using the telemetered water take data (as we support elsewhere in the NES) to model the effect on flows upstream.
- Model the impacts on flow.

In addition, where abstraction is unlikely to impact environmental flows such as locations like the West Coast, **we support** less intensive processes to set environmental minimum flows.

Unintended consequences

Accurately setting water flows and calculating water footprints is becoming increasingly important to meet international export market requirements.

DairyNZ supports accounting for water use efficiency and reporting on water footprints, but we have some concern that the minimum flow requirements proposed do not take into account flows set to meet hydroelectricity production. In these cases, minimum flows are based on electricity generation, not on environmental flow. However, the methodology that is used to calculate water footprints fails to differentiate the two, and therefore assumes an impact that is not directly attributable to low flows.

We recommend that the definition for minimum flows accounts for environmental impacts. This would ensure water footprints are calculated based on the impacts of flow, as opposed to flows defined by other objectives (e.g. cultural, hydroelectricity [Waikato River Hydro dams], thermal dilution [Huntly Power Station], or recreational reasons).

Reporting water use

Question 38

Do you have comment on proposed telemetry requirements?

DairyNZ supports:

- The accurate capture of data on water takes and the capture of real time data to allow for decisions that will generate more efficient water use and allocation decisions.

- The use of pragmatic regional council exemptions where:
    - Technical challenges mean the costs of telemetered monitoring are likely to outweigh the benefits.
    - Water takes are isolated, or

- Water takes are for short timeframes and during times of the year where water availability is adequate (e.g. water for frost protection).

DairyNZ is keen to provide input into further development of the telemetry proposals and rules to ensure they are fit for purpose and will meet the outcomes sought.

Telemetry costs

IrrigationNZ calculates telemetered water reporting costs to range from $1,250 to $1,700 for a straightforward site set up. Costs can increase considerably at remote, less accessible sites. These can range from $2,200 – $3,000, with associated monthly monitoring charges typically between $120 - $180. These costs reflect the need for satellite services, more complex cabling, and/or the installation of a base station to host/service multiple sites.

Time frames

DairyNZ supports a staged approach to implementing telemetry water use monitoring. Priority should go to over-allocated regions, or regions with pre-RMA water rights that have no water use reporting component. Installation of telemetered water meters in these regions would allow councils to compare actual water use to allocated rights and make informed decisions on renewal of water use consents under the RMA.

DairyNZ supports a staged approach where larger takes are prioritised and telemetered before small takes in anticipation that the cost for remote monitoring of small takes reduces with advances in technology.

Raising the bar on ecosystem health

Question 39

Do you have any other comments?

See responses to questions 20, 21, 30 and 31, and our overarching comments at the start of the Raising the Bar on Ecosystem Health section.

Draft National Policy Statement for Freshwater Management

Question 40

Are the purpose, requirements, and process of the National Objectives Framework clearer now? Are some components still unclear?

In the previous sections of this submission we have made extensive comments on all aspects of the NPS-FM's proposed provisions. In summary, we do not think the proposed changes have provided additional clarity in all instances. While we recognise MfE's efforts in explaining why changes are required, the question as to how these changes will be implemented requires significant additional work.

Question 41

What are your thoughts on the proposed technical definitions and parameters of the proposed regulations? Please refer to the specific policy in your response.

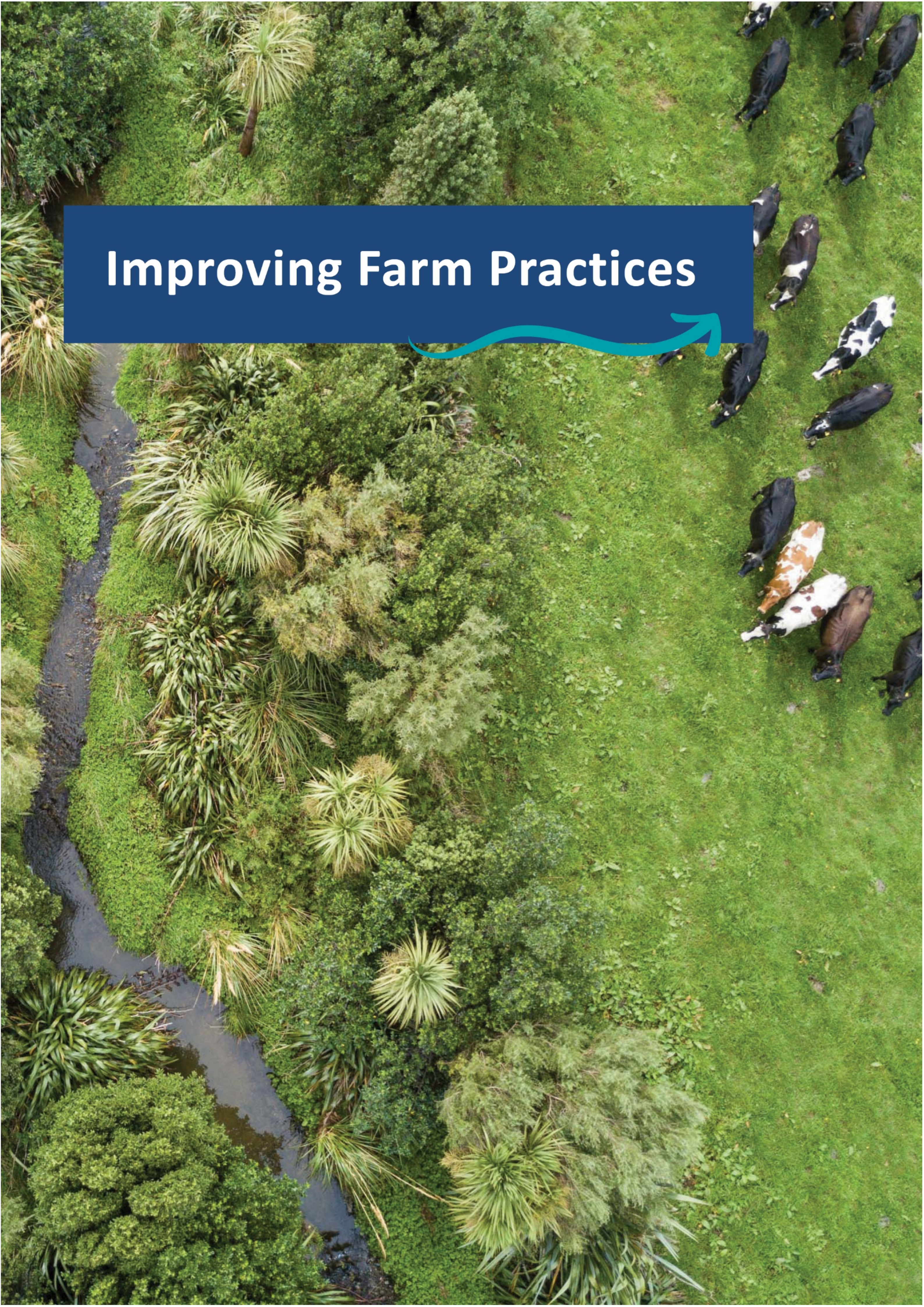
As mentioned in our response to question 40 above, we have provided detailed comments on the technical feasibility of the proposed regulations in the previous sections of this submission. We would be happy to answer any additional questions that MfE may have.

Question 42

What are your thoughts on the timeframes incorporated in the proposed regulations? Please refer to the specific policy in your response.

Please see the responses to questions 41 and 42 above.

Improving Farm Practices



Our overarching comments

The discussion document contains an extensive range of proposals to improve farm practices and our key comments are as follows:

Interim control standards

In the proposed NES, **DairyNZ supports** identifying practices that are high risk for diffuse contaminants and applying standards for these across all farms. We agree some activities require more scrutiny through a resource consent process. We support interim control standards for livestock and land use intensification which apply to catchments without existing NPS-FM limits.

Future NPS processes will identify whether catchments are fully or over allocated, and this is the time to make judgments on headroom. Therefore, we expect these interim control standards to be replaced by more specific provisions following these NPS processes. To support this process and identify gaps in understanding, we recommend a requirement for regional councils to define the allocation status for nitrogen, phosphorus, sediment and bacteria for all catchments within 12 months, based on existing information.

Standards that apply everywhere

DairyNZ recommends more activities be drafted as permitted activities with conditions clearly spelling out what is expected. These need to be written in an unambiguous way to prevent discretionary judgements being made on farm.

As drafted the NES relies on discretionary activity consent requirements that are unnecessary in terms of managing adverse effects. Standards that should be re-drafted as permitted activities, with conditions to manage potential adverse effects, include earthworks to restore wetlands, maintenance of drains near wetlands, and sealed stock holding areas (clauses 10, 12 and 29 respectively). We cover this in our response to wetlands questions 25, 26, and NES standards questions 76 and 77.

The effect of re-drafting will give greater clarity about farm practices that can be done as of right by dairy farmers to reduce the risk of diffuse contaminants leaving farms. In general, **DairyNZ supports** national- standards that work in a variety of situations and farm contexts.

DairyNZ believes that a well-constructed permitted activity standard, with conditions, will achieve the desired behaviour change on farm in a more cost-effective way, for both individuals and regional communities. For this reason, we propose substantial amendments to the wetlands provisions so that wetland restoration on dairy farms is enabled, and constructed wetland water quality benefits can be fully realised.

Constructing NES standards so they sit at the lowest appropriate level of the regulatory oversight scale will enable councils to focus their resources on limit-setting processes and new requirements for inventories and monitoring environmental health. As detailed in the Farm Plan Options section, **DairyNZ supports** mandatory Fresh Water Farm Plans (FW-FPs) as a standard in the NES's FEP. DairyNZ believes FEPs are the key to delivering rapid on-farm change and delivering environmental outcomes.

Farm plans and practice change will lead to water quality improvements

DairyNZ support mandatory farm environmental plans underpinned by Good Farming Practice Water Quality principles as a primary step to mitigate environmental risks on individual farms and to start improving water quality outcomes for all contaminants quickly.

DairyNZ work undertaken in partnership with the Waikato River Authority between 2012 and 2015 led to the voluntary adoption of Sustainable Milk Plans across 642 dairy farms in the Upper Karapiro catchment. A scientific assessment to quantify the likely impacts of these plans and associated mitigation actions on nutrient loading to the Waikato River system suggested reductions in farm nitrogen and phosphorus losses of 8% and 21%, respectively, following completion of intended actions (Burger et al. 2015[42]). This research supports that farm plans do lead to reductions in contaminant loading, particularly for contaminants mobilised through overland flow pathways and which are known to have an impact on ecosystem health outcomes.

Identifying catchments where more action is needed now

DairyNZ supports the principle of identifying priority catchments for immediate action where the science is clear. We support a simplified nitrogen reduction approach as part of a farm plan in Schedule 1 catchments until more comprehensive regional limit-setting processes are complete.

In Schedule 1 catchments, **DairyNZ supports** the 90th percentile option in clause 47(2). In deciding which farms must reduce nitrogen, **DairyNZ supports** a nitrogen surplus approach as proposed by Fonterra. This means nitrogen inputs will be reduced from the highest 10% of dairy farms in those catchments, in addition to having a FW-FP and intensification controls. This will effectively reduce nitrogen loss in the listed catchments and meet deadlines, compared to the overly complex process proposed in the NES, which cannot be delivered within the next three years for all farm types. This also retains a focus on improving farm practices, ahead of allocation.

The sole focus on nitrogen for identifying Schedule 1 catchments misses opportunities to identify where sediment and phosphorus have large impacts on receiving water bodies. DairyNZ has not put up additional catchments because we expect comprehensive NPS-FM processes will soon identify which catchments are fully or over allocated for water quality or quantity. We recommend that this is addressed by regional councils within 12 months, and based on existing data.

As mentioned, we agree with the approach of targeting catchments where significant gains can be made through quick action where those catchments can be identified as being impacted by nitrogen. However, the approach taken to identify those catchments in Schedule 1 relies on data from water quality monitoring sites, and does not account for the impact that nitrogen is having on water quality outcomes. Rather, the approach simply calculates the 90th percentile of sites with >1.5 g/m^3 of TN (with a range of exemptions). The proposed approach also excludes locations where point sources such as wastewater and industrial discharges are major sources of nitrogen. If the policy is aiming for quick-acting reductions in nitrogen, all sources of nitrogen should be considered.

[42] Burger, D.F., R. Monaghan, A. Brocksopp, N. McHaffie & M. Scarsbrook. Potential reductions in farm nutrient loads resulting from farmer practice change in the Upper Waikato catchment: SMP Final Call analysis. Published DairyNZ report.

DairyNZ recommends that policy used to identify target catchments should consider a sub-catchments approach that assesses the impact on measures of ecological health. By way of example, in the Piako catchment only the Waitoa sub-catchment meets MfE's criteria for being >1.5 g/m^3 TN. Subsequently, other parts of the upstream catchment should not be included in the target catchment as they do not meet the specified MfE criteria for inclusion. Waingongoro is another example where, despite meeting MfE's nitrogen criteria, biological stream health (i.e. MCI) in the mainstem shows good ecological health. These examples demonstrate how the current method applied by MfE to identify priority catchments is too narrow and neglects to capture any of the holistic measures of ecosystem health outlined in the proposed NPS-FM.

We summarise our key analysis of the proposed Schedule 1 catchments in Table 3. If high-risk catchments are to be identified, a comprehensive review is required of those already identified in Schedule 1, including assessment of current initiatives already underway to improve water quality.

Table 3. Summary of DIN and MCI exceedances, and comment on justification for inclusion of schedule 1 catchments.

Catchment	DIN exceeds 1.5 g/m3	WQ sites where DIN >1.5 g/m3	% of catchment where DIN exceeded	MCI at DIN exceedance points	Justification for being selected as schedule 1 catchment
Aparima	**No**, max. mainstem =0.67; max trib. = 0.81	na	0%	91-124 at 8 sites	**No.** This catchment does not meet the operational definition, based on water quality at freshwater sites within the catchment (assuming estuaries not included in criteria for selection) **No.** This catchment does not meet the operational definition, based on water quality at freshwater sites within the catchment (assuming estuaries not included in criteria for selection).
Mataura	**Yes, 2 tribs** max. main-stem DIN = 1.1 g/m3	-Waimea Stm 3.1 g/m^3 -Oteramika Stm 1.8 g/m^3	8.4%	92 85	**Yes.** But only the two sub-catchments that comprise c. 8% of the Mataura catchment – and assuming these areas do not have active catchment management groups. Using established MCI – both streams have C band macroinvertebrate health.
Oreti	**Yes, 2-3 tribs** max mainstem DIN =1 g/m^3	-Waikiwi Stm 2.7 g/m^3 -Winton Stm 1.63 g/m^3 -Irthing Stm 1.47 g/m^3 – *note Irthing is just below the MfE 1.5 g/m^3 threshold*	3.4% 4.4% 13.1%	76 81 122	**Yes.** But only Waikiwi and Winton. Irthing, despite being close to 1.5 g/m3, is a good example of a site where D band DIN corresponds to excellent macroinvertebrate health.
Waihopai	Yes, mainstem	-Waihopai River 2.0 g/m^3	All (mainstem site exceedance)	77	**Yes.** *Note urban impacted Otepuni has 1.2 g/m3 DIN and MCI score of 67.*
Waimatuku	Yes, mainstem	Wahopai Stm (at Lorneville) = 3.0 g/m^3	All	80 (at d/s site)	**Yes.** Meets criteria.
Waingongoro	Yes, mainstem	Waingongoro SH45 = 1.9 g/m^3 Waingongoro at Eltham = 1.2 g/m^3	All (lower mainstem exceedance)	97 113	**No.** Despite meeting the MfE nutrient criteria, biological stream health (i.e. MCI) in the mainstream of the lower river is 97 – which is C band (close to B band using original scoring). Upstream at Eltham (1.15 g/m^3 DIN) the macroinvertebrate score is 113 (B band).
Waipao	yes	Waipao at Draffin = 2.5 g/m^3	All	No data	**Yes.** Meets criteria.
Piako	Yes – Waitoa Max. Piako mainstem 1.3 g/m^3	-Waitoa River at Landsdowne 2.1 g/m^3 -Waitoa River at Mellon Rd recorder = 2.1 g/m^3	Only Waitoa?	65	**Yes.** Waitoa sub-catchment meets the criteria, but not the Piako (at least not upstream of the most d/s site at Paeroa-Tahuna Rd where DIN = 1.34 g/m^3). Note – a good example of DIN not aligning with macroinvertebrate stream health at Piako at Kiwitahi – i.e. has 0.78 g/m^3 DIN (C band) and 54 MCI score (one of the lowest values).
Waihou	Yes, 1 trib. Max mainstem DIN = 1.2 g/m3	Oraka Stream = 2.1 g/m^3	20% (Oraka)	No MCI at Oraka stream. MCI at other sites in catchment range from 85 - 131	**Yes.** But should be limited to Oraka sub-catchment, the only part that exceeds MfE criterion. *No macroinvertebrate monitoring at this site.*
Motupipi	Yes trib and mainstem	Motupipi = 1.64 g/m^3 Powell stream = 1.5 g/m^3		81 81	**Yes.** Meets criteria, but nutrients are unlikely to be an issue. There should be more focus on *E.coli* and habitat. MCI, using original banding, is just within C band. We understand there is already an active sub-catchment group working on restoration, and nutrient losses (Landcare report 2008).

Restricting further intensification

Question 51

Do you support interim controls on intensification, until Councils have implemented the new NPS-FM? Why/why not?

DairyNZ supports the proposed interim controls on intensification. DairyNZ broadly supports policies for no further intensification in over-allocated catchments.

In under-allocated catchments, consents could be granted for further intensification. But these should not be provided until the limit setting process is complete. This includes confirmation of Māori rights and interests.

During the development of this submission MfE officials clarified that an applicant could assess the potential risk of increased sediment and *E. coli* loss through modelling (where appropriate) and/or expert opinion on the effectiveness of proposed mitigations for managing sediment and *E. coli* under a FEP. For example, sediment and bacteria loss can be actively and effectively managed via buffers and riparian planting at farm scale. **DairyNZ supports** this proposal.

DairyNZ is concerned about the accuracy, practicalities (and costs) to farmers in assessing whether loss of sediment and *E. coli* would increase as part of their consent application. There are currently no robust or validated tools available to allow sediment and bacteria loading to be modelled at the farm scale.

MfE also confirmed during consultation that the requirement for limit setting is either that the new NPS-FM has been implemented, or either of the 2014/17 versions have been implemented.

DairyNZ does not support the inclusion of no increase in winter forage cropping as a criterion for triggering a requirement for consent as this could result in perverse impacts. Tighter Intensive Winter Grazing standards under the new National Environmental Standard may mean increases in winter cropping in more suitable areas and/or increases in the area of any one farm being used for winter grazing. Provided cow numbers remain the same, this would actually reduce the intensity of the winter grazing activity.

Question 52

For land-use change to commercial vegetable growing, do you prefer Option 1: no increase in contaminant discharges or Option 2: farms must operate above GMPs. What are your reasons for this?

DairyNZ supports Option 1. We **do not support** a potentially high-risk land use being excluded from an interim requirement not to increase nutrient losses.

Question 53

How could these regulations account for underdeveloped land, and is there opportunity to create headroom?

The interim intensification controls ensure catchment contaminant loads do not increase between now and when values and limits are established through the NPS-FM process.

The appropriate time for a conversation about creating headroom for underdeveloped land in catchments that are defined (through FMU process) as fully or over-allocated, is in the context of an allocation framework.

Farm Plan Options

FEPs are the best way to deliver improvements in rivers quickly.

This is because farmers take **ownership and responsibility** for the plans. The preparation of the plan involves working with the farmer, not dictating what must happen. The joint preparation of the reports gives farmers input and control over the process. This leads to a greater feeling of responsibility and increases positive environmental actions on farm.

FEPs provide a **farm-specific risk assessment**, which helps farmers identify and target the biggest risks on their farm.

The development of an FEP involves understanding environmental goals in the context of their business, its challenges and the farmer's aspirations for it. In this context, the farmer can work with their advisor to **prioritise actions**. As with any business, not all improvements can happen overnight. Some changes will require significant investments in infrastructure or changes to how the farm is managed. Others will be easier to make. The FEP process helps farmers understand what is most critical on their farm and develops an agreed set of priorities for the life of the plan.

FEPs address the **four critical contaminants** for freshwater quality: nitrogen, phosphorus, sediment and *E.coli*. One action may help address multiple environmental challenges, such as stock exclusion, which helps with phosphorus, sediment and *E.coli*.

FEPs involve **collecting important information**. This will be used to help inform future FW-FPs and support more strategic decision making over the long term.

DairyNZ believes FEPs help to **change farmers' mindsets** about their land and water resources.

DairyNZ has seen how effective FEPs can be

From 2011 – 2018, DairyNZ implemented a similar tool called a Sustainable Milk Plan (SMP). Approximately 1,700 SMPs were completed in eight catchments in New Zealand. SMPs focused on reducing the environment footprint from diffuse nitrogen discharges, with some actions also reducing *E.coli*, sediment and phosphorus.

In 2012, DairyNZ and Waikato River Authority co-funded 642 plans in Upper Waikato and in 2015 a similar programme in Waipa for 285 dairy farms. SMPs had similar elements to FEPs – assessment of risk, agreement of actions, and follow-up of progress. The difference is that the SMPs and their actions were voluntary. For some of the catchments DairyNZ collated data around mitigation and actions to estimate potential reductions in farm nitrogen and phosphorus losses as a result of implementation.

In Upper Waikato, this showed reductions in nitrogen and phosphorus leaving the farm of approximately 8 and 21%, respectively if fully implemented (Burger et al. 2015[43]).

Key DairyNZ learnings that apply to the FW-FP provisions in the NES are that actions have to be developed with the farmer and written in a way that can be followed up in subsequent visits, including by certified auditors. The SMP was a precursor to other more specific milk processor tools and programmes, including those by Fonterra, Miraka, Tatua and Synlait.

DairyNZ notes that not all FEPs are created equal, and that follow up and ongoing engagement with the farmer is critical to their success. We have expanded on these points in our responses to Q56.

Regional councils know how important FEPs are

FEPs are a central component to many regional councils' plans to manage freshwater. The following councils have FEP requirements in their plans (or proposed plans): Environment Canterbury, Waikato, Horizons, Southland, Environment Bay of Plenty and Hawkes Bay.

Waikato: The effectiveness of farm environment plans was thoroughly investigated by experts and modelled as part of Waikato regional Plan Change 1. This showed that farm environment plans, implemented over 10 years in stages, met or exceeded the required targets in the regulation for nutrients, sediment and microbial contaminants (a 10% change from existing water quality to long term water quality targets).

Southland: A recent survey by the Aparima Community Environment Project in Southland investigated the correlation between FEPs and active management of environmental risk across dairy and other farming systems (Research First, 2019[44]). The implementation of winter grazing practices was dependent on whether the farm had an FEP. Those that had FEPs were more likely to implement good practices compared to those without FEPs (Figure 6).

[43] Burger, D.F., R. Monaghan, A. Brocksopp, N. McHaffie & M. Scarsbrook. Potential reductions in farm nutrient loads resulting from farmer practice change in the Upper Waikato catchment: SMP Final Call analysis. Published DairyNZ report.
44 Research First (2019) Aparima Community Environment Project: Farmer good farming practice survey. Prepared for Aparima Community Environment Project. 28p.

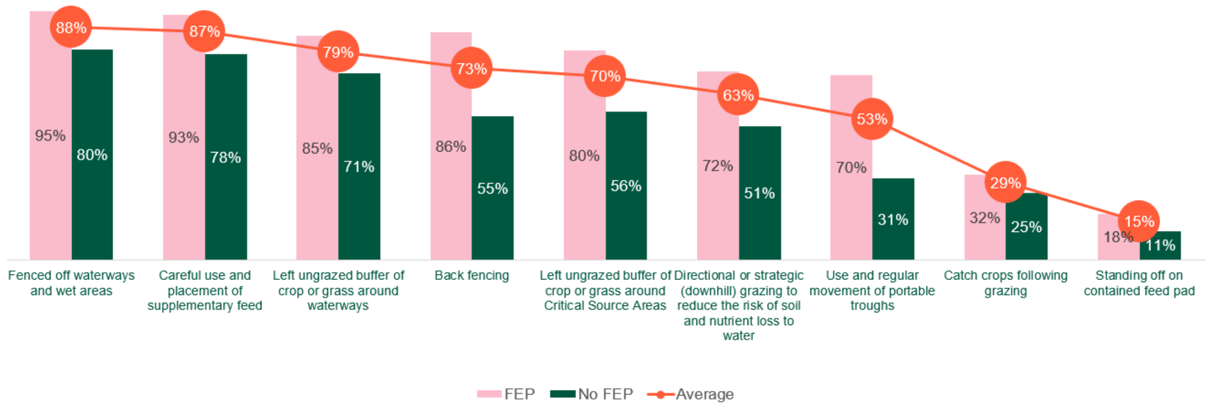


Figure 6: Responses to an Aparima Community Environment survey on FEPs, asking which winter grazing practices farmers implemented in 2018. The survey was carried out by Research First.

Question 54

Do you prefer mandatory or voluntary farm plans (acknowledging that farm plans may be required by councils or under other parts of the proposed Freshwater NES)? What are your reasons for this?

DairyNZ supports a mandatory (as opposed to voluntary) requirement for all farms to manage environmental risks to freshwater under the FW-FP standard in the NES's FEP, given the clear benefit for water quality outcomes.

We are seeking assurance that existing certified plans will not need to be immediately reproduced and a commitment from Government to work with farming sectors to ensure there is sufficient capacity and capability to deliver certified and audited plans to all farms, dairy and non-dairy, within the required timeframes.

The proposed approach is consistent with the dairy sector's preference for tailoring farm-specific risk-management frameworks to manage environmental effects. This is why the dairy sector has already committed to having all farms implementing and reporting under certified farm sustainability plans by 2025, under our Dairy Tomorrow strategy.

At present, it is the dairy sector only that has committed to certified FEPs. Requiring all farm systems to produce similar plans (FW-FPs) will increase the pressure on the pool of certified farm planners available. We have concerns about the ability of all farmers to be able to meet the deadlines for certifying plans at reasonable cost.

DairyNZ recommends:

- Government works with industry groups[45] on certification and initiatives to ensure sufficient capability and resources to support farmers in developing and implementing FW-FPs.

- Government funds are made available for the new roles of certifier and auditor to ensure the 2025 FW-FP deadlines are met. The purpose of this funding is to ensure a sufficient pool of experts is available to farmers and that processes and procedures are in place for moderating between advisors to ensure consistency across NZ. Further details are provided in response to question 56.

- Provision is made for a transitional timeframe to allow farm and nutrient plans obtained under specific regional plan requirements to be updated, either by 2025 or when they come up for review under regional council rules. We note that farmers would be free to update their plans based on changes in farm practices or activities, and have these updates certified. In our experience, sector and regional council support in the roll out of any farm plan policy is critical. In Canterbury and Hawkes Bay the dairy sector has been heavily involved in the implementation of farm and nutrient plans where these have been required by regional council plans.

- Government establishes an industry-Government working group to facilitate implementation.

- Government prepares an electronic version of the content of FW-FPs set out in clause 38. This would operate as a template that streamlines FW-FP provision and that can be used around the country. It could include links to speed up the search for basic information – e.g. where a farm map can be downloaded.

We support the earlier FW-FP delivery date of two years after commencement of the NES for those farms in clause 37 (1), including all farms in Schedule 1 catchments, commercial vegetable production and Kaipara highly erodible land.

Question 55

What are your thoughts on the proposed minimum content requirements for the freshwater module of farm plans?

DairyNZ supports the high-level description of farm plan requirements and the more detailed description of FW-FP content as set out in of the proposed NES[46]. We note much of the basic content generally aligns with existing FEP frameworks (Canterbury LWP, Southland WaLP and Waikato PC1).

---

[45] Primary sector groups and farm planner industry groups such as NZIPIM
[46] Clause 38 of the proposed NES

DairyNZ recommends:

- Clarifying some of the content and ensuring alignment throughout the NES. For example, there is an inconsistency in that good farming practices are referred to in clause 40 but not in clause 38 (which refers to best practice options or to solely avoiding, remedying or mitigating the loss of contaminants).

- Using the industry-agreed Good Farming Practice Action Plan for Water Quality[47] principles to guide FW-FP actions. This is consistent with the approach in other regions (such as Canterbury and Waikato) where this approach appears to be working well. The focus is on actions to address risks identified on farm, rather than being a risk identification process.

Question 56

What are your thoughts on the proposed priorities and timeframes for roll out of farm plans, as set out in the proposed Freshwater NES.

DairyNZ supports the need to act more quickly in catchments with existing water quality concerns and no current requirement for FEPs, which is the term often used in regional plans, and which the NES refers to as a Freshwater Module of a Farm Plan (FW-FP). For the reasons mentioned in Q54, we have concerns about increasing pressures on the pool of certified farm planners, which could affect the ability of farmers to deliver on these plans.

We recommend Government considers options to expedite the certification process and encourage appropriately skilled people to obtain certification, for the high-risk catchments in particular.

There are many ways Government can help the agriculture sector to deliver certified FW-FPs. The dairy sector has already made significant investments to get on track to delivering high quality FEPs for all dairy farms. However, we are concerned that Government support should be carefully designed, appropriately balancing the interests of early and late adopters, and minimising the potential for free-rider challenges to occur.

The following are examples of how Government funding could be used to help delivery of FW-FP goals in a fair and effective way:

- Development of training programmes for certifiers and auditors.
- Ensuring there are training certifiers and auditors throughout the country.
- Development of systems and processes to deliver FW-FPs (e.g. auditing scheme, FW-FP planning tool, Overseer® or other modelling approaches).

[47] Good Farming Practice Governance Group. (2018). Good farming practice: Action plan for water quality 2018.

Question 57

Do you have any comment on what would be required to ensure this proposal could be effectively implemented, including options for meeting the cost of preparing, certifying and auditing of farm plans; and on financing options for other on-the-ground investments to improve water quality?

As noted above, **DairyNZ recommends** Government:

- Works with industry groups[48] on certification and initiatives to ensure sufficient capability and resources to support farmers in developing and implementing FW-FPs.
- Establishes an industry-Government working group on implementation.
- Continues to support the MPI/MfE Integrated Farm Planning initiative and FEP approach being developed through that process.
- Considers options to expedite the certification process and encourage appropriately skilled people to obtain certification (for the high-risk catchments in particular).
- Clarifies some of the content and ensuring alignment throughout the NES.

Some additional considerations follow:

Availability of certified practitioners

The certification and auditing proposal, and the associated accreditation of certifiers and auditors, puts the ability to deliver this policy at risk. It also puts the quality of the plans, and therefore the effectiveness of the policy, at risk. This view is based on our experiences in the Canterbury and Waikato regions.

In the Waikato, the New Zealand Institute of Primary Industry Management (NZIPIM) recently provided detailed evidence during the Plan Change 1 (PC1) hearings that foreshadowed potentially severe shortages in the number of suitably qualified persons seeking to become certified farm environment planners.[49] They estimated that at least 125 certified farm planners would be required to implement PC1. Based on a survey of their Waikato and Bay of Plenty members, NZIPIM estimated that 93 of their members (maximum and best-case scenario) would become certified farm planners. For this reason, they did not think it was realistic to achieve priority 1 FEPs by 2020 (four years after notification of PC1).

This was despite:

- Having approximately 5,000 farms in the catchment requiring farm environment plans.
- Plan change rules were the same across the catchment, but rule implementation was staged to recognise the time and resources for nitrogen baselines and farm plan development, and the limited availability of trained and experienced advisors who could become certified farm environment plan advisors.
- NZIPIM members outside the PC1 catchment (e.g. in the Bay of Plenty) focusing their time on the PC1 catchment.

---

[48] Primary sector groups and farm planner industry groups such as NZIPIM

[49] New Zealand Institute of Primary Industry Management. (2019). Statement of primary evidence of Lee Antony Matheson, 15 February 2019. Available at: https://www.waikatoregion.govt.nz/assets/WRC/Council/Policy-and-Plans/HR/64.pdf

We are not saying this policy cannot be delivered. Rather, we are providing this example to highlight the technical and logistical challenges associated with the requirement for all farms in all regions to obtain FW-FPs, and therefore the need to prioritise where plans are rolled out first.
We see support from the sector, appropriately skilled and qualified farm planners and quality farm plans as the key to success. We want to see quality FW-FPs that are a good use of time, add value to each farm business, and deliver the desired environmental outcomes.

DairyNZ recommends that if a current, certified FEP meets regional council regulations for freshwater management, it does not need to be recertified as a FW-FP until 2025, or until it comes up for audit (review). We acknowledge that aspects of the plan may need to be updated, such as adding a section on intensive winter grazing, for example. However, a full, certified and audited FW-FP would not need to be completed until 2025.

Ongoing support is critical

Farmers are busy and are contending with many new rules and regulations regarding their businesses.

When DairyNZ carried out its Sustainable Milk Plans (SMPs) programme there were two farm visits. The first, when actions were agreed, followed by a final visit six-10 months later to review actions and verify and document completion. Support and advice were provided between the two visits.

The ability for farmers to touch base with their team, and know the prompts were coming, provided them with the confidence and sense of responsibility to deliver on agreed actions. There does not need to be an audit of their performance, as such, but more a check in on how actions are progressing. There may be good reasons as to why progress has not been as expected, and early intervention helps to ensure the situation is remedied sooner rather than later.

This ongoing support is also important in ensuring the mental wellbeing of all on farm. Additional changes to management practices or requiring increased investment may be stressful. Again, finding this out early enables early intervention.

Availability of auditors

We have similar concerns about the proposed auditing process, noting the proposal for all FW-FPs to be audited within 24 months and thereafter every two years.

We support the intent of the policy. There is merit in review and audit of farm actions against FW-FPs. Our concern is whether there will be appropriate resourcing to deliver on expectations.

Addition points on NES drafting matters

DairyNZ notes the absence of definitions for some key terms. Examples include: land disturbance, land management unit, on or near and contaminant.

DairyNZ notes the NES uses the term 'best practice options'. We request this term is deleted and replaced with 'good management practices' or 'good farming practices' as they are common farming terminology. The Good Farming Practice Action Plan for Water Quality[50] has been adopted as a reference for certifiers. The principles in the action plan also needs to be linked to the text in the NES's FEP.

Immediate action to reduce nitrogen in Schedule 1 catchments

Question 58

Which of the options (or combination of them) would best reduce excess N leaching in high nitrate-nitrogen catchments? Why?

This interim policy is intended to remove nitrogen from identified catchments while longer-term provisions are being developed over the next four years through NPS-FM council limit and rule-setting processes and the Fair Allocation work programme. It therefore needs to be a fast-acting interim measure, and is not intended to achieve the larger, more widespread structural or land-use change that may be required to improve water quality.

This policy is targeted at catchments with measured nitrate concentrations in water, where catchments were ranked, and some put into Schedule 1 for immediate action. DairyNZ supports simple methods that remove nitrogen from that catchment in a short time frame. The NES does not set out to determine the sustainable level of nitrogen, nor the catchment objectives/nitrogen catchment load limit. It is simply targeting nitrogen losses well beyond the realm of good practice.

The nitrogen baseline should be generated using a streamlined and transparent method and the option of 90th percentile should be chosen.

The approach should be simple to ensure streamlined and practical implementation. The method of identifying the highest 10% of dairy farms should be based on nitrogen surplus, which is a simple calculation that does not require certified advisors or modelling. The nitrogen surplus calculation uses farm data (N in Fert + N in supplement; N in product + N in exported feed. This can be calculated using Overseer® or a simple nitrogen surplus tool.

Strengths of this method are that it:

- Is based on a well-recognised nitrogen balance approach.
- Uses a limited amount of farm data that is readily obtainable.
- Excludes estimation of legume N2 fixation, which is variable and difficult to accurately quantify.

[50] Good Farming Practice Governance Group. (2018). Good farming practice: Action Plan for water quality 2018.

This approach is also well-recognised internationally and has been used elsewhere to restrict farm nitrogen losses (e.g. in the Dutch nitrogen accounting system[51]) and drive improving efficiency in farm systems with reduced environmental risk[52].

The approach should be short lived because there are important issues that must be addressed in each catchment. An interim approach cannot address all the complexities of people, land and water in a NZ-wide regulation. We assume comprehensive NPS-FM compliant regional plans will soon replace the interim provisions, starting in approximately four years' time.

DairyNZ's position is that through a simple, short lived regulation the riskiest practices can be managed quickly to achieve the intended policy outcomes of immediate action and improving farm practices ahead of the allocation process. We are confident that nitrogen leaching will be addressed through the substantive regional council limit setting processes. Addressing further nitrogen reductions, which must also take into consideration location (this influences nitrogen loss through soil type, rainfall and drainage class), should be undertaken as part of future comprehensive limit-setting approaches with each regional or sub regional community.

DairyNZ supports nitrogen loss (leaching below root zone using Overseer®) being used in comprehensive limit-setting plans. In anticipation of these more comprehensive processes, **DairyNZ supports** the need to collect robust individual farm information**.** This information will be used in developing baselines and help feed into the development of allocation concepts/frameworks. This information can also be used to apply more precision-based mitigation solutions at catchment scale.

DairyNZ supports the FW-FPs approach as outlined in NES Subpart 3 (Option 3 of the discussion document). We also support the NES alternative provision (Option 1), but in the form of a simpler nitrogen baseline method with nitrogen reductions managed by way of a controlled activity consent.

Once nitrogen baselines are obtained, farms are ranked from low to high then a cut-off value is determined and those farms above the value must reduce to that value. The nitrogen baseline should be determined using a simple surplus process (N in Fert + N in supplement; N in product + N in exported feed), rather than an Overseer® derived nitrogen loss number. The approach should be simple and ensure streamlined and practical implementation. Overseer® can also provide a nitrogen surplus figure. Farmers who prefer to use Overseer® could choose to do so. Fonterra's work on the two models shows a high correlation between the two approaches for nitrogen surplus (r^2value >0.95).

DairyNZ believes that nitrogen surplus is the best way to reduce nitrogen in Schedule 1 catchments quickly. The immediate action to reduce nitrogen loss proposal is an interim measure, and we expect it will be replaced by future NPS-FM limit-setting regional plan requirements/rules that may require Overseer® baseline files. DairyNZ has concerns about the capacity of rural professionals to deliver the required number of Overseer® files, especially in the larger priority catchments such as Waihou/Piako and Southland. The surplus approach is also more relatable to farmers, which will help drive faster action.

[51] Statement of primary evidence of Dr Stewart Francis Ledgard for DairyNZ Limited in the matter of: of the proposed Variation 5 to the Proposed Canterbury Land and Water Regional Plan – Nutrient Management and Waitaki. 22 July 2016.
[52] Schröder, J.J., and Neeteson, J.J., (2008), Nutrient management regulations in The Netherlands. Geoderma 144: 418-425.

Until a future comprehensive limit-setting process has been undertaken, we suggest a nitrogen surplus approach, in combination with identifying the highest risk practices through FW-FPs to reveal the highest 10% of dairy farmers and reduce nitrogen discharge, alongside all other potential contaminants. While we acknowledge the surplus approach does not specifically address nitrogen loss below the root zone as impacted by climatic and topographical variables, it does address the intent of this proposed policy.

> '*This policy is targeted to where the highest impact is occurring from nitrogen losses. It does not set out to determine the sustainable level of nitrogen, nor the catchment objectives/nitrogen catchment load limit. It is simply targeting nitrogen losses well beyond the realm of good practice.*'[53]

There are links between nitrogen inputs and leaching. These are likely to be particularly pronounced in catchments that have high nitrogen levels in their waterways. Whilst there is only a relatively small number of analyses between the two approaches, Environment Canterbury's Section 42A Report as it relates to the fertiliser nitrogen modelling proxy included a preliminary comparison of these methods. Although much more comprehensive assessment is required, the report concluded there would be no substantial difference in nitrogen leaching from either the nitrogen loss (Overseer®) or nitrogen surplus approach[54]. The result of a nitrogen surplus method to estimate baseline and reduce nitrogen inputs is that there will be less nitrogen entering waterbodies in Schedule 1 catchments.

The sole focus on nitrogen misses opportunities to identify catchments where sediment and phosphorus have equal or greater impact on water quality decline. DairyNZ has not put up additional catchments where this is the case. We expect NPS-FM processes will identify which catchment is fully or over-allocated for water quality or quantity.

Rule framework

DairyNZ proposes the following changes to the rules framework for managing this interim standard:

a) Replace all reference to nitrogen loss with reference to a simple nitrogen surplus that accounts for purchased nitrogen inputs and does not attempt to estimate clover fixation.

b) Define purchased nitrogen surplus as:

   Nitrogen surplus figure means the amount of nitrogen surplus calculated as: nitrogen brought on to the farm in fertiliser and nitrogen brought on to the farm in feed minus the amount of nitrogen exported from the farm in productive outputs'.

c) Amend the threshold value calculation in Clause 47 to refer to nitrogen surplus figure not nitrogen loss figure and amend the square box in Clause 47(2) to state 90%.

d) Delete reference to Overseer®, including deleting the definition of Overseer® and Overseer® modeler.

[53] Regulatory Impact Analysis for Consultation on Essential Freshwater Package, p289
[54] Statement of primary evidence of Dr Stewart Francis Ledgard for DairyNZ Limited in the matter of: of the proposed Variation 5 to the Proposed Canterbury Land and Water Regional Plan – Nutrient Management and Waitaki. 22 July 2016.

e) Amend the NES standard in clause 38 that sets out the content of a FW-FP to include a subclause (5) setting out nitrogen management for farms in Schedule 1 catchments. This is likely to be a cross reference to additional clauses that require nitrogen baselines being determined for Schedule 1 catchments using a nitrogen surplus method, and nitrogen reductions for those farms over the 90th percentile nitrogen surplus baseline value. These are the changes as per information note in Subpart 4 of the NES.

f) Delete clause 45 (requirement for farmers at or over the nitrogen surplus 90th percentile to have to apply for a discretionary activity consent if a certified FW-FP has not been completed). Instead, add this as a requirement of the controlled activity in Clause 44 so that the matters the consenting authority reserves control over include the reduction of nitrogen surplus figure where it is at or above the threshold value.

Question 59

If you are in a high nitrate-nitrogen catchment, what would you have to do differently under these options?

Option 1 (with baseline determined using nitrogen surplus not nitrogen leaching): Farmers above the threshold for nitrogen surplus in a catchment would reduce farm inputs. They would choose which of the nitrogen-critical inputs of bought-in feed or fertiliser (and the proportion of each) would deliver the required reductions. Nitrogen surplus could be calculated using Overseer® or a simple nitrogen loss calculation.

Option 1 (as proposed – using Overseer®): Farmers above the threshold for nitrogen loss in a catchment due to geographic factors (soil type, rainfall etc) would likely require significant change in farm system type. This is likely to have significant economic impact in the short term, and ahead of the limit-setting process.

Fonterra is the only organisation in New Zealand that has experience implementing Overseer® at scale, and provides useful information on their experiences in their submission.

Option 2. This is not included in the draft NES, so it is difficult to provide detailed comments. It is a blunter instrument than the nitrogen surplus approach preferred, because it targets one farm management aspect only. There is every likelihood the nitrogen deficit created by restriction in nitrogen fertilizer could be replaced by imported supplements, thus negating any potential reductions in nitrogen loss.

Option 3. DairyNZ supports tailored farm plans (with the content set out in Clause 38 of the NES) for a FW-FP that is developed by a certified advisor, manages risks across all contaminants and is audited. DairyNZ responses are contained under discussion document questions 54-57. We support FW-FPs, in combination with the modified Option 1, to deliver a streamlined and practical implementation approach to reducing nitrogen.

Question 60

In addition to those already identified, are there other high nitrate-nitrogen catchments that should be subject to these options?

DairyNZ does not believe more catchments should be added at this stage. Our preference is that all available resources are invested in completing NPS-FM limit-setting process for all remaining catchments, noting that regional councils will have to notify proposed plans within a very short time (four years).

Within existing listed catchments, approximately 2,400 dairy farmers will have to obtain a FW-FP and cap or reduce nitrogen inputs on their farm. If any further catchments are added to the list of Schedule 1 catchments for immediate action risks to water quality decline from all diffuse contaminants should be included.

Question 61

Do you think the action already underway in five regions (identified in section 8.4) will be effective in reducing excessive N leaching in those high nitrate-nitrogen catchments?

Yes, with the caveat that there are significant implementation challenges that will be exacerbated as new deadlines are imposed. This is one reason why DairyNZ prefers baselines of nitrogen surplus as a streamlined implementation approach to reducing nitrogen in the NES Schedule 1 catchment. We note that regional processes in the five regions identified, and others throughout New Zealand, are highly complex with significant implementation challenges as many previously permitted land users move into a highly regulated framework. As such, differences in effectiveness are likely to be achieved in different regions.

Question 62

Should there be higher thresholds for farms that produce food products in winter, and if so, which food products?

All farming that is high-risk for contaminant loss should be subject to the parallel controls. Creating exceptions for particularly high-risk activities, such as winter food production, is inconsistent with the objectives of the proposal.

Question 63

What alternative or additional policies could contribute to reducing N loss?

See response to question 58, and the detailed proposal in Fonterra's submission.

Question 64

Do you have any comment on what would be required to ensure this proposal could be effectively implemented?

There are significant challenges utilising Overseer®. This has been realised in regions, such as Canterbury and Horizons, which have failed to meet implementation timeframes and resulted in significant costs being incurred by farmers (as discussed), as well as a mistrust that has stemmed from significantly different outcomes following version changes. Alternative methods, such as focusing on nitrogen surplus, are likely to be more effective in delivering both accelerated step-change and environmental objectives in the short-term and ahead of limit-setting processes, where a more comprehensive estimate of contaminant loss for each property will be required.

Excluding stock from waterways

Question 65

Do you support excluding stock from waterways? Why/why not?

Yes, **DairyNZ supports** excluding stock from waterways. Excluding cattle from waterways is one of the most important things that dairy and drystock farmers can do to protect water quality.

We note that there is some crossover and potential conflict between the requirement for farms to have an FW-FP (prescribed by the NES) and the draft regulations. The NES cites that an FW-FP (in order to be certified by a farm environment planner) must be consistent with Good Farming Practice[55]. Good Farming Practice prescribes stock exclusion as being compatible with land form, stock class and intensity, which may cause some confusion with the setbacks prescribed in the proposed stock exclusion regulations. Clause 38(3) needs to be amended to clarify the distinction between the waterbodies covered by the draft regulations and waterbodies covered under the FW-FP.

DairyNZ supports in principle stock exclusion (including crossings) requirements for those waterways prescribed in the document. We also support the use of FW-FPs as a pragmatic and tailored approach to identify areas for stock exclusion that are not captured by the proposed regulations – e.g. ephemeral waterways, swales, etc.

[55] 40(3)(b)NES

DairyNZ recommends:

- Stock exclusion is addressed through the FW-FP, rather than through separate, additional regulations.

- The slope threshold be set at 15 degrees in order to recognise the increased risk of sediment, phosphorus and pathogen loss to waterbodies on steeper slopes. Based on estimated load reductions that are achieved through excluding stock from waterways (McDowell 2017[56]), Figure 7 shows the impact of increasing slopes on the amount of contaminant entering waterways. By increasing the slope of waterways >1m wide requiring stock exclusion from five degrees up to 15 degrees we estimate that load reductions for total phosphorus increase from 13 to 24%, for suspended sediment from 11 to 22% and for *E. coli* from 14-25%.

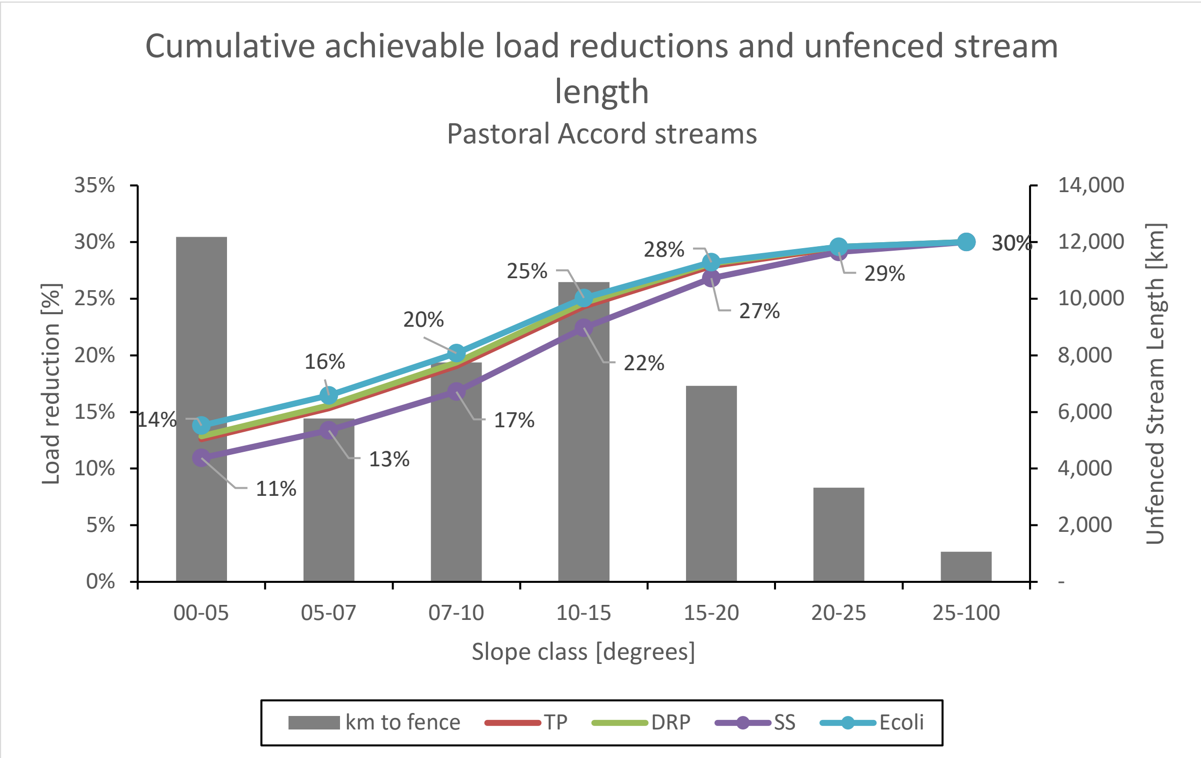


Figure 7: the impact of increasing slopes on the amount of contaminant entering waterways.

DairyNZ has concerns about using carrying capacity as a threshold rather than stocking rate. We have yet to see a carrying capacity threshold that is based on effects. Our view is that stocking rate is the major factor in determining risk (cf. carrying capacity).

[56] McDowell, R. W., N. Cox, and T. H. Snelder. 2017. Assessing the yield and load of contaminants with stream order: Would policy requiring livestock to be fenced out of high-order streams decrease catchment contaminant loads?. *Journal of Environmental Quality - Landscape and Watershed Processes*. 46: page1038-1047.

DairyNZ seeks further clarification on the definition of drains and how so-called artificial watercourses are considered. An artificial watercourse has a wider definition than a drain in regional plans and tends to cover one or more man-made channels, irrigation and drainage canals, water supply races, and roadside drains. In contrast, a drain is typically defined as an artificial watercourse used for land drainage purposes. It can be a surface drainage channel, an open race or sub-surface pipe, a tile or mole drain, or a roadside drain. In a recent NIWA report up to 10 definitions of waterways were identified (Milne et al 2019)[57]. MfE holds a definitions database in relation to terms used and defined in both regional and district plans. It would be useful if this information was used to develop a set of standardised definitions.

Question 66

Do you have any comment on the proposed different approach for larger and smaller waterbodies?

Yes, we support the approach in providing clarity on priorities for stock exclusion. This enables farmers to focus on excluding those larger waterways in the first instance, whilst utilising the FW-FP process to balance priorities for managing smaller/ephemeral waterways against addressing wider risks posed by their specific farm systems, geographic features and constraints.

Question 67

Do you have any comment on the proposed 5m setback, or where it should be measured from?

DairyNZ does not support the five-metre setback. Our main concern is that this contradicts the requirements for a FW-FP (as prescribed in the NES). We are also unclear about why an average of five metres was chosen. We note that the RIA refers to a recommendation of five-metre default setback by the Cawthron Institute.[58]

However, no reference is provided for the Cawthron recommendation. Whilst the intention of the proposal is to improve water quality, it would be reasonable to expect setback distances to vary based on slope/land use. However, this is not the case. DairyNZ assumes that the focus is wider than water quality, and seeks to enhance on-farm biodiversity (potential to form carbon sinks), etc. This is not clear from the proposal and it lacks any clear pathway/guidance if this is the objective.

In addition, most of the research focusing on the benefit of setbacks has been conducted on plots at, and greater than, five meters, meaning our understanding of the effectiveness of setbacks in the range of one-five meters is lacking. Given the high cost of fencing, the loss of productive land associated with the proposed five-metre setback, and the greater returns of increasing the slope class to capture more waterways, DairyNZ is concerned by the lack of empirical evidence supporting the five-meter average setback on low-slope land.

[57] Milne, J. & J. Luttrell. (2019). Regulatory barriers for uptake of edge-of field, farm scale diffuse source mitigation measures: An assessment of Regional Plan requirements and regional council incentives. NIWA Client Report.
[58] Ministry for the Environment. (2019). Interim regulatory impact analysis for consultation: Essential freshwater. Part II: Detailed analysis. Page. 381

Dairy farmers have already excluded stock from almost all (98%)[59] of Accord waterbodies (>1m) on a voluntary basis. Given this, the requirement to shift these fences as soon as 2025 will unfairly penalise, and demoralise, these early adopters through needing to fence twice. Allowing existing fences to remain in place until 2035, or the end of the fences' lifetime, whichever comes sooner, is a more efficient and fairer approach, especially considering the limited additional benefit of shifting fence lines on low-slope land for water quality.

DairyNZ supports a three-metre wide average setback being applied.

We recommend that a definition of 'active bed' is utilised, reflecting that specified in the Greater Wellington Regional Plan[60]. Clearly defining the point at which setbacks apply is crucial for ensuring clarity of expectations for farmers and consistency of implementation.

We also seek clarification on how the proposed 'average' set-back (on average across a farm) is to be calculated, and, specifically, whether fencing of smaller waterways and wetlands contributes towards the overall average width. It is our opinion that it should, both as a mechanism of encouraging further stock exclusion, and recognising the disproportionately high level of contaminants that come from smaller, non-Accord waterways (~70%, McDowell et al 2017)[61]. Further, to improve overall water quality outcomes, we suggest the slope class at which stock exclusion is required for waterways >1m wide should be increased to 15 degrees. This approach would see greater protection for waterways that are more susceptible to sedimentation, a key driver of ecosystem health degradation.

Question 68

Are there any circumstances that are appropriate for allowing exemptions to the stock exclusion regulations? If so, please give examples

Flood control restrictions and requirements should take precedent, as set by regional councils.

---

[59] 98.3% of Accord waterways had stock excluded by 17/18 milking season. Dairy farmers have already fenced 24,744 km of 'Accord' water bodies and 10,900 km of 'non-Accord' waterbodies. *Sustainable Dairying Water Accord: Five Years On.*

[60] Greater Wellington Regional Plan. Proposed Natural Resource Plan. http://www.gw.govt.nz/assets/Proposed-Natural-Resources-Plan/Web-update-docs/Proposed-Natural-Resources-Plan-Decisions-Version-Track-Changed-Updated-Part-1.pdf. Page 27.

[61] McDowell, R. W., N. Cox, and T. H. Snelder. 2017. Assessing the yield and load of contaminants with stream order: Would policy requiring livestock to be fenced out of high-order streams decrease catchment contaminant loads?. *Journal of Environmental Quality - Landscape and Watershed Processes*. 46: page1038-1047.

Controlling intensive winter grazing

Question 69

Do you prefer Option1: Nationally set standards or Option 2: Industry-set standards? Why?

In principle, **DairyNZ supports** nationally set mandatory standards. However, we urge Government to consider amending the standards proposed under the national option, as per question 70.

DairyNZ recommends amending the NES to include a requirement for a Winter Grazing Plan. This should include contingency for adverse events. Alternatively, if a FW-FP is required of all farms, a Winter Grazing Plan should be a module (if needed).

Question 70

For the proposed nationally set standards, which options do you prefer for the area threshold, slope, setback and pugging depth components of the policy?

In principle, **DairyNZ supports** nationally set mandatory standards for winter grazing on forage crops for all farms. The listed practices are already commonly referred to as Good Management Practices in the agricultural sector. The following is a summary of DairyNZ's position on each of the proposed wintering practices in the NES:

- **Slope: DairyNZ supports** the 15° slope criteria. Additional risk factors will be managed with other practices, particularly management of critical source areas and waterway buffers. Risk factors associated with slope should be managed via other practices, particularly management of critical source areas and waterway buffers. DairyNZ is concerned about the efficiency of many farms requiring a consent for little or no environmental gain (if the slope is too low). We note there is need for protocols on how and where to measure slope.
- **Area threshold: DairyNZ recommends** an alternative of 100 ha or 15%, as has been chosen in Southland. We understand the need to have a trigger point for councils to assess Intensive Winter Grazing. However, decreasing the area-based threshold is a consenting efficiency issue. We are concerned about the efficiency of many farms requiring a consent for little or no environmental gain.
- **Critical source area:** A standard for this was not proposed in the discussion document. **DairyNZ recommends** that critical source areas should be clearly mapped as part of FW-FPs, ensuring there is no room for different interpretations during auditing and compliance visits. **DairyNZ supports** that these critical source areas are grazed only when dry and grazed last.
- **Buffer width/setback: DairyNZ supports** a five-metre buffer width in intensive winter grazing. A 20m buffer width would have significant implications for loss of grazing land. However, the buffer strip needs to be combined with no cultivating or grazing of critical source areas to avoid contaminant loss to waterbodies.

- **Pugging:** Pugging is unlikely to result in adverse environmental (and animal welfare) impacts if the other parts of this standard are met and FW-FP is developed and complied with, as required under the NES. There is a lack of rigorous scientific research regarding the relationship between pugging depth and surface runoff of contaminants to water bodies, whereas research shows critical source area management has potential to reduce contaminant losses significantly. This should be the focus for management, as opposed to managing pugging. However, a requirement to have a Winter Grazing Plan, including contingency in case of adverse weather events, must be added to these conditions. In addition, the no pugging requirement contradicts clause 28 which permits the use of sacrifice paddocks providing there are no critical source areas present. Consequently, **DairyNZ does not support** the pugging provisions in their current form.

- **Re-sowing: DairyNZ does not support** the inclusion of the re-sowing requirement, currently required within one month. The current structure of the clause could drive perverse outcomes – e.g. farmers could leave a low number of stock grazing in a paddock, so grazing is not complete, pushing back the required deadline.

- **Grazing direction: DairyNZ does not support** the inclusion of the direction of winter grazing on a slope (from top to bottom) as a mandatory condition. This approach could compromise broader animal welfare objectives. We also believe the same outcome can be achieved with alternative grazing options.

- **Cropping: DairyNZ does not support** the proposal to classify increasing cropping area, after 2021, as a discretionary activity. This could result in perverse impacts: tightened wintering rules may mean areas of winter cropping may increase in more suitable areas which, provided overall cow numbers remain the same in any one catchment, would reduce the overall intensive winter grazing intensity within the region. However, this could also result in an increase in the intensity of stocking density at a paddock scale, increasing the risk of contaminant loss to freshwater.

DairyNZ makes the following recommendations:

- **Winter grazing plan:** An amendment to the NES, requiring a Winter Grazing Plan. This should include a contingency plan for adverse events – e.g. if a FW-FP (FEP) is required, a Winter Grazing Plan should be included as a module.
- **Slope measurement:** There are currently no protocols or proposed method outlining how, where and so forth to measure slope**.** This needs to be addressed to support implementation.
- **Re-sowing:** If the re-sowing clause is included in the NES, DairyNZ's recommendation is that it is included only where practicable – e.g. re-sowing should not be required on heavy soils as perverse impacts could result from soil damage from heavy machinery during re-sowing before these heavy soils have had a chance to dry out.

- **Grazing direction:** The use of strategic direction grazing, in place of mandatory top to bottom grazing of the slope, should be encouraged. This enable farmers to achieve the same outcomes with alternative grazing options while meeting animal welfare objectives.

Restricting feedlots

Question 71

Do you have comment on the proposal to restrict feedlots?

DairyNZ supports the proposal that feedlots should meet relevant resource consent requirements. However, we are concerned that the definitions of 'feedlot' and 'stock holding area' when read together may inadvertently bring other housing facilities (e.g. wintering barns, herd homes, calf shelters, and stand-off pads) within the scope of the feedlot provision. Research conducted as part of our Wintering Systems Project (Botha and O'Connor, 2015[62]) strongly suggests these additional housing facilities will trigger both limbs of the 'feedlot' definition outlined in clause 27(1)(a) of the draft NES. This is because there are subtle, but nonetheless important, variations in the way wintering barns and other housing facilities are managed across the North and South islands. For example, in Southland it is common practice for farmers to place their herds in housing structures from late May/early June, with late calving cows remaining in the structures until late August/early September.

The challenge is that the discussion document suggests there should be a strong presumption that 'feedlots' should be tightly restricted, and be afforded discretionary activity status. While we agree this should be the case in relation to conventional feedlots, we suggest a more nuanced approach is required for other housing facilities. In particular, the draft NES should not create unnecessary regulatory barriers to the current use and future development of farm management systems that deliver improved environmental benefits, especially in relation to reducing nitrogen leaching and pugging.

Reducing pollution from stock holding areas

Question 72

Do you support the proposal relating to stock holding areas? Why/why not?

No. While we agree stock holding areas need to be managed to control effluent and contaminant loss to give effect to the NPS-FM, we do not agree that the discretionary activity consent required as part of clause 29 is the most effective and efficient way to manage potential adverse effects.

DairyNZ supports an alternative approach where stock holding areas are given permitted activity status as well as being part of the approach set out in the NES under FW-FPs.

[62] Botha, N. and O'Connor C. 2015. *Improved Off-paddock Dairy Systems Project* Prepared by AgResearch for DairyNZ.

This approach aligns with that proposed in Waikato's PC1. It also allows for integration of the local landscape into the management of stock holding areas, with the oversight of a certified advisor and third-party auditing.

Question 73

Do you think sacrifice paddocks should be included?

No. For the reasons outlined above, we support a permitted activity status and management through FW-FPs. We agree sacrifice paddocks should be situated at least 50 metres away from any water bodies, water abstraction bores, drainage ditches and coastal marine areas. We also agree sacrifice paddocks should not be established in critical source areas.

Question 74

What would you have to do differently if this proposal was implemented?

An additional resource consent would be required if the proposed stock holding areas rules were effected. For some farmers, additional infrastructure to collect and process effluent collecting from stock holding areas would be required.

Question 75

Do you have any comment on what would be required to ensure this proposal could be effectively implemented?

DairyNZ's view is that the best method of ensuring standards are met and rules followed is to include stock holding areas in FW-FPs. This should be accompanied by regular auditing of the FW-FPs to ensure implementation and timelines are being adhered to.

We have some concerns about the implementation of the current proposal including the definition of "one day" and how that might be accurately recorded and audited, regardless of whether a consenting pathway is adopted. DairyNZ notes MfE's confirmation during consultation that for the definition of stock holding, one day equals 24 hours, and that the threshold of time can be a cumulative 30 days over one year or 10 (24 hour) days in a row.

Draft proposed National Environmental Standards for Freshwater

Question 76

Are the definitions used in the policies accurate, and if not, how do you suggest improving them?

No, in some cases the definitions are not accurate, or are open to interpretation. Amendments and reasons for NES wetland provisions are contained in our response to question 25 and 26.

There is no definition for dairy farming, although this is referred to in the NES. DairyNZ requests a new definition to be added to clause 25 that reads:

> 'Dairy farming means farming for commercial milk production from dairy cows'.

The definition of 'dairy support' should be re-drafted to clarify the practical circumstances under which a farm would be classified as dairy support. This is to recognise that many farms are mixed enterprises and have widely different levels of bought in feed and fertiliser and therefore risk of nitrogen loss, to support grazed drystock.

As indicated in the response to question 71 above, the definition and threshold for stock holding area requires amendment. In addition to our previous comments, we note NES's approach to calf-sheds remains unclear. We recommend calf raising sheds used for animal husbandry purposes are explicitly excluded from the stock holding area definition for the purposes of clause 29.

Question 77

What are your thoughts on the proposed technical definitions and parameters of the proposed regulations? Please refer to the specific policy in your response.

DairyNZ views and supporting recommendations are outlined in our responses to questions 25 and 26 above.

Question 78

What are your thoughts on the timeframes incorporated in the proposed regulations? Please refer to the specific policy in your response.

Resourcing and capacity to meet NPS-FM and implement NES

There are many catchments where the regional council limit-setting process is incomplete. The proposed NPS-FM has given councils more to do, and less time to do it. DairyNZ has not assessed the numbers of new consents likely to be sought under clauses 31-36. Although councils will recover the majority of associated costs, we are concerned that capacity constraints – specifically the lack of experienced personnel to assess discretionary and non-complying activity consents – will be a limiting factor.

Of more concern to DairyNZ is timeframes being shortened for complex, limit-setting processes. Where they do not exist regional agreements with iwi partners for co-management and recognition of Te mana o te Wai will take time to set up. In an attempt to meet deadlines in the proposed NPS-FM, many councils may replace intensive sub-regional, local approaches that involve communities with traditional, broad-brush region-wide approaches. This will impact the ability of regional communities, including dairy farmers, to engage in limit-setting processes.

We are also concerned that the timeframe for the freshwater module of farm plans, particularly if a nitrogen reduction is required, will not be achievable by 2025 under NES clause 37(2). In response, DairyNZ has requested additional Government resources to fast track the set-up of databases and procedures around certified advisors and auditors for farm plans, and that a streamlined implementation method for nitrogen reductions to a 90th percentile nitrogen surplus value is used as an interim measure in schedule 1 catchments.

In particular, FW-FP farm plans under the alternative nitrogen cap option as written (clause 42-48) is not practical to implement.

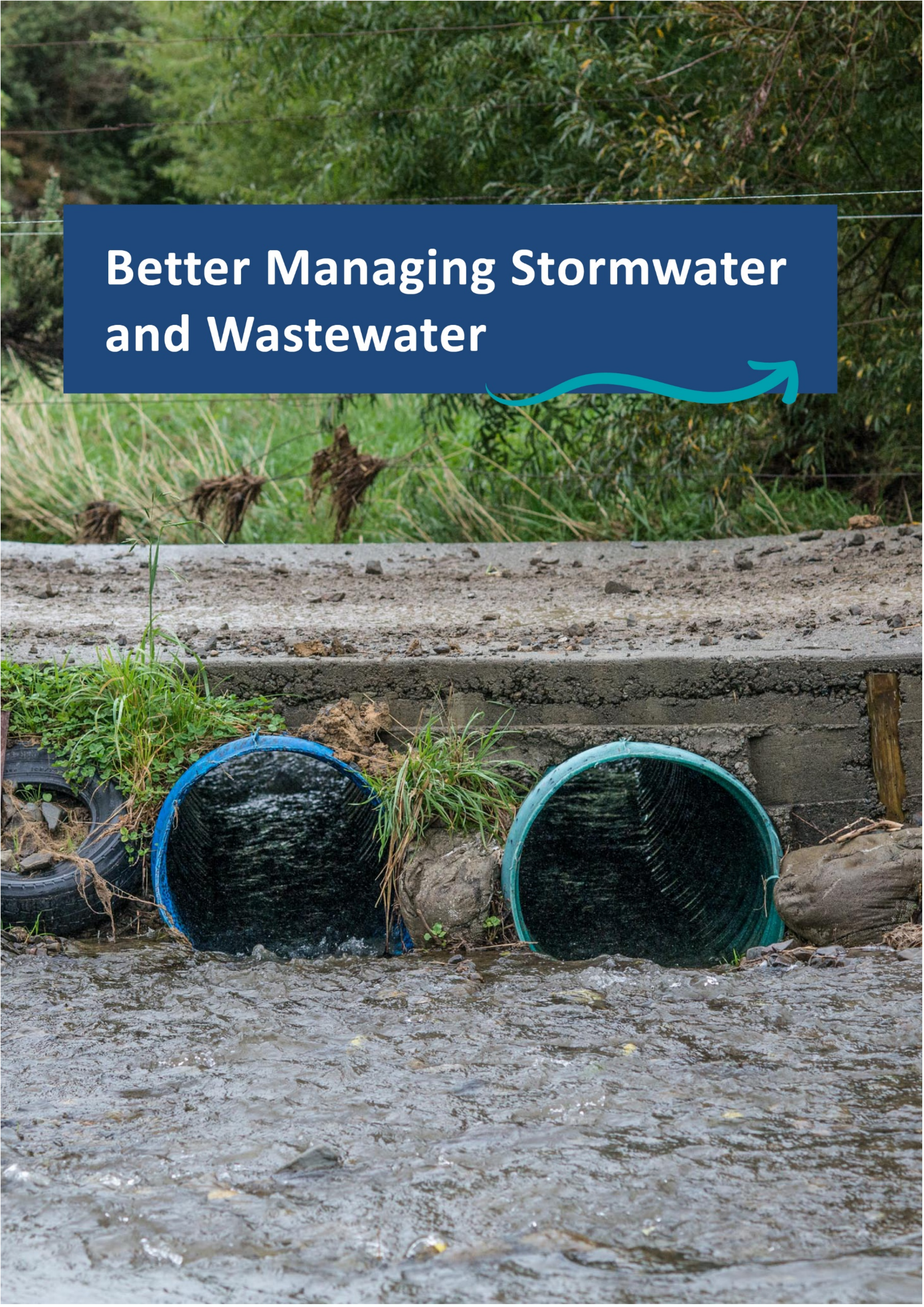
If this proposal was being reviewed from a section 32 RMA perspective, it is not the most effective and efficient way to achieve the objective of improving water quality in schedule 1 catchments because:

- There are likely to be significant process bottlenecks both at the nitrogen baseline and council resource consenting stages. Our previous experience suggests that, rather than bringing in external planning contractors to manage workload pressures, councils will most likely be forced to let implementation deadlines slip in order to meet other competing resourcing demands.

- The NES does not acknowledge that it will take time for farmers to develop the expertise necessary to achieve nitrogen reductions. An Overseer® modeller (e.g. a recent graduate from a nutrient management course) may not be able to help farmers develop scenarios and identify the most efficient and effective means of reducing their nitrogen load.

- The NES does not acknowledge the consequences of a fast rate of change and sole focus on one contaminant. Forcing decisions for nitrogen reductions to meet deadlines, may be more costly for the dairy sector in the medium term. For instance, to meet nitrogen limits within the next few years, a DairyNZ demonstration farm in Waikato settled on costly infrastructure (a wintering barn) to reduce nitrogen leaching at high risk times, but had to change this after determining this option would increase greenhouse gas emissions.

Better Managing Stormwater and Wastewater



Question 46

Does the proposed Wastewater NES address all the matters that are important when consenting discharges from wastewater networks? Will it lead to better environmental performance, improve and standardise practices, and provide greater certainty when consenting and investing?

DairyNZ supports:

- All users of New Zealand's land and water resources playing their part to improve our water quality. In our experience, there is value in having national direction and transparency regarding the expectations for management of practices that affect our waterways. The proposals as outlined could be helpful in lifting environmental performance and improving the management of wastewater treatment around NZ.

- The inclusion of all the potential requirements as proposed on page 58 - 62 of the discussion document.

- The introduction of nationally consistent expectations to support regional council and operators in running and managing wastewater treatment facilities.

Question 47

Do you agree with the scope of the proposed risk management plans for wastewater and stormwater operators? Are there other aspects that should be included in these plans?

DairyNZ supports:

- The framework proposed for the risk management plans, at the minimum accounting for the risks to the environmental, people and social/cultural values.

- The consideration of future pressures being incorporated into the system.

Question 48

What specific national level guidance would be useful for supporting best practice in stormwater policy and planning and/or the use of green infrastructure and water sensitive design in stormwater network design and operation?

This is beyond our area of technical expertise.

Question 49

What are the most effective metrics for measuring and benchmarking the environmental performance of stormwater and wastewater networks? What measures are most important, relevant and useful to network operators, regional councils, communities and iwi?

This is beyond our area of technical expertise.

Question 50

Do you have any further comments?

Our remaining comments are:

- We support the proposals for improved measurement and reporting, particularly increasing transparency and reporting that is relevant and meaningful to local communities.
- The Essential Freshwater package is an important component of a much broader national policy reform agenda. In addition to the proposed NPS-FM and NES, Government is also consulting on a proposed National Policy Statement for Highly Productive Land (NPS-HPL) with consultation on the proposed National Policy Statement for Indigenous Biodiversity expected to get underway shortly. The scale and intensity of policy activity will inevitably create some inter-operability challenges. For example, the discussion document does not provide any guidance on how the NPS-FM will interact with the NPS-HPL.

There will be instances where land use controls may be required in order to meet Government's freshwater management objectives in areas that may contain highly productive soils. It is unclear how local authorities should embark on the complex task of balancing NPS-FM and NPS-HPL priorities. This underscores one of the key points made elsewhere in this submission regarding the need for MfE to provide clear and consistent guidance regarding the application of this new suite of NPSs to support the implementation process and reduce the risk of policy fragmentation.

Appendix 1:

Water quality state and trend along a pastoral pressure gradient

Introduction

To provide context for our submission, we present an objective summary of water quality state and trend based on the latest (2019) LAWA data. This analysis has been undertaken by assessing water quality state and trend across dairy and pastoral pressure gradients, characterised by increasing high producing grassland and decreasing natural landcover. Pastoral landcover was identified as a major pressure on water quality at a national scale (MfE, 2019).[63]

Impacts of dairy land use on load

Water quality state reflects land use, with the greater the deviation from natural state, the generally more degraded water quality becomes (relative to reference state). Agricultural exotic grassland occupies approximately 40% of New Zealand and is one of the major pressures on water quality. Of the approximately 11 Mha of exotic grasslands, 1.8 Mha (16%) is dairy land use with the remaining 9 Mha (84%) drystock land use.

Much of the national water quality discussion around the impact of pastoral landcover focusses on dairy and its rapid expansion and intensification beginning in the 1990s. For example, between 1995 and 2015:

- Effective dairy hectares increased from 1.18 to 1.75 Mha (+48%).
- Total production increased from 733 to 1,890 Mkg MS (+157%).
- Production per hectare increased from 623 to 1,048 kg MS per ha (+68%).

Over this period (1996-2012), the growth of the dairy was largely linear until 2014-2015, after which time all relevant growth metrics (expansion, hectares, cows, production) have remained either constant or decreased (Figure A1.1).

While there has been significant expansion in dairy land, a substantial amount of mitigation work has been carried out by dairy farmers and the sector. For example, between 1995 and 2015 it is estimated that:[64]

- Stock exclusion from Accord streams increased from 48 to 97%.
- Land application of farm dairy effluent increased from 35 to 97%.
- Targeted fertiliser returns to effluent-treated areas went from 0 to 41%.
- Deferred and/or low rate effluent irrigation increased from 0 to 11%.
- Reduction in over watering (irrigation) changed from <10% to 40%.
- Wintering off-pasture increased from 0 to 7%.

Using these estimates of mitigation implementation, Monaghan et al. (2019)[65] estimated contaminant losses from dairy land use in 1995 and 2015, and losses in 2015 if mitigations over the 20-year period had not been undertaken. The investment by farmers has been particularly beneficial for minimising losses of N and P from dairy farming systems. Without these mitigations, mean

[63] Ministry for the Environment & Stats NZ (2019). New Zealand's Environmental Reporting Series: Environment Aotearoa 2019. Available from www.mfe.govt.nz and www.stats.govt.nz.
[64] Monaghan R., Manderson A., Basher L., Spiekermann R., Dymond J., Smith C., Eikaas H. Muirhead R., Burger B., McDowell R. (2019). Mitigating the impacts of pastoral livestock farming on New Zealand's water quality: what has been achieved in the past 20 years? (draft manuscript)

annual nitrogen and phosphorus losses on a weighted per hectare basis in 2015 would have been approximately 45% and 98% greater, respectively.

When factoring in dairy land use expansion over this period (i.e. 40% increase in land area), these mitigations have resulted in total phosphorus and sediment loads from dairy are being comparable or lower to those in 1995. However, total nitrogen loads increased over this time, and mitigations have not been able to offset the expansion of the sector. Total production of the sector (between 1995 and 2012) increased by almost 160%, and total nitrogen loads over this time increased by 60%.

While nitrogen is a key contaminant of concern, several recent national studies have shown the importance of fine sediment loading as a key driver of degraded ecosystem health.

Water quality state

Consistent with a pressure-state approach used by the Ministry to report on water quality[63], we report water quality state using the most current LAWA data (five-year period ending 2018), grouped according to pastoral landcover. Two pressure gradients were used: percentage of dairy land use for state, and pasture landcover for trend. The later was used for presenting trend as the low pressure landcover group is consistent with near reference state conditions.

A summary of the two-pasture pressure gradient used is provided in Figure A1.1 (percentage of total pastoral landcover) and Figure A1.2 (percentage dairy land use). Figure A1.1 characterises the increasing pastoral pressure gradient with median high producing grassland (HPG) landcover (orange bars) increasing from 2% to 72% (left to right). This is accompanied by a decrease in median natural landcover from 80 to 1% (left to right) The 0-15% pasture class comprised a median natural landcover and HPG cover of 80% and 2%, respectively. Accordingly, this low-pressure group is considered to represent minimally disturbed upstream catchments and is referred to as ‘near reference’ condition.

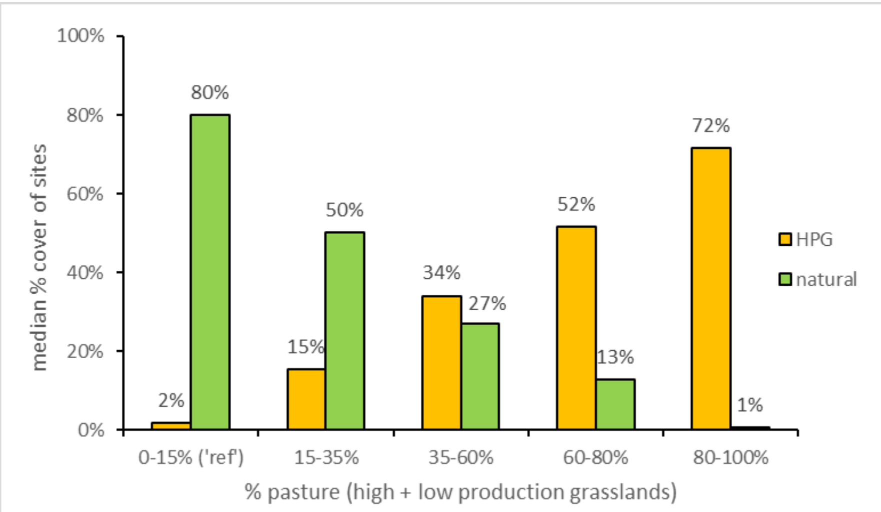


Figure A1.1 Median percent (%) high producing grassland and natural landcover across the six pastoral classes used to group state and trend data over a pressure gradient

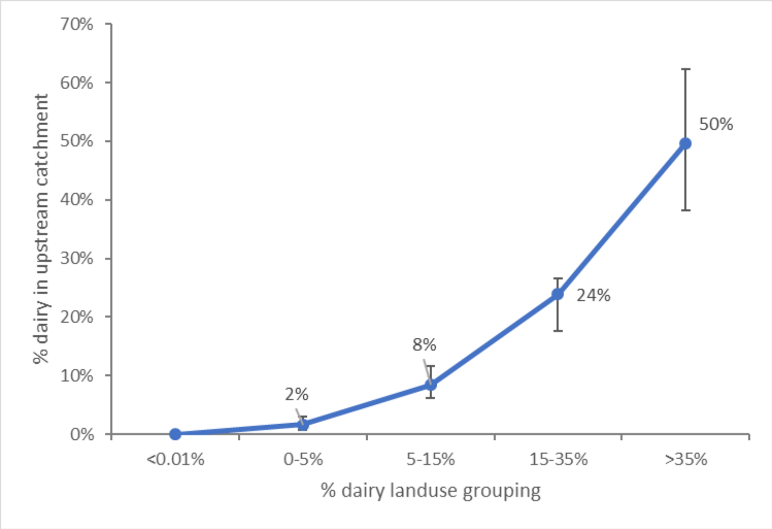


Figure A1.2: median % dairy in upstream catchment of each dairy pressure group – lower and upper error bars represent 25th and 75th percentile values

Water quality state was assessed across a dairy land use pressure gradient where the median percentage of dairy ranges from 0 to 50% (Figure A1.2). The median dairy land use within the five groups defining the dairy gradient were 0, 2, 8, 24 and 50%. Data for nitrogen, phosphorus and suspended sediment are summarised in Figure A1.3. The results indicate that:

- Water quality state shows an increase in N concentrations across the dairy pressure gradient, but less marked increases in P and suspended sediment (turbidity and clarity) across the same gradient. This is shown spatially for monitored catchments, against different nutrient thresholds, in Appendix 1 (Figures 1- 3, main submission document). Median concentrations in the group with the highest dairy land use pressure >35% showed that:
    - Median and 75th percentile nitrate concentrations were 1.2 g/m^3 and 2 g/m^3, respectively – exceeding the proposed DIN threshold values, but below the nitrate threshold for 95% protection of aquatic organisms. Despite these elevated nitrate concentrations, we note that the 50th and 25th percentile values for MCI scores (using this same data set and dairy grouping), were 95 and 86, respectively (Figure A1.4) – indicating good to fair macroinvertebrate community health in these catchments with high dairy pressure.
    - Median and 75th percentile DRP concentrations were around 0.018 and 0.04 g/m3, respectively – less than the original DRP ecosystem health bottom line derived by Death et al. of 0.057 g/m3.
    - Median and 75th percentile turbidity values were approximately 3 and 5.5 NTU, respectively – comparable to the ANZECC guideline trigger values of 4.5 and 5.4 NTU (80th percentile reference site values) and less than the bottom-line turbidity value of 7 NTU, which corresponds to a macroinvertebrate extirpation threshold of 5% - i.e. 95% of macroinvertebrates protected (Appendix H, Stage 3 sediment report), although the 90th percentile value increased to 11 NTU.

- Finally, the median *E.coli* concentrations were 265 per 100ml in the highest dairy pressure group (i.e. median dairy land use of 50%). Lower pressure dairy groups with 8 and 24% dairy land use also had elevated median *E.coli* concentrations of 163 and 200 per 100ml. These three groups have median *E.coli* concentrations that exceed the national bottom-line value of 130 per 100 ml. This indicates that relative to nutrients and sediment, *E.coli* pathogens appear to be the contaminant that is most limiting with respect to meeting community values/national bottom lines.

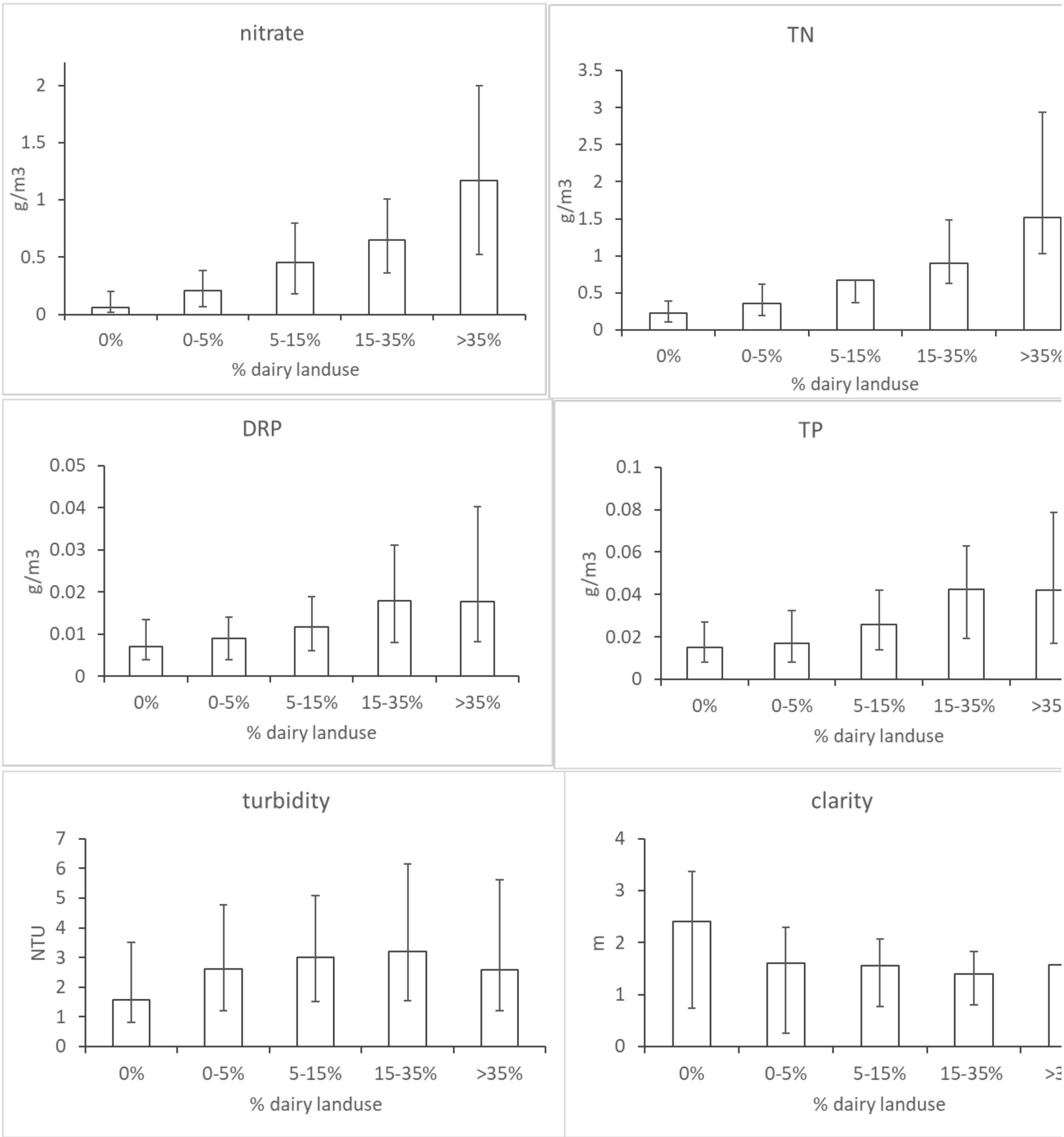


Figure A1.3: Median values for select water quality variables (nitrate, TN, DRP, TP, clarity and turbidity) grouped by dairy land use pressure. Lower and upper error bars represent 25th and 75th percentile values, respectively. Median % dairy landuse in each group is shown in Figure A1.2.

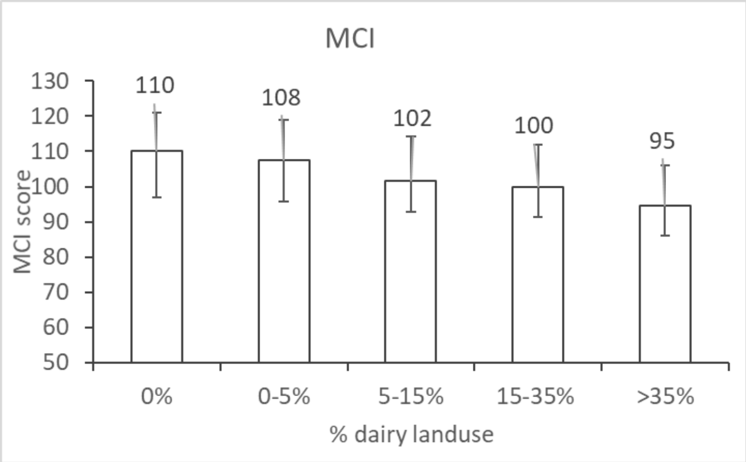


Figure A1.4: Median MCI (macroinvertebrate health) grouped by dairy land use pressure. Bars represent median values, and lower and upper error bars are 25th and 75th percentile values. (note that higher values of MCI are better)

Water quality trend

Water quality trend (grouped by pastoral landcover) was assed based on LAWA data for the 10-year period ending 2018. To account for external factors that influence the percentage of improving sites with minimal upstream pastoral landcover pressure (i.e. near reference condition), the percentage of improving sites for each group were normalised to the percentage of improving trends observed for near reference condition sites (i.e. those with total pasture landcover <15% - recognising that this corresponds to a median natural landcover of 80%). These data are summarised in Figure A1.5.

Key results include:

- The proportion of improving sites varied across the nine water quality measures, although most showed a greater proportion of sites degrading (orange) than improving (green) for the 10-year period 2009-2018.

- In general:
    - Turbidity, TN, nitrate-N, DRP, TP and MCI had more sites degrading than improving.
    - Ammonia-N had more sites improving than degrading.
    - Clarity had approximately equal numbers of sites improving and degrading.

- By contrast, trends for the ten year period ending 2017 showed more sites were improving for all 9 LAWA variables except MCI.

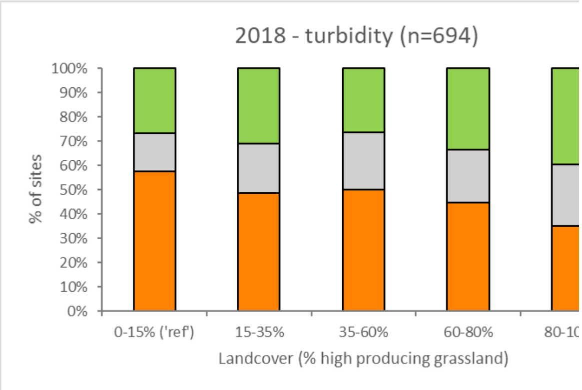
- It is important to recognise that the decrease in the percentage of improving sites occurs across the pastoral gradient, and is often more pronounced for catchments in lower pressure groups (i.e. near reference).

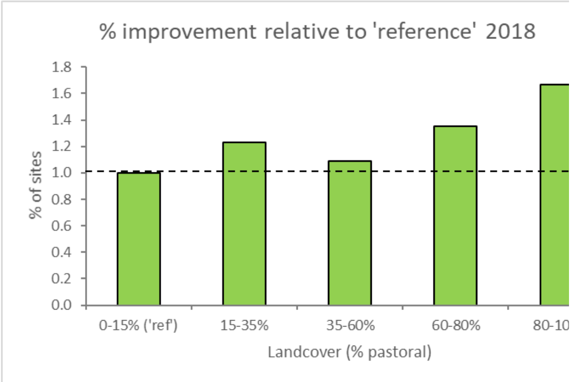
- **This suggests that external factors such as climate are driving the observed decrease in improving trends – and not land use pressure.**

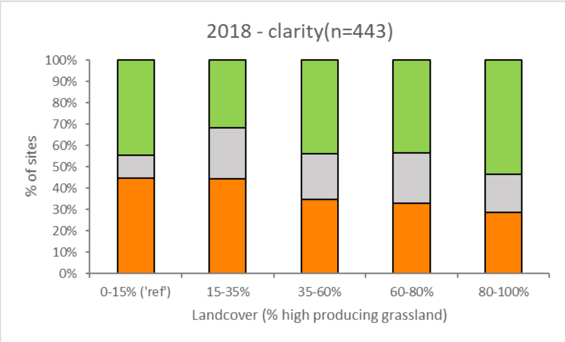
- The results of normalising the percentage of improving sites relative to near reference sites indicates that despite the overall decrease in improving trends between 10 year periods ending 2017 and 2018, the percentage of improving sites at high pastoral pressure sites (i.e. >70% HPG landcover) was often comparable or greater than that observed for near reference sites with minimal pressure from pastoral land use. This reflects a greater ability to mitigate contaminants in catchments with high pastoral pressure, the impact of which get superimposed on the state and trend fluctuations caused by external factors (i.e. climate).

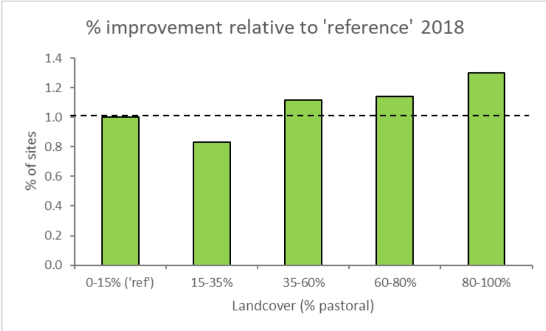
- This trend variability and susceptibility of 10 year trends to a change in one year (i.e. a different outcome despite the fact the two trend periods have 90% of data in common) highlights the need for a better understanding of the limitations of trend reporting especially with LAWA moving to annual reporting on state and trend.

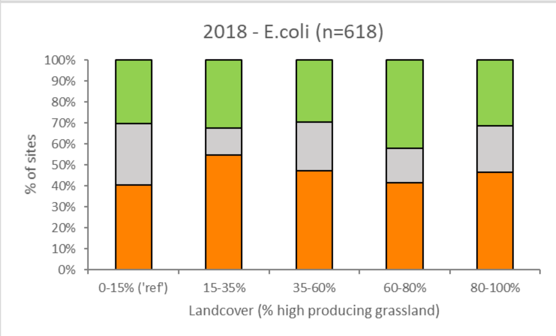
- Current trend assessment methods do not provide a robust, stable indicator of long-term direction of travel of water quality state. Landowners require confidence that the mitigations they are undertaking and investing in are leading to improvements in water quality state and trend downstream. This requires fit-for-purpose state and trend reporting tools/protocol that provide robust, stable and trusted methods of tracking water quality state over time.

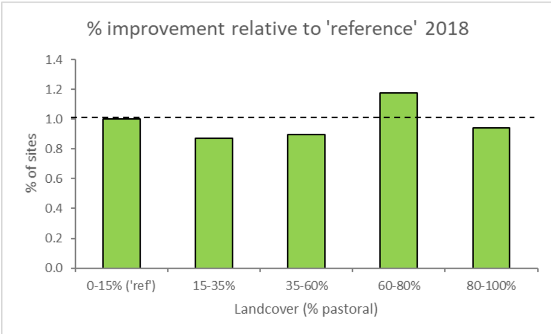

2018 - turbidity (n=694)
% of sites
0-15% ('ref')
15-35%
35-60%
60-80%
80-10
Landcover (% high producing grassland)

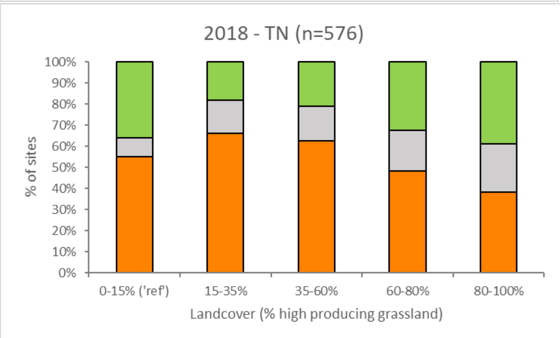

% improvement relative to 'reference' 2018
% of sites
0-15% ('ref')
15-35%
35-60%
60-80%
80-10
Landcover (% pastoral)

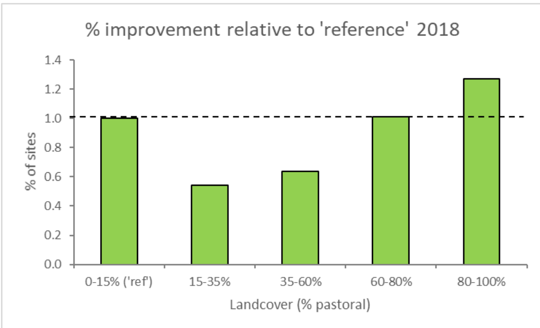

2018 - clarity(n=443)
% of sites
0-15% ('ref')
15-35%
35-60%
60-80%
80-100%
Landcover (% high producing grassland)

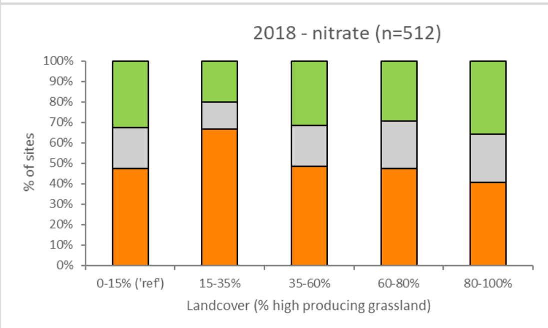

% improvement relative to 'reference' 2018
% of sites
0-15% ('ref')
15-35%
35-60%
60-80%
80-100%
Landcover (% pastoral)

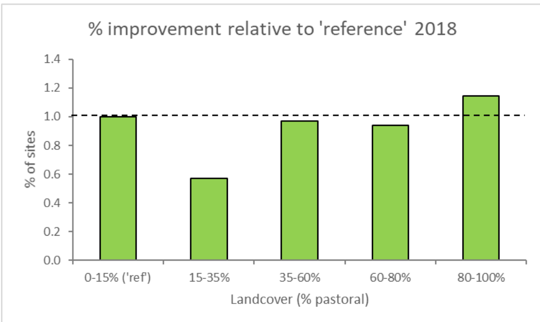

2018 - E.coli (n=618)
% of sites
0-15% ('ref')
15-35%
35-60%
60-80%
80-100%
Landcover (% high producing grassland)


% improvement relative to 'reference' 2018
% of sites
0-15% ('ref')
15-35%
35-60%
60-80%
80-100%
Landcover (% pastoral)


2018 - TN (n=576)
% of sites
0-15% ('ref')
15-35%
35-60%
60-80%
80-100%
Landcover (% high producing grassland)


% improvement relative to 'reference' 2018
% of sites
0-15% ('ref')
15-35%
35-60%
60-80%
80-100%
Landcover (% pastoral)


2018 - nitrate (n=512)
% of sites
0-15% ('ref')
15-35%
35-60%
60-80%
80-100%
Landcover (% high producing grassland)


% improvement relative to 'reference' 2018
% of sites
0-15% ('ref')
15-35%
35-60%
60-80%
80-100%
Landcover (% pastoral)

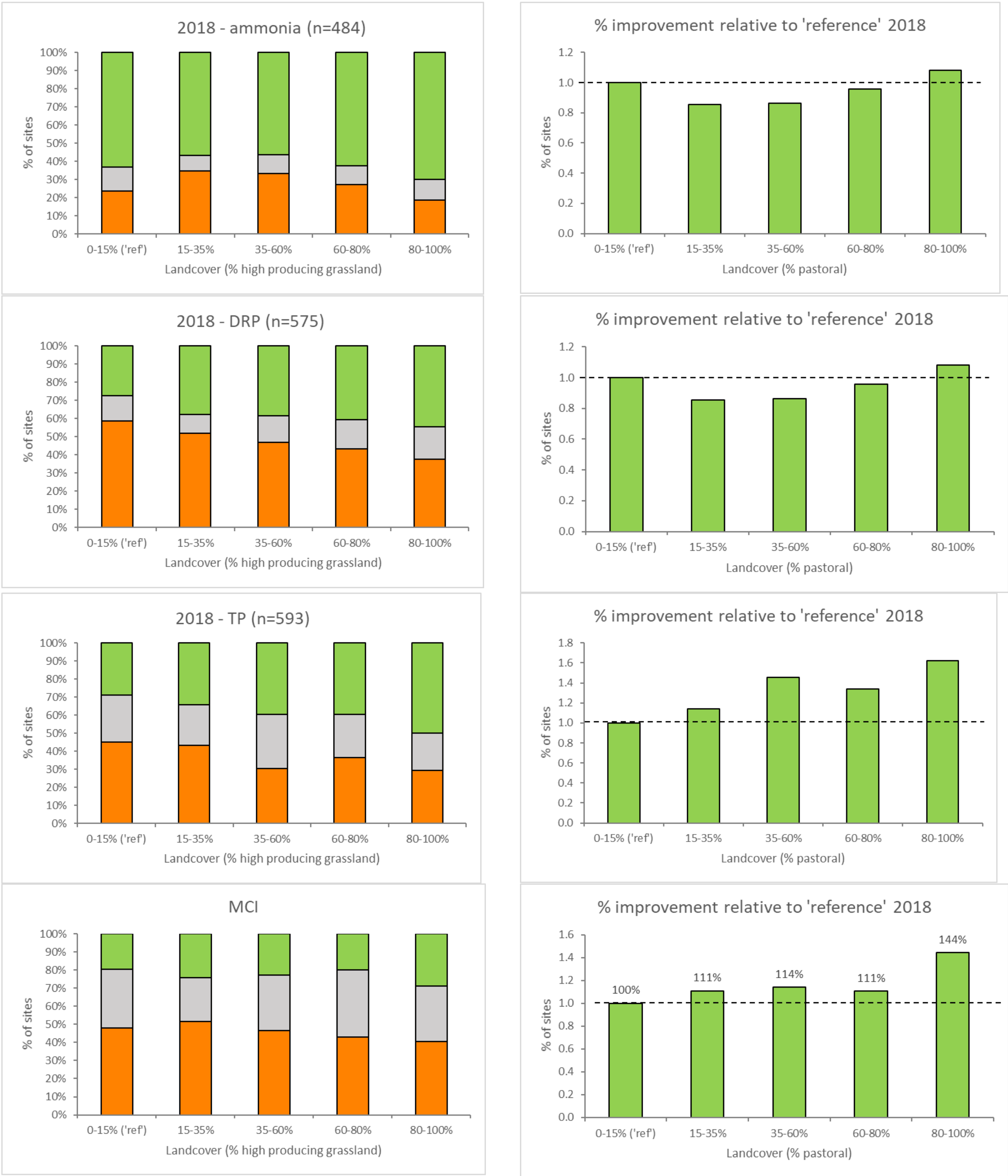


Figure A1.5: summary of water quality trend grouped by pastoral landcover. Graphs on the left show percentage of improving (green), degrading (orange) and indeterminate (grey) trends for each of the pastoral landcover groups. Graphs on the right show the percentage of improving trends normalised to near reference condition (or minimally disturbed condition along the pastoral gradient) – value <1 (below the dashed line) indicate the pastoral group had a lower percentage of improve sites (relative to reference) and values >1 (above the dashed line) indicate the pastoral group had a higher percentage of improving sites (relative to reference).

Appendix 2:

Raising the bar on ‘ecosystem health’: the proposed nutrient attributes and bioindicators

What is ecosystem health?

Ecosystem health is a universal term used to describe the overall condition and functioning of an ecosystem. For aquatic systems there are many components which contribute to and determine ecosystem health, including:[65]

- Aquatic life.
- Physical habitat.
- Water quality.
- Water quantity.
- Ecological processes.

Ecosystem health is therefore not a robust and scientifically defined measure, but rather is assessed based on a range of physical, biological and chemical measures.

There is no universally accepted benchmark for a healthy ecosystem. The apparent health status of an individual ecosystem can vary depending on the health measures employed and the societal aspirations driving the assessment.

How is ecosystem health measured?

Biological measures of ecosystem health (i.e. aquatic life) are important as water quality is not always a good indicator of aquatic organism health. Aquatic life is generally assessed based on the ***presence, absence and diversity of aquatic*** **organisms**.

In New Zealand the **Macroinvertebrate Community Index (MCI)** is a common measure of invertebrate community quality, providing a sensitive indicator of the overall biological health of streams. The MCI index has been widely applied to monitor ecosystem health since the mid-80s.[66]

Fish are also an important component of New Zealand streams but have been shown to be less sensitive to stressors and pressure gradients and are difficult to normalise to a reference condition compared to macroinvertebrates.[67,68] Compared to most other countries, New Zealand has a sparse freshwater fish fauna, with just over 50 species of which 35 are endemic. By contrast, there are over 800 known species in North America. Interpretation of fish indices are also complicated by physical barriers to fish migration (e.g. hydro-dams), and because New Zealand has an unusually high proportion of native fish that are diadromous (i.e. have a marine phase in their life-cycle), barriers, including culverts and weirs, make fish less sensitive for assessing broader diffuse water quality impacts.

---

[65] Clapcott J, Young R, Sinner J, Wilcox M, Storey R, Quinn J, Daughney C, Canning A, 2018.Freshwater biophysical ecosystem health framework. Prepared for Ministry for the Environment. Cawthron Report No. 3194.89 p. plus appendices.
[66] Clapcott J, & Goodwin J. 2014. Relationships between MCI and environmental drivers. Prepared for Ministry for the Environment, Cawthron Report No. 2507. 21p
[67] Pingram M, Collier K, Hamer, M, David B, Catlin A, Smith J. 2019. Improving region-wide ecological condition of wadeable streams: Risk analyses highlight key stressors for policy and management. *Environmental Science and Policy,* 92, 170-181.
[68] Schallenberg M, Kelly D, Clapcott J, Death R, MacNeil C, Young R, Sorrell B, Scarsbrook M. 2011. Approaches to assessing ecological integrity of New Zealand freshwaters. Science for Conservation 307. Department of Conservation, Wellington. 84p.

Protecting ecosystem health is highly complex

Ecological responses of streams to land use in their catchments can be highly complex. In particular, land use can impact primary production, invertebrate and fish production, and other ecosystem processes. While nutrients can have adverse effects on aquatic ecosystem health via direct (e.g. nitrate toxicity) and indirect (e.g. trophic) effects, trophic effects (e.g. stimulating plant growth/production), as well as habitat, shade and other physical processes generally have greater impacts. This is highlighted in Figure A2.1 below.

Because multiple factors or drivers influence ecosystem outcomes, many of which are interrelated, it is over-simplistic to assume that managing for single factors will deliver the water quality and ecosystem health outcomes we all seek.

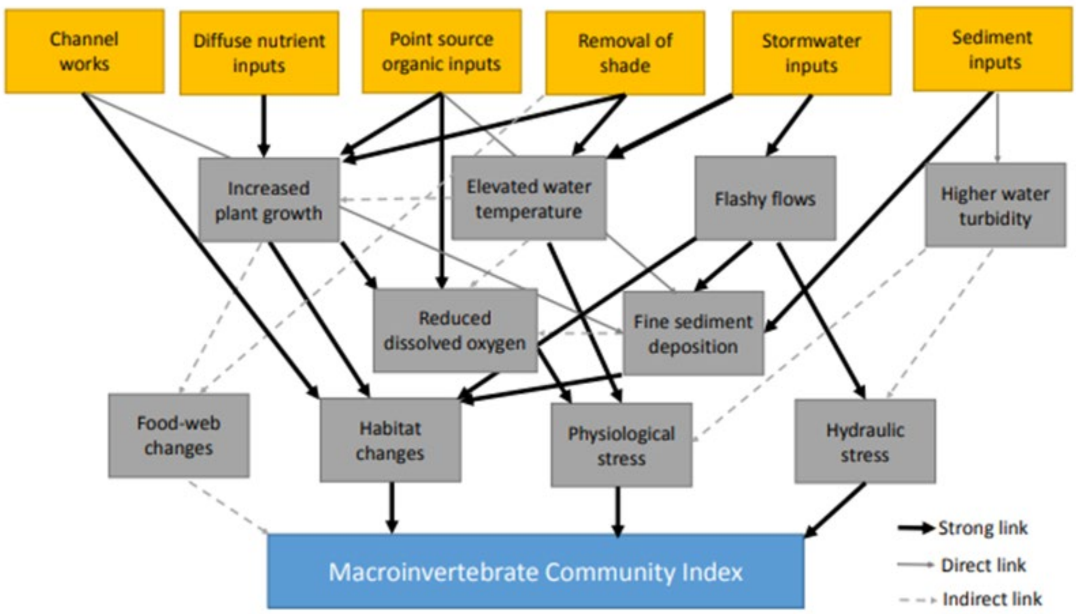


Figure A2.1: Diagram showing the relationship between human pressures on waterways and MCI. From Clapcott and Goodwin (2014)69.

What has been proposed: ecosystem health nutrient attributes (dissolved inorganic nitrogen and dissolved reactive phosphorus)

While ecosystem health is already a compulsory value in the NPS-FM, as addressed through trophic effects of nutrients in hard-bottom rivers via the periphyton attribute, STAG proposed that the existing attributes are not adequate for managing ecosystem health in waterways. The periphyton attribute is based on a biological response, as it is the mass of periphyton (i.e. the response) that can adversely impact ecosystem health, rather than nutrient concentrations which lead to the growth (especially when present at concentrations that are not directly toxic).

[69] Clapcott J. & J. Goodwin. (2014). Relationships between MCI and environmental drivers. Prepared for Ministry for the Environment. Cawthron Report No. 2507. 21p.

Nutrients are a driver of periphyton biomass, but for a given nutrient concentration, periphyton biomass response will vary stream to stream, depending on many other factors including temperature, accrual period (frequency of significant freshes), substrate and shading. A concern raised by STAG, and driving the new proposed ecosystem health nutrient attributes, is that the toxicity attributes are '*insufficient for maintaining or improving ecosystem health in river in which there is no conspicuous periphyton*'.[70]

To address the concern that current attributes were not adequately managing for ecosystem health, STAG has recommended DIN and DRP limits which are intended to '*capture ecosystem health effects in soft-bottomed waterways not captured by the periphyton attribute*'.

The proposed DIN and DRP thresholds are based on **multiple lines of evidence of multiple** ecological responses to nutrients. These are summarised in Appendix 4 (p.54) of the STAG document,[71] and include:

- Periphyton (two measures based on Chlorophyll-a concentration).
- Macroinvertebrates (using three measures; MCI, QMCI and ASPM).
- Fish (one measure).
- Ecosystem processes (three measures; respiration, production and cotton decay).

The only technical data scientifically describing how these values were derived is a one-page summary provided in Appendix 4.[72]

These values were underpinned by the unpublished manuscript of Death et al. which included periphyton, macroinvertebrate and fish responses.[73] The values derived from this manuscript were different, notably the bottom-lines for nitrate (>95% of DIN at most site) and DRP were higher – 1.32 and 0.057 g/m^3, respectively. For DRP – this is three times higher than what is proposed for the NPS-FM attribute.[73]

In our opinion, the approach taken by STAG is not robust, and the problem statement driving the development of the ecosystem health attribute (i.e. soft-bottom streams not being adequately protected) has been over-stated. The workstream is based on the need to develop nutrient thresholds that protect streams (mainly soft-bottom) from the trophic level effects of nutrients. Importantly, these trophic level effects occur at nitrogen concentrations that are lower than toxicity thresholds. In the subsequent sections below we discuss the issues with the proposed DIN and DRP bottom-line thresholds, which highlight that the STAG recommendations are not consistent with current scientific understanding around managing stream ecosystem health outcomes.

What does science tell us about the relationship between nutrient and ecosystem health?

[70] Freshwater Science and Technical Advisory Group (STAG). (June 2019). Report to the Minister for the Environment. 58 p.
[71] Note that there is a lot of inaccurate information in the media about nitrate toxicity thresholds; in particular, the bottom-line value of 6.9 g/m^3 and that this represents where organisms die. This is incorrect. All toxicity data used to derived the NPS-FM nitrate toxicity were chronic, long-term exposure experiments based on non-lethal effects (i.e. growth rates or reproduction rates). Nitrate concentrations up to 6.9 g/m^3, corresponds to growth effects on up to 20% of aquatic species (mainly sensitive species such as fish)
[72] Freshwater Science and Technical Advisory Group (June 2019). Report to the Minister for the Environment. 58 p.
[73] Death, R. G., Magierowski, R., Tonkin, J. & Canning, A. D. Submitted. Clean but not green: a weight-of-evidence approach for setting nutrient criteria in New Zealand rivers. Marine and Freshwater Research

Consensus amongst scientists is that protecting and restoring ecosystem health is highly complex.

There is consensus amongst scientists that protecting and restoring ecosystem health of stream and rivers is complicated.

For example, using the macroinvertebrate community health as the integrity measure of ecosystem health, recent studies looking to understand drivers of MCI have emphasised the complexity of relationships between MCI and other variables, and the difficulty in isolating the role of individual stressors. Examples include:

- Pingram et al. (2019):[67] '*Monitoring of ecological responses to human pressures, and subsequent mitigation interventions, is essential for sustainable environmental management. However, identifying causal pathways and mechanisms in multi-stressor settings remains challenging*.'
- Leps et al. (2015):[74] '*It is broadly acknowledged that freshwater ecosystems are affected by multiple stressors, but the relative importance of individual stressors in impairing riverine communities remains unclear*.'
- Clapcott and Goodwin (2014):[66] '*Overall results suggest that site MCI scores are related to land use through a complex chain of causality, which makes isolating the role of specific variables difficult.'*
- Graham et al. (2019):[75] '… *no single driver was clearly dominant; the analyses conducted demonstrate that there are multiple drivers influencing each metric and the drivers likely interact with each other*.'

As such, the proposed ecosystem health DIN and DRP threshold are inconsistent with current scientific understanding of drivers, and what is required to improve biological health outcomes of streams. This is perhaps best exemplified in Pingram et al. (2019)[67] where the authors concluded:

> '*These analyses identify that management actions targeted at improving instream habitat quality, particularly reducing fine sediment deposition, when applied across the entire stream network are likely to yield the most widespread improvement in biological condition indices. Our findings also highlight the importance of extending policy development beyond a singular focus on water quality if ecosystem health objectives are to be met*.'

Pingram et al. (2019)[67] emphasised that the attributable risks to stream biological health from nutrients were relatively low compared to other stressors such as fine sediment and habitat diversity and quality. This led to the authors concluding that sole management of nutrients may not improve ecosystem health (as stated below):

> *'This finding potentially indicates that, despite their ecological importance, sole management of nutrients cannot be expected to lead to greater ecological improvement at a regional scale than other management approaches*.'

Storey (2018)[76] presented evidence against the use of similar nutrient thresholds for improving biological health of streams. He summarised his position as follows:

[74] Leps M, Tonkin J, Dahm V, Haase P, Sundermann A. Disentangling environmental drivers of benthic invertebrate assemblages: The role of spatial scale and riverscape heterogeneity in a multiple stressor environment. *Science of the Total Environment*. Vol 536, 546-556

[75] Graham E, Stephens T, Wright-Stow A, Matthews A, Brown L, Patterson M, Patterson M (2019). Drivers of macroinvertebrate communities in the Horizons Region, NIWA Report 2019136HN prepared for Horizons Regional Council and DairyNZ. 103 p.

'In my opinion, the approach of achieving target MCI levels in streams by reducing dissolved nutrient concentrations alone (as recommended by Death and Canning) is too simplistic and may be ineffective in many stream reaches. The reason is that reducing one of the stressors affecting macroinvertebrate communities while not reducing others will not result in significant change to the macroinvertebrate community except where that one stressor is the main cause of degradation in the macroinvertebrate community.'

Increased nitrate concentrations are associated with a decline in catchment indigenous vegetation cover and an increase in catchment 'heavy' pastoral cover. These changes in land use are also associated with increased light (which promotes periphyton growth), elevated water temperatures, loss of riparian vegetation as habitat for adult aquatic insects, increased deposited and suspended fine sediment, a shift in food resources from terrestrial organic matter to periphyton, loss of instream habitat complexity and more rapid and extreme changes in flow. All of these changes are known to affect macroinvertebrate community health.[76]

Suggested ecosystem health attributes assume nutrients are key driver of ecosystem health

The proposed nutrient attributes assume that nutrient concentrations are a key driver of instream ecosystem health (e.g. MCI score/band). This over-simplification risks prioritising a singular focus on nutrients, at the expense of addressing key drivers such as habitat, flow and fine sediment.

The STAG document seems to address this over-simplification as follows[72]:

'While there may not always be a direct link and well-defined mechanistic models between nutrients and components of a healthy ecosystem, ecosystems are dominated by indirect relationships and the framework for managing the health of fresh water must account for this.'

While we acknowledge that there are relationships between nutrients and ecosystem health, it is important we have confidence that any management changes required to deliver the proposed nutrient bottom lines will deliver the outcomes sought, and in the most effective way. In this case, there is a high probability that this will not be achieved (see below).

The multiple lines of evidence approach does not work for many responses.

The multiple lines of evidence approach taken by STAG does not provide increased robustness in the proposed threshold value as the same limitations that apply to one biological response, also apply to others. In other words, increasing the number of biological responses to a technically flawed derivation, does not address the underlying technical flaws. Below we describe the multiple reasons this approach is not sound.

The inclusion of the periphyton and macroinvertebrate responses is justified, as there is general understanding that the effect of sub-toxic concentrations of nitrate on macroinvertebrate is caused by periphyton growth reducing habitat for sensitive macroinvertebrates. However, the inclusion of fish IBI and especially ecosystem processes are less convincing. Information about ecosystem processes is so uncertain that Table 22 of the draft NPS-FM (2019) was not populated with numeric or narrative attribute states. Given this, it is difficult to see how STAG, with acceptable certainty, could map thresholds for these relatively obscure measures to MCI and periphyton band thresholds.

[76] Storey, R.G. (2018). Statement of primary evidence of Richard Goodwin Storey on behalf of Wellington Regional Council. Technical – Water quality. Before the proposed Natural Resource Plan hearings panel.

Fish IBI has also been identified as being less sensitive to stressors, which may reflect their longer life-cycles, greater mobility and unknown extent of barriers to longitudinal connectivity throughout the catchment downstream to the sea).[67]

The complexity of relationships between ecosystem indicators and nutrients may account for their insensitivity to DIN and DRP. For DRP, the range between the A/B and C/D thresholds varied only by a factor of 1.2-1.3. Thresholds varied only by a factor of 1.2-1.3. For fish, the A/B and C/D DIN threshold value ranged only by a factor of 1.5.

All indicators of ecosystem health included in the multiple lines of evidence approach (macroinvertebrates, periphyton, fish, ecosystem metabolism) had poor relationships with DIN and DRP. The co-efficients of determination (r2) values ranged between five and 20% (in other words, nutrient regression did not account for 80-95% of the observed variation in ecosystem health measure). We note that even the external reviewer (Prof. Hamilton) expressed concern about the very weak relationship between fish IBI and nutrients (i.e. r2 values of 9% and 4% for nitrate and DRP, respectively). STAG acknowledges the nature of the weak relationships stating:

> '*Whilst many of the relationships had weak nutrient relationships and uncertainty is inevitable, using multiple lines of evidence provides strength – if one relationship is poor, then it is only a single line among numerous other lines." (STAG document "Proposed nutrient Attribute tables for the NPS-FM (22/05/2019).'*

However, this is particularly problematic as it was not a case of just one relationship being poor – many lines of evidence had weak relationships. In addition, a more robust approach to using multiple lines of evidence would surely be to exclude thresholds derived from poor relationships. We question how poor relationships strengthen other lines of evidence.

Furthermore, it is noted that even within the same ecosystem health indicator, the use of modelled vs observed nutrient concentration data in macroinvertebrate regressions resulted in very different bottom-line DIN thresholds (1.6 and 5.1 g/m^3, respectively). It is therefore questionable as to how multiple lines of evidence improve confidence, when greater variation in thresholds is observed within the same ecosystem health indicator.

The approach taken also conflicted with principles that STAG used to underpin the development of the ecosystem health attribute. In the Proposed nutrient attribute tables for the NPS-FM (22/05/2019), STAG list their principles for developing the guidelines. Two of these are:

- '*Recognition that nationally correlative relationships do not always translate to site specific thresholds.'*

- *'A single set of criteria apply nationally, and more stringent criteria derived locally if required.'*

The first principle acknowledges that nationally derived thresholds will not always translate (i.e. be meaningful) at regional/sub-catchment/FMU scales. Presumably, given the nature of least squares line fitting, there will be an equal chance of these thresholds being either too permissive, or too stringent. However, the second principle permits only local thresholds to be derived if they are more stringent. This is inconsistent with a risk assessment approach, threshold derivations which place greater emphasis on site-specific outcomes, and the current periphyton attribute approach that requires councils to derive meaningful regional/site specific instream nutrient criteria (as it is known that national guidelines have high uncertainty). It is difficult to reconcile the logic of STAG in acknowledging the uncertainty in their national thresholds, but being confident that any regional/site-specific thresholds need to be more stringent than their national values (with low certainty). The approach undermines and disincentives councils to develop meaningful nutrient criteria as part of action plans to maintain/improve ecosystem health (i.e. macroinvertebrates).

Application of ecosystem health nutrient attributes to soft-bottomed stream is conceptually flawed.

Proposed ecosystem health nutrient attributes apply to soft-bottom streams (those that do not support conspicuous periphyton), while the periphyton attribute deals with trophic effects of nutrient enrichment in hard-bottom streams (those that can support conspicuous periphyton growth). Note that a flow chart outlining the process to be followed by councils was in provided in Appendix 5 of the STAG document[70], but that the chart was not reproduced in the Action for Healthy Waterways document.

The application of the proposed nutrient thresholds to soft-bottom streams is conceptually flawed. This is because where nutrients are correlated to macroinvertebrates, there is expert consensus that the causative link is periphyton biomass, which alters habitat (e.g. smothering cobble bed) and food quality for macroinvertebrates.[65,77,78,79,76]

This being the case, a major limitation of applying these thresholds to soft-bottom streams is that they do not support benthic periphyton growth. Soft-bottom stream substrates do not provide the same habitat that hard-bottom substrates do, which is why soft-bottom stream sampling protocols target non-benthic habitats like wood and macrophytes. What this means is that the proposed nutrient thresholds are derived from relationships that apply to hard-bottom streams, and there appears to be little validation for their application to soft-bottom streams.

In addition, STAG has also failed to acknowledge that ecosystem health protection from trophic effects of nutrients is already covered by the existing periphyton attribute and new ecosystem health attributes. The current periphyton attribute, more specifically the nutrient note, applies to both hard and soft-bottom streams. If a stream does not support periphyton (i.e. soft bottom), council must set instream criteria required to meet any other freshwater objective, and the criteria must also account for any sensitive downstream receiving environments (e.g. lakes, wetland and estuaries). The common mistake (which STAG has made) is the assumption that for soft-bottom streams nutrient management defaults to the toxicity attribute. This is not the case, and new integrated ecosystem health attributes, like macroinvertebrates and dissolved oxygen, will require action plans where ecosystem health outcomes are not being met. Hence these action plans will need to consider all drivers, including nutrients. This means that through the existing periphyton attribute, and with action plans triggered by the new attributes, trophic/ecosystem health requirements for soft-bottom streams are adequately captured without the need for the proposed DIN and DRP attributes.

[77] Dodds, W.K., Welch, E.B. (2000) Establishing nutrient criteria in streams. Journal of the North American Benthological Society, 19(1): 186-196.

[78] Greenwood, M.J., Booker, D.J., Smith, B.J., Winterbourn, M.J. (2016) A hydrologically sensitive invertebrate community index for New Zealand rivers. Ecological Indicators, 61: 1000-1010. http://dx.doi.org/10.1016/j.ecolind.2015.10.058

[79] Miltner, R.J. (1998) Primary nutrients and the biotic integrity of rivers and streams. Freshwater Biology, 40(1): 145-158

Further issues are evident when considering the way in which the nutrient thresholds were developed. The DIN/DRP attributes were developed to address streams that do not support conspicuous periphyton growth. However, the multiple lines of evidence approach was developed from data collected from hard-bottomed streams where nutrients are more likely to promote periphyton growth, which in turn degrades macroinvertebrate habitat and therefore community composition. Given soft-bottom streams do not support conspicuous periphyton, and do not have cobbly habitats that can be degraded by periphyton proliferations, the mechanism for impacting macroinvertebrates is not relevant. Hence the applicability of many (if not all) the multiple lines of evidence to derive nutrient thresholds for soft bottom streams is highly questionable.

If the proposed ecosystem health nutrient attributes approach worked, we would expect to see strong alignment between current MCI state, and proposed DIN/DRP banding and limits

DIN.

We undertook an assessment of 450 State of the Environment (SoE) monitoring samples (the same data presented in the Environment Aotearoa 2013-2017 report) to assess alignment between current MCI status and the proposed nutrient bottom lines. This analysis revealed that of the 105 D band MCI sites, only 34 (32%) had DIN values below the proposed bottom line of 1 g/m^3. Interestingly, 35 (33%) of the D band MCI sites had A band median DIN concentrations (Figure A2.2). That is, 1/3 of sites failing the macroinvertebrate (proposed) bottom-line already have median DIN concentration <0.24 g/m3 (i.e. A band). This is consistent with studies indicating that nutrients are not the major drivers of ecosystem stream health.

Of the 223 sites with A band DIN concentrations (i.e. <0.24 g/m3, blue bars), 24 (11%) had A band MCI scores, 94 (42%) had B band MCI scores, 70 (31%) had C band MCI scores, and 35 (16%) had D band MCI scores. Almost 90% of sites with median DIN concentrations of <0.24 g/m3 (i.e. A band) did not correspond to A band macroinvertebrate health (Figure A2.2).

At the other end of the nitrate gradient of the 71 sites had D-band DIN concentrations (i.e. >1.0 g/m3), none had A band MCI scores, six (8%) had B band MCI scores, 31 (44%) had C band MCI scores, and 34 (48%) had D band MCI scores.

Overall, more than 50% of sites with DIN concentrations that exceed the proposed bottom-line of 1 g/m^3 have corresponding macroinvertebrate health scores that are C band or better (Figure A2.2).

These data highlight the uncertainties, and risks, of setting DIN bottom-lines to protect and restore biological health of streams.

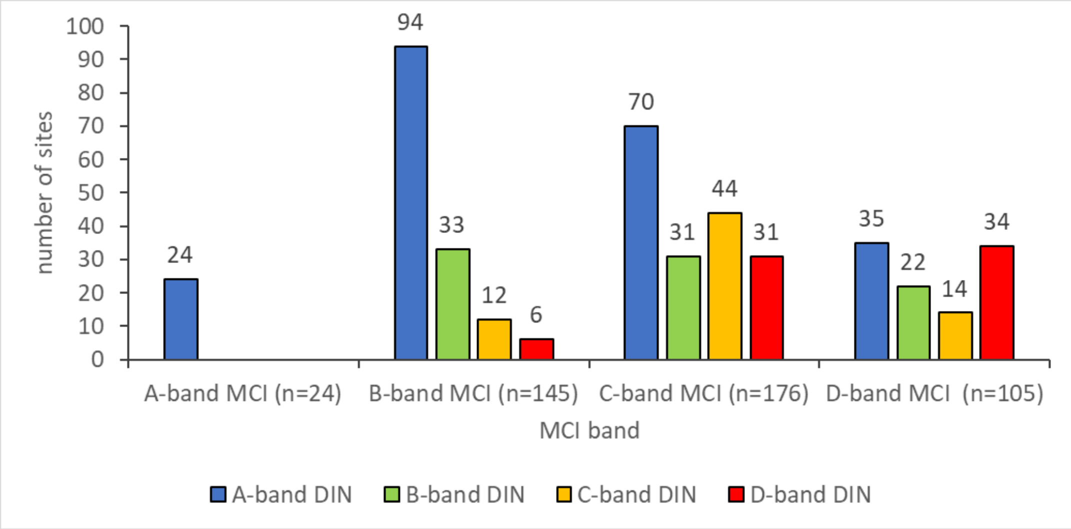


Figure A2.2. Distribution of median DIN concentrations (grouped via proposed DIN bands) for sites within each proposed macroinvertebrate (MCI) band. The 2013-2017 dataset was the same used for Environmental Aotearoa 2019 reporting – total number of samples = 450)

DRP

The same assessment of 450 SoE sites, but comparing MCI and DRP, revealed that DRP showed more pronounced overlap with MCI bands than DIN, with A-D concentration bands being represented in all MCI bands (A-D). 50% of A band macroinvertebrate sites (n=25) had median DRP concentrations in lower bands (i.e. B-D); c. 20% had concentrations exceeding proposed bottom-line of 0.018 g/m^3.

61% of D band macroinvertebrate sites (n=105) had DRP concentrations that were less than the proposed bottom-line threshold of 0.018 g/m^3; 18% had A band DRP concentrations (i.e. <0.06 g/m^3) (Figure A2.3).

92% of sites with A band DRP did not correspond to an A band MCI score. Of the 153 sites with A band DRP concentrations, 12 (8%) had A band MCI scores, 57 (37%) had B band MCI scores, 65 (42%) had C band MCI scores, and 19 (12%) had D band MCI scores.

At the other end of the DRP gradient, of the 93 sites with D band DRP (>0.018 g/m3), 5 (5%) had A band MCI scores, 18 (19%) had B band MCI scores, 29 (31%) had C band MCI scores; and 41 (44%) had D band MCI scores.

If nutrients were driving ecosystem health outcomes, we would expect to see a strong relationship between DIN and MCI.

The uncertainty in the level of agreement between DIN and MCI bands (Figure 2.3) is easily explained by the significant overlap in DIN concentrations between different MCI bands, which have been superimposed on the original correlation between MCI and median nitrate from the Death et al. manuscript (Figure A2.3).[73] These data show how variable median nitrate concentrations are for any given MCI band, and subsequently the problem with using nitrate to predict ecosystem health outcomes, as well as the challenge of using nitrate management as a lever to improve stream and river health outcomes.

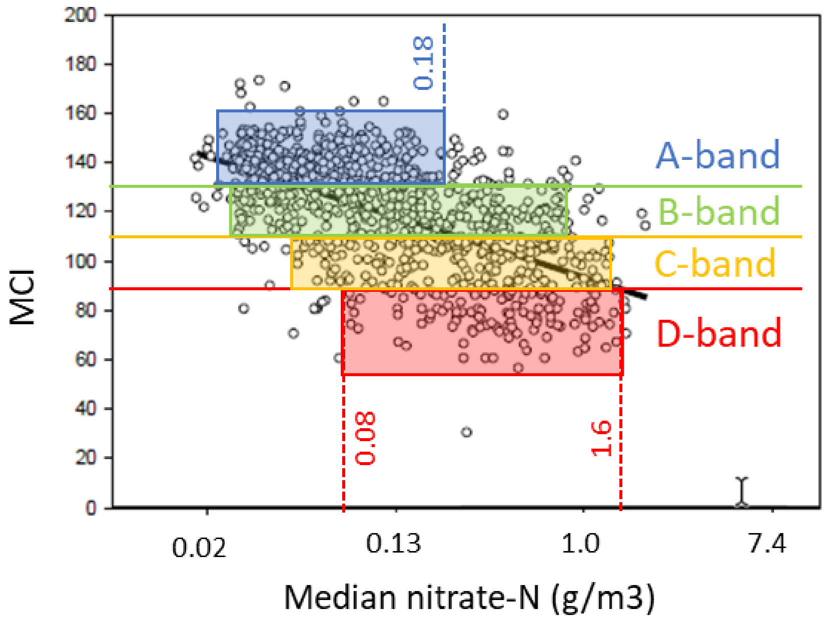


Figure A2.3. Original MCI vs nitrate-N regression taken from Death et al. manuscript. The proposed MCI thresholds (y-axis) are shown, and the colour boxes indicate the distribution of median nitrate concentrations within each MCI band.

Further evidence on the challenges of linking MCI and nutrients, and defining thresholds can be found in the document Comparison of MCI – nutrient relationship analyses of Canning and Snelder (23 June 2019). This analysis highlighted the uncertainty (and disagreement) regarding the derivation of ecosystem health nutrient thresholds. The paper demonstrated that using measured MCI and nutrient concentrations from approximately 400 SoE monitoring sites, yielded regressions with r^2 values of around 10 to 15%, and bottom line (C/D) thresholds for DIN of 4.5 to 5.5 g/m^3, and DRP thresholds (C/D) of 0.06 to 0.1 g/m^3. By contrast, where modelled nutrient concentrations were used with the SoE macroinvertebrate data, r^2 values increased to around 20%, with DIN and DRP bottom-line thresholds of 1.6 and 0.03 g/m^3, respectively. Consequently, using the same subset of macroinvertebrate data, observed and modelled DIN concentration data resulted in bottom lines of 5.1-5.5 and 1.6 g/m^3, respectively. Despite the stronger relationship, STAG used modelled data (from a larger data set comprising of 1852 samples) to develop the DIN bottom-line of 1 g/m^3 (DRP = 0.038 g/m^3), and consequently an approximate four to five -times lower threshold.

An alternative approach to provide for the protection of aquatic organisms

Raising the bar by strengthening nitrate and ammonia toxicity to provide 90% protection levels for aquatic organisms

As shown above, the proposed approach to managing ecosystem health through setting stringent nutrient bottom lines is not based on robust scientific analysis, or that of the scientific community. An alternative approach is to increase the bottom-line level of protection for nitrate-N and ammonia-N toxicity from 80% to 90% and manage ecosystem health requirements for soft-bottom streams through existing requirements (or controls) specified in the periphyton attribute note (NPS-FM 2017).

The reasons for this approach:

- Current NPS-FM bottom-lines are based on 80% protection level. ANZECC guidelines define two protection levels for highly disturbed (highly modified) systems; 80% and 90% - the current toxicity bottom-lines are based on the more permissive of the two protection levels (80%).

- This position could be justified if there was a lot of chronic toxicity (i.e. long-term exposures; non-lethal effects) for native New Zealand species, which would provide certainty that the lower level of protection adequately protects key native aquatic species. This is not the case. The nitrate-N toxicity threshold dataset contained two native species (caddisfly and inanga) and the ammonia-N toxicity dataset contained four native species (two types of mayfly, freshwater mussel spat, and fingernail clam), all of which were impacted at 80% protection levels.[80]

- Interestingly, the NPS-FM ammonia toxicity should already be based on a 90% protection level. The 2014 technical memorandum on the Ministry's website recommends increasing the bottom-line protection level from 80 to 90%.[80] The author states:

  'The use of the chronic 80th percentile guideline value was originally proposed as a "bottom line" threshold (MfE 2013). However, the 80th is greater than all of the mussel species and the NZ fingernail clam measuring chronic survival and growth endpoints, while being less than mayfly and other native or resident species. ***The use of the 90th percentile guideline values as a bottom line is recommended****. These values are protective of the native fingernail clam, though some effects are indicated for the North American juvenile mussels, which are not resident in New Zealand.'*

- Using the same chronic toxicity dataset used to derive the NPS-FM thresholds, and shifting from 80% to 90% protection, would mean:
  - **Nitrate-N toxicity bottom-line would decrease from 6.9 to 3.8 g/m^3.**
  - **Ammonia-N toxicity bottom-line would decrease from 1.2 to 0.55 g/m^3.**

DairyNZ suggests this is a preferable approach to the proposed DIN/DRP nutrient limits for ecosystem health, and one that would provide increased protection for aquatic organisms.

Impacts of STAG recommendation to increase MCI band thresholds by 10 units

New Zealand has used the 80 / 100 / 120 thresholds to define poor, fair, good and excellent macroinvertebrate health since the mid-1980s. The MCI score of 80 has been used to define the bottom-line – and is used in Policy CB3 of the current NPS-FM (2017).

[80] Hickey, C. (2014). Derivation of indicative ammoniacal nitrogen guidelines for the National Objectives Framework. NIWA. Reference: MFE13504. Available at: https://www.mfe.govt.nz/sites/default/files/media/Fresh%20water/derivation-of-indicative-ammoniacal.pdf

STAG group recommended increasing the bottom-line for macroinvertebrate health (using MCI as the example) from 80 to 90, and then presumably to maintain 20 MCI band widths, all thresholds were adjusted up 10 MCI units, so that the proposed threshold are now 90 / 110 / 130. This has significant implications for a number of sites (and sub-catchments) that will fall below the national bottom-line. For example, using 2013-2017 data, of 832 MCI sites, shifting the bottom-line MCI value from 80 to 90 will increase the number of D band sites from 72 (9%) to 167 (20%). See Figure A2.4 below.

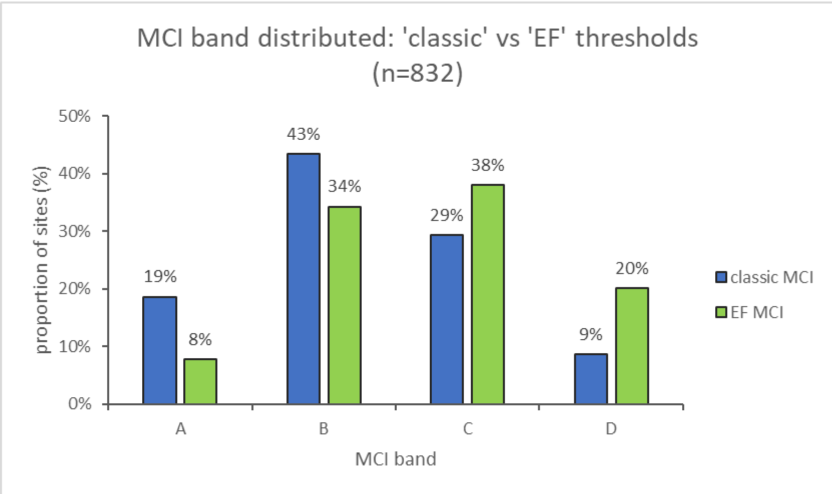


Figure A2.4. Distribution of MCI banding using current, and proposed bands. Data are based on 832 State of the Environment monitoring sites between 2013 and 2017.

No scientific justification for this change was provided. It should be noted that a group of macroinvertebrate experts recently recommended a macroinvertebrate attribute (based on MCI) which retained the standard threshold values of 80 / 100 / 120.[81] The authors based their assessment on 25-30 years of MCI data, with no mention of increasing the bottom-line value from 80 to 90.[81] Presumably, a convincing scientific argument drove the decision to change thresholds, based on data collected over a much shorter period)2014 and 2018/19).

It is noted that the Death *et al.* manuscript that was the inspiration (STAG terminology used) for the ecosystem health attributes, and yet in the version of this manuscript appended to evidence submitted in PC1 in Waikato, the nutrient thresholds were based on the conventional 80 / 100 / 120 MCI thresholds.[73] Again, we are finding it difficult to see the scientific justification for the recommended change in a measure that has been used for c. 30 years in New Zealand.

The justification provided in the STAG document is largely a judgement call that is not supported by scientific data or literature. It states:

> *'The current NPS-FM contains an MCI value of 80, which was described by Stark as 'gross pollution and possible severe pollution'. This group does not believe 'possible severe pollution' to be an appropriate place to set a national bottom-line.'*

[81] Collier K, Clapcott J, Neale M. (2014). A macroinvertebrate attribute to assess ecosystem health of New Zealand waterways for the national objective framework – issues and options. Environmental Research Institute report 36, University of Waikato, Hamilton.

DairyNZ does not agree with this justification for the following reasons:

- STAG have used the Stark (1998) descriptions for the category class corresponding to a score <80 (i.e. the D band) – this had a description of **'probable severe pollution'**; the description of fair class (i.e. C band) with MCI values between 80 and 99 is **'probable moderate pollution'**. Moderate pollution is a narrative description that is entirely consistent with a C band state. For example, lake trophic state narrative for the C band is 'lake ecological communities are moderately impacted….'. The river trophic attribute (periphyton) has a C band narrative of 'periodic short-duration nuisance blooms **reflecting moderate nutrient enrichment…**'.

- The Stark descriptions (1998) were nuanced by Collier et al. (2014)**Error! Bookmark not defined.** into NPS-FM narrative objective states. For the proposed C band (i.e. MCI score of 80 to 99), the narrative attribute wording was 'fair quality environment where moderately highly tolerant species dominate'. This definition is entirely consistent with C band narratives which reflect a moderate level of degradation.

- Of relevance, for Waikato-Waipa PC 1, a technical sub-group recommended the plan change apply thresholds of 80 / 100 / 120 (they did not support a bottom-line of 90).

In addition, **DairyNZ does not support** QMCI and ASPM as multiple metrics for measuring macroinvertebrate community health will result in ambiguous assessments. We support the use of the MCI as a metric recommended for SoE monitoring, with a long history, and supported by MfE in monitoring protocols. We agree with the findings of Clapcott et al. (2017) that MCI is '*a sensitive indicator of the multiple stressor effects on macroinvertebrates resulting from dominant land uses in New Zealand, and can be used to distinguish the ecosystem health of streams at a national scale'.*[82]

MCI is the most widely used and cost-effective indicator of ecosystem health.'[83,] Furthermore, MCI was one of three indices producing the greatest discrimination between forested reference sites and urban and pastoral stressors from a total of 17 candidate macroinvertebrate indices.[84]

DairyNZ has concerns about the additional costs and resourcing of imposing requirements for quantitative sampling to determine QMCI, which has implications for sector initiatives to monitor ecosystem health via the macroinvertebrate attribute. We support the assertion of Stark[83:]

> '*Biomonitoring is NOT research – it is research-backed – but above all it should be cost-effective. In my view increasing the cost and complexity of routine biomonitoring will not result in improved river health in New Zealand*).'

[82] Clapcott J, Wagendorf A, Neale M, Storey R, Smith B, Death R, Harding J, Matthaei C, Quinn J, Collier K, Atalah J, Goodwin E, Rabel H, Mackman J, Young R. (2017). Macroinvertebrate metrics for the National Policy Statement for Freshwater Management. Nelson, Cawthron Institute. Cawthron Report No. 3070. 139p.
[83] Stark, J.D. (2019). Re: Draft National Policy Statement for Freshwater Management. Stark Environmental. Publish 24 October 2019.
[84] Collier KJ 2007. Temporal patterns in the stability, persistence and condition of stream macroinvertebrate communities: relationships with catchment land-use and regional climate. Freshwater Biology 53: 603-616

Summary: What does DairyNZ support and not support?

DairyNZ supports STAG recommendations to undertake a review of the proposed DIN and DRP national bottom lines.

DairyNZ does not support the proposed DIN and DRP attributes of ecosystem health.

DairyNZ agrees that ecosystem health needs to be managed, which means accepting there are indirect and complex relationships that need to be managed to ensure biological health outcomes are met. This is why we support the proposed inclusion of the macroinvertebrate attribute (using MCI, with caveats). However, we disagree with nutrients being used as the main lever to address ecosystem health when this position is contrary to published science and scientific consensus (e.g. Pingram et al 2019).

The inclusion of a macroinvertebrate attribute (and existing periphyton attribute) provides biological stream health indicators and importantly, bottom-lines that set minimum levels of stream health. If these are not being met, DairyNZ fully supports the requirement for councils to establish action plans to improve stream health. Action plans should be catchment-specific, and in many instances, nutrients are just one of many environmental drivers (and often not a major one) that need to be considered in order to improve instream health outcomes.

DairyNZ is not opposed to the ecosystem health nutrient thresholds (once peer-reviewed) being made available as guidance for councils, which may, if helpful, be used to inform action plans triggered by low or declining MCI scores. This is analogous to the approach recommended for the periphyton default nutrient guideline values (refer to p. 48 of the Action for Healthy Waterways document).[85]

DairyNZ does not support the application of ecosystem nutrient thresholds to soft-bottom streams as there is no evidence to support that the relationship between nutrients and stream health are applicable to these stream types.

DairyNZ asserts that the proposed ecosystem health DIN and DRP are largely superfluous, given than the trophic attribute for rivers (periphyton) requires setting nutrient criteria in soft-bottom streams that will meet any other freshwater objective. This could include dissolved oxygen, macrophytes or toxicity. This attribute also means nutrient criteria must take into account the needs of sensitive downstream environment.

If the proposed DIN/DRP thresholds were to be retained in the NPS-FM, DairyNZ advocates for sensible caveats/exceptions to the bottom-line value. At a minimum, this would have to include exemptions in sub-catchments where instream ecosystem health objectives (as measured by relevant bioindicators like periphyton, MCI and/or fish) are already being met.

DairyNZ supports the approach to include an *action plan* for managing macroinvertebrates

The draft NPS-FM presents a pragmatic approach to managing attributes, such as macroinvertebrates, that rely on complex/indirect relationships with a multitude of stressors, of which nutrient is one, but not often a major driver. However, the STAG recommendation for attributes that define global nutrient limits to deliver a macroinvertebrate/ecosystem outcome (e.g.

[85] Ministry for the Environment. (MFE). (2019). Action for healthy waterways – A discussion document on national direction for our essential freshwater. Wellington: Ministry for the Environment

a MCI band score) is inconsistent with the action plan framework, which recognises the need to understand and manage complexity and uncertainty. Including the proposed ecosystem health nutrient attributes in Appendix 2A removes the ability for decision-making in the face of uncertainty by imposing limits on resource use that are unlikely, on their own, to improve ecosystem health outcomes.

DairyNZ supports increasing nitrate and ammonia toxicity protection for aquatic organisms.

DairyNZ supports increasing the bottom-line level of protection from 80%, to 90%, for both the nitrate-N and ammonia-N toxicity attributes in combination with managing ecosystem health requirements for soft bottom streams through existing requirements, or controls, specified in the periphyton attribute note (NPS-FM 2017).

DairyNZ supports the inclusion of MCI for assessing biological health.

DairyNZ supports the inclusion of a macroinvertebrate attribute based on MCI for assessing the biological health of streams (ecosystem health), although we do not support the amended band thresholds (i.e. 90 / 110 / 130) which depart from the 80 / 100 / 120 threshold values used in NZ since the mid 1980s, and were recommended as basis of the original macroinvertebrate attribute.[81] No data have been presented to support the changes recommended by STAG.

DairyNZ supports the existing periphyton threshold for managing ecosystem health in hard-bottomed rivers.

DairyNZ supports the periphyton attribute for managing ecosystem health in hard-bottom rivers. The requirement to consider any other freshwater objective, including sensitive downstream environments, for FMUs that do not support conspicuous periphyton (i.e. soft-bottom streams) partially addresses the concerns that these streams are managed only for nitrogen toxicity. This position would be strengthened by recommending moving to 90% protection levels for the bottom-line of the toxicity attributes.

DairyNZ does not support the proposed fish attribute for ecosystem health.

The STAG document states a single justification for the fish attribute – that there are currently no metrics in the NPS-FM for habitat, and that although fish IBI is not a direct measure of habitat, some functional groups would respond to the loss or addition of habitat. Given that the draft NPS-FM includes macroinvertebrates – a better measure of habitat – it would seem that including a fish attribute is superfluous. It is noted that currently only around half of the regional councils have a fish IBI in place. Collectively, these make the proposed fish IBI attribute a less suitable compulsory national measure of biological stream health.

DairyNZ does not support multiple measures of macroinvertebrate health.

Multiple measures of macroinvertebrates health are unnecessary and will add confusion. A 2001 MfE macroinvertebrate monitoring guidance document recommended MCI for state of the environment monitoring programmes.[86] **DairyNZ supports** MCI as the single metric for the proposed macroinvertebrate attribute.

---

[86] Stark, J. D.; Boothroyd, I. K. G; Harding, J. S.; Maxted, J. R.; Scarsbrook, M. R. (2001): Protocols for sampling macroinvertebrates in wadeable streams. New Zealand Macroinvertebrate Working Group Report No. 1. Prepared for the Ministry for the Environment. Sustainable Management Fund Project No. 5103. 57p.

Appendix 3:

Sediment

Sediment Attribute technical points

DairyNZ position:

DairyNZ fully supports the inclusion of suspended and deposited fine sediment in the NPS-FM but are concerned about how the currently framed attributes will be implemented. In particular, how councils and communities will be able to integrate and implement these complex attributes (a total of 24 classes and 96 thresholds across the two sediment measures) into existing frameworks (i.e. alignment with existing delineated catchments/FMUs, priority catchments, catchment groups and existing water quality monitoring networks).

The inclusion of fine sediment measures in the NPS-FM is long overdue and welcomed by DairyNZ. But to fully realise the opportunities of their inclusion, they should be incorporated in a way that responds to the challenges and needs of regulators and communities. DairyNZ suggests the following recommendations to improve the 'workability' of the fine sediment attributes, to deliver a clear and technically robust framework possible to enable the management of significant adverse effects from fine sediment in NZ streams and rivers.

Recommended approach

DairyNZ recommends an approach that focusses on setting bottom lines for fine sediment that are consistent with effects-based thresholds published in international and national studies.

The proposed fine sediment attributes suffer from several technical issues that create questions around the validity of the attributes. These technical issues include:

- a classification system that does not account for natural state variation in fine sediment;
- novel methods that have not been peer-reviewed or validated;
- reliance on modelled data; derivation of bottom-line thresholds that approximate to near reference conditions in several sediment classes.
- These issues highlight the concern that the technical work underpinning the proposed attributes has not been adequately 'sense-checked'.

Instead we recommend a proposed alternative approach based on the following:

- A suspended sediment attribute that is consistent with effects-based bottom-line thresholds reported in national and international literature, and the principle/limitations discussed in other MfE-commissioned reports.[87,88]
- A deposited sediment approach that defines a bottom-line threshold.

The rationale for these recommendations are discussed in more detail below.

Recommendation for Suspended sediment

We recommend that attributes only define bottom-lines that represent turbidity values most likely to result in significant adverse effects. There are two potential approaches (or a hybrid of the two): (1) increase in of 5 NTU relative to reference state (i.e. 0.5 to 2.5 NTU)[89]. This would equate to absolute turbidity bottom-lines of between around 5.5 and 7.5 NTU, consistent with the 'global average' extirpation thresholds derived in Appendix H of the Stage 3 sediment report.[90]

An example of how this could be executed is provided in Figure A3.1. Blue datapoints (95% confidence intervals shown) represent modelled reference state (McDowell et al. 2013, used by MfE in deriving default guideline values, DGVs)[89], and the orange datapoints represent proposed bottom-line of a 5 NTU increase above reference. The dashed line shows the global average turbidity value of 7.2 NTU corresponding to this 5% macroinvertebrate extirpation threshold (Table A3.1; Appendix H in the Stage 3 sediment report).[91]

[87] Depree, C., Clapcott, J., Booker, D., Franklin, P., Hickey, C., Wagenhoff, A., Matheson, F., Shelley, J., Unwin, M., Wadhwa, S., Goodwin, E., Mackman, J., Rabel, H. (2018). Development of ecosystem health bottom-line thresholds for suspended and deposited sediment in New Zealand rivers and streams: NIWA Client Report prepared for the Ministry for the Environment 190 p (plus appendices).
[88] Clapcott et al. Clapcott, J.E., Young, R.G., Harding, J.S., Matthaei, C.D., Quinn, J.M. and Death, R.G. (2011) Sediment Assessment Methods: Protocols and guidelines for assessing the effects of deposited fine sediment on in-stream values. Cawthron Institute, Nelson, New Zealand.
[89] McDowell RW, Snelder TH, Cox N (2013). Establishment of reference conditions and trigger values for of chemical, physical and micro-biological indicators in New Zealand streams and rivers. AgResearch report prepared for Ministry for the Environment. 70 p.
[90] Franklin et al. (2019). Deriving potential fine sediment attribute thresholds for the National Objectives Framework. NIWA Client Report 2019039HN. Prepared for the Ministry for the Environment (February 2019)
[91] Franklin et al. (2019). Deriving potential fine sediment attribute thresholds for the National Objectives Framework. NIWA Client Report 2019039HN. Prepared for the Ministry for the Environment (February 2019)

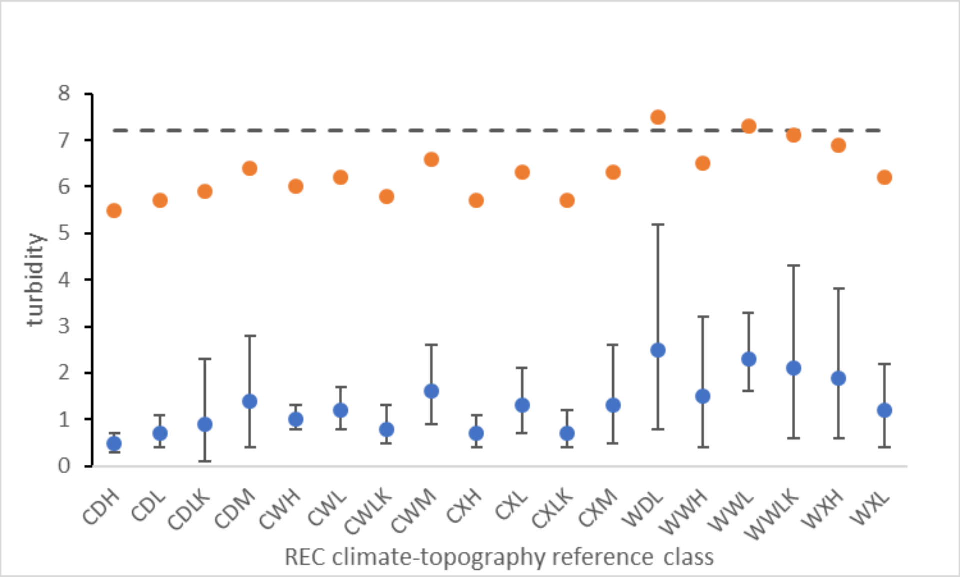


Figure A3.1 – Climate – Topography REC classes (McDowell et al 2013)[89] showing modelled reference state (blue) and suggest bottom-line (C/D) thresholds from 5 NTU increase (orange). The black global average turbidity value of 7.2 NTU corresponding to this 5% macroinvertebrate extirpation threshold (Appendix H in the Stage 3 sediment report).[92]

Table A3.1: Selected literature thresholds limited to the lower (most conservative) range of suspended sediment effects (Table 7-6 from Stage 2 sediment report)

study	comment
Newcombe (2003)	reactive distance - EL50[a] = c. 7 NTU (brook, lake and rainbow trout)
Vogel Beauchamp (1999)	reactive distance LOEL[b] = 3 NTU (*Salvelinus namaycush*)
Quinn et al. (1992)	50% effects level (EL50) macroinvertebrates = 3.7 NTU
Lloyd (1987)	increase of 5 NTU (in cold, clear water stream) could reduce primary productivity by 3-13%
	high level of protection would be 5NTU above natural conditions for clear, cold water streams
Boubee et al. (1997)	avoidance response , estimated EL25[c] values of 6.7 and 6.5 NTU for banded kokopu and koaro, respectively
De Robertis et al. (2003)	5-10 NTU decreased rate at which sable fish pursue prey and the probability of capture
Cavanagh (2014)	21 day experiment tank trials, ināanga, kōaro, eels and brown trout. Ināanga showed a significant decrease in growth rates from 5 to 15 NTU.
Hay et al. (2006)	Predicted 50% reduction in the reactive distance of 520 mm brown trout at 10 NTU
Newcombe (2003)	Impact assessment model for fish – with duration exposures from 1 h to 11 months
	Severity score ranging 1-14; 1-3 = *slight impairment*; 4-8 *significant impairment* (feeding and other behaviour begin to change); 9-14 = *severely impacted*.
	4 month duration: '3 to 4' or '4 to 5' transition is predicted to occur at 0.77 and 0.55 m (corresponding to c. 5 and 7 NTU), respectively.
	11 month duration: '3 to 4' or '4 to 5'or '5 to 6' transition is predicted to occur at 1.1, 0.77 and 0.55 m (corresponding to c. 3-3.5, 5 and 7 NTU), respectively.

[a] EL50 = 50% effects limit. [b] LOEL lowest observed effects limit. [c]EL25 = 25% effects level

[92] Franklin et al. (2019). Deriving potential fine sediment attribute thresholds for the National Objectives Framework. NIWA Client Report 2019039HN. Prepared for the Ministry for the Environment (February 2019)

Recommendation for Deposited sediment

DairyNZ recommend taking an approach that defines a bottom-line threshold. The use of A/B and B/C bands infer a level of scientific precision that we do not have. We emphasise the importance of focussing on thresholds that define where significant adverse effects occur. Most typically, this will involve the deposition (and infilling) of fine sediment in hard-bottom streams that naturally contain low amounts of sediment. However, there are also impacts from deposited sediment in hard bottom streams that contain naturally moderate levels of deposited fine sediment; and finally, there are the impact of excessive fine sediment being deposited in naturally soft-bottom streams. In the latter case, we recommend that this is something that probably needs additional work, given the limited applicability of visual assessment methods to monitor sediment pressure in these environments.

Accordingly, we recommend an approach similar to the deposited sediment attribute proposed in the Stage 2 sediment report, which defines three broad deposited categories/scenarios: for example:[87]

I. *naturally low deposited fine sediment* (e.g. <20%) - then bottom-line either absolute value of 30% or <15% increase on background, which is consistent with Reid and Quinn (2011)[93] ;
II. *naturally moderate levels of deposited fine sediment* (e.g. 20-50%) then bottom line of 60% deposited fine sediment; and
III. naturally high levels of deposited fine (i.e. >50%, or 'soft-bottom'), excluded from attribute.

This is analogous to the approach recommended in the Stage 2 sediment report (refer to Table A3.22), which has been included below. It is largely consistent with thresholds defined by previous New Zealand studies. For example, 20% sediment cover was the threshold at which %EPT began to significantly decline using a sigmoidal model on a relatively small dataset consisting of 30 Canterbury stream sites. Clapcott et al. (2011) settled on a deposited fine sediment threshold of 20%, driven largely by salmonid literature from North America.

Clapcott et al (2011) reported that streams supporting macroinvertebrate community indicative of very good stream health (MCI > 120) were typically associated with sediment cover of 20% or less using a small national data set.**Error! Bookmark not defined.** This supports setting a higher threshold of 30% deposited fines sediment.

[93] Reid D. Quinn J. (2011). Preliminary information for developing sediment guidelines for streams of the West Coast, New Zealand.

Table A3.2 Macroinvertebrate thresholds recommended for a deposited fine sediment attribute in the Stage 2 sediment report (Table 4.8)[94]

Predicted reference class (range of natural-state '% sediment cover')	name (descriptor) for reference class	Recommended threshold comparable to NPS-FM bottom-line (% sediment cover instream)[2]
0-30%	low-to-medium	30%
30-60%	high	60%
>60%	soft-bottom	na[1]

[1] streams classed as naturally soft-bottom are exempt from deposited sediment thresholds. [2]Assessed as annual mean, based on a monthly monitoring regime. The minimum record length for grading a site based on an instream visual assessment of % fine sediment cover (SAM2) is 2 years.

Additional technical comments and concerns

1) **The classification system is problematic:**

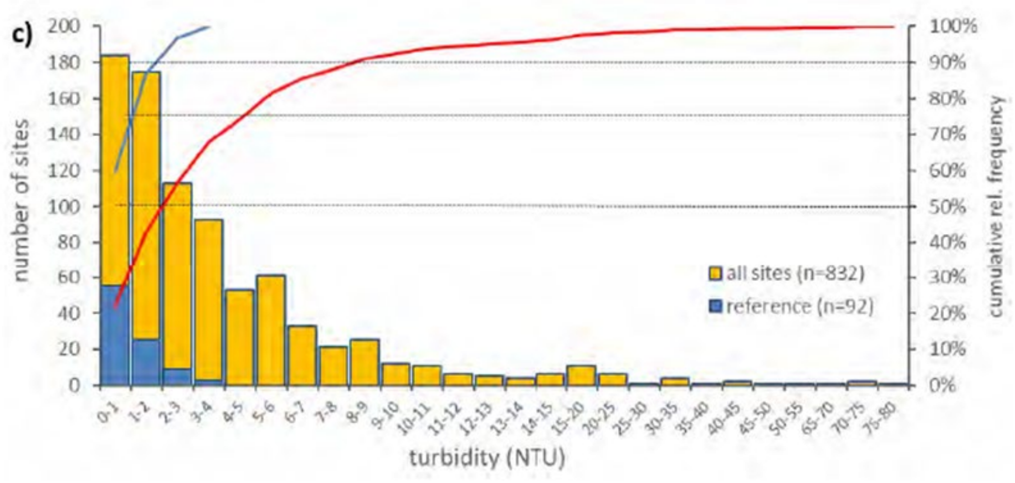
The classifications systems for fine sediment do not meet the contracted requirements specified by the Ministry which were to "*Develop a classification system that differentiates New Zealand rivers according to "reference state" variation in ESV*[95] *characteristics*"

The classification system for both deposited and suspended sediment used in the NIWA Stage 3 report[96] did not address a key (contracted) requirement of the classification system that differentiates New Zealand rivers according to "reference state". In other words, if NZ was undeveloped, the classification should supposed to account for natural variations in fine sediment, for example, rivers in one part of the country may have naturally higher turbidity than other parts of the country on account of natural variability in geology and/or climate. It is this 'natural' variability in fine sediment that the classification system was intended to address.

However, the approach used all available data, which is problematic as monitoring data available is dominated by impact sites. Monitoring sites are distributed through modified catchments, and the variations in turbidity across this data set are heavily influenced by land use, and not natural variations.[87] This is illustrated in Figure A3.2 – a classification system based on natural state variation in turbidity involves the range of reference state data (blue). The proposed classification system is based on the turbidity range of all data (orange) which reflects land use pressure superimposed on a smaller natural state variability. Reference site data made up only 10% of the total SoE monitoring data set, with remaining 90% comprising 'impact' sites – meaning the sediment ESV characteristics

[94] Franklin et al. (2019). Deriving potential fine sediment attribute thresholds for the National Objectives Framework. NIWA Client Report 2019039HN. Prepared for the Ministry for the Environment (February 2019)
[95] ESV = environmental state variable, which refers to suspended sediment (measured as turbidity) and deposited sediment (measured by visual determination of % deposited fine sediment cover)
[96] Franklin et al. (2019). Deriving potential fine sediment attribute thresholds for the National Objectives Framework. NIWA Client Report 2019039HN. Prepared for the Ministry for the Environment (February 2019)

will be influenced by land use. The result is a classification that does not “differentiate New Zealand rivers according to reference state variation in sediment characteristic”.



Distribution of suspended sediment measures (TSS, visual clarity and turbidity) across all sites (orange bars, red line) and reference sites (blue bars, blue line). Cumulative frequency (relative) distributions are plotted as curves with value corresponding to the right y-axis.

Figure A3.2 – Figure 2-2 from the NIWA stage 2 report[97]

Using suspended sediment as the example, a potential issue is that as the cluster analysis increases the amount of differentiation (i.e. moving from L1 to L4), clusters identified as having relatively high reference state values are being ‘driven’ entirely by non-reference sites (outside the ‘blue’ reference state distribution shown in Figure A3.2). For example: class L1.1 (reference 2.4 NTU) gets split into 3 classes (L2 aggregation), one of which (L2.2) has a modelled reference state of 5.2 NTU. This is then split into 2 further classes in the L3 aggregation, yielding L3.2 and L3.3, with modelled reference states of 5.8 and 3.8 NTU, respectively. This process was most likely heavily influenced by impact sites, which is confirmed in Figure D-13 of the Stage 3 Report, which shows the class L2.2 has a single reference state, and classes L3.2, L4.5 and L4.8 have no reference state sites in the data set.[90] The results of the cluster analysis and 4 levels of aggregation are shown in Table A3.3.

[97] Franklin et al. (2019). Deriving potential fine sediment attribute thresholds for the National Objectives Framework. NIWA Client Report 2019039HN. Prepared for the Ministry for the Environment (February 2019)

Table A3.3 result of cluster analysis and different aggregation levels used in developing the suspended sediment classification system (Table 3.2 from the Stage 3 report[98])

Agg. L1	Ref	% River Net.	Agg. L2	Ref	% River Net.	Agg. L3	Ref	% River Net.	Agg. L4	Ref	% River Net.	CTG Classes
1	2.4	56.82	1	2.1	30.83	1	1.6	7.05	1	1.6	7.05	WW_Low_VA; CW_Low_VA
						6	2.1	22.37	12	2.2	22.37	CW_Mount_HS; CW_Hill_SS
						7	4.9	1.42	2	4.9	1.42	WD_Low_Al
			2	5.2	17.26	2	5.8	14.42	5	5.9	10.81	WW_Low_SS; WD_Low_SS
									8	3.6	3.61	CD_Low_SS
						3	3.8	2.84	6	3.8	2.84	WW_Low_HS
			4	2.5	8.72	8	2.5	8.72	3	1.1	2.72	CD_Low_HS
									4	2.7	6.01	CW_Low_SS
2	1.1	31.70	3	1.2	31.70	4	1.5	14.58	7	2	10.92	CD_Low_Al; CW_Hill_VA
									10	0.9	1.63	CW_Lake_Any
									11	0.9	2.03	CW_Low_HS
						5	1.0	17.12	9	1.0	17.12	CW_Hill_HS; CD_Hill_HS; CW_Low_Al

For each class produced by the cluster analysis, a modelled reference state was calculated; however, the issue is that the cluster analysis that defined the classes was influenced by impact sites. This was evident from Figure D-13 (p 169 in Stage 3 report) that showed that the high turbidity classes (L2.2, L3.2 and L4.5) had little differentiation between modelled reference state and the median for all data in the class.[90] We note that modelled reference state values of 5-6 NTU (for sediment classes L2.2, L3.2 and L4.5) are approximately 2-times higher than any CTG reference states reported by McDowell et al (2013).**Error! Bookmark not defined.**

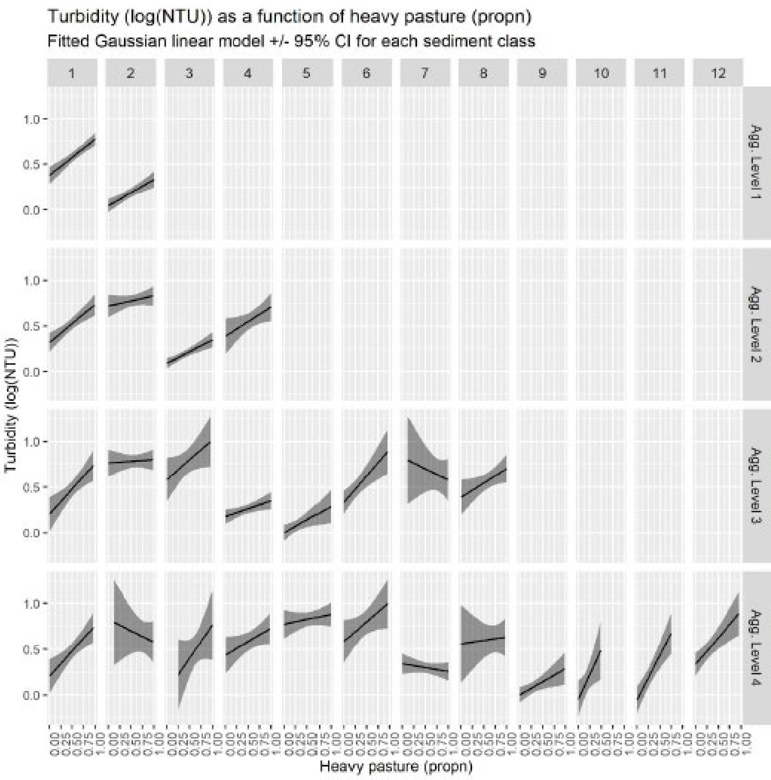
As a general comment, higher levels of aggregation resulted in unusual sediment profiles (e.g. class 7 or L4.7 showed decreasing turbidity with increasing heavy pastoral landcover), and often very high uncertainties in modelled reference state (shown by width of grey area on the Y-axis where heavy pasture =0%). This further adds to the uncertainty in the classification system, and subsequent threshold analysis which heavily reliant on modelled reference state.

Based on the above discussion, we are concerned that the classification has resulted in classes like L4.5, which are potentially more reflective of land use in the CTG classes, rather than genuine differences in reference state (as indicated by the large modelled reference state value of 5.9 NTU in Figure A3.3). This class has no reference sites, and the derivation of sediment effects thresholds is dominated by impacted sites with impoverished biological communities. This has likely contributed

98 Franklin et al. (2019). Deriving potential fine sediment attribute thresholds for the National Objectives Framework. NIWA Client Report 2019039HN. Prepared for the Ministry for the Environment (February 2019)

to the near order-of-magnitude difference in C/D band thresholds (ranging from 1.5 NTU in class 9 to 13.1 NTU in class 5) that is proposed to reflect the natural state variation in the effects of suspended sediment in New Zealand rivers and streams.

Figure A3.3 describing turbidity as a function of heavy pasture (Figure D-12, Stage 3 Report).



Workability of the sediment attribute and classification system

The classification which is based on nested REC classes (climate – topography – geology; or CTG) produces an unworkable ‘mosaic’ of sediment classes that vary considerably over relatively small spatial scales (i.e. 10’s of km), creating significant issues for management of sediment at sub-catchment / FMU-scale. This is demonstrated in Figure A3.4 and A3.5.

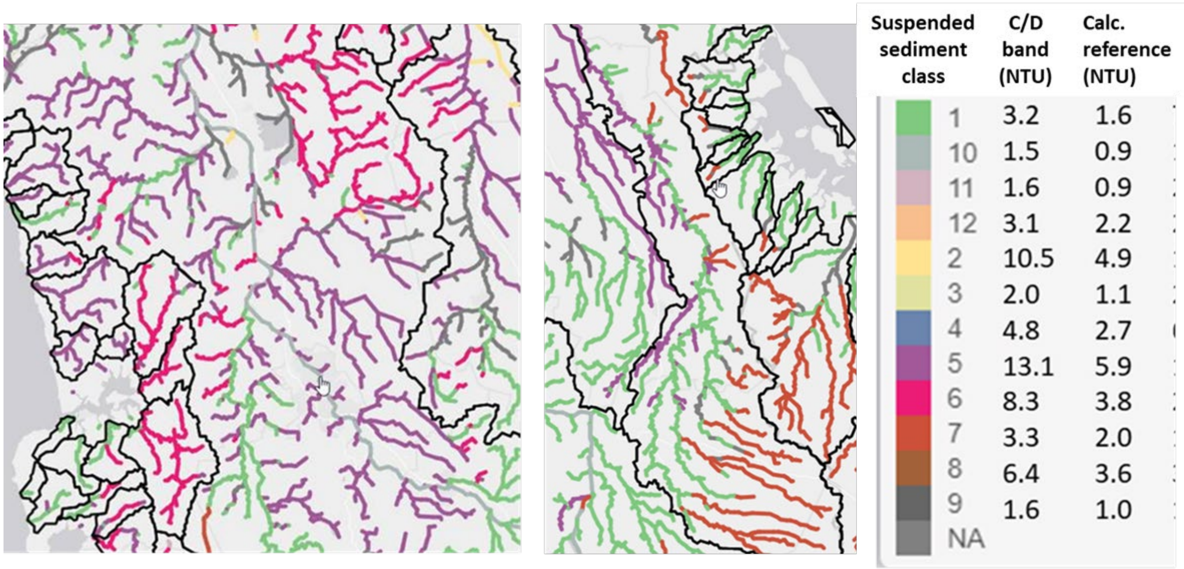


Figure A3.4 - example of the suspended sediment classification in action. Map on the left shows the lower Waikato and Waipa catchments (West coastline can be seen); map on the right shows Hauraki Plains and Kaimai ranges (east coastline, Tauranga Harbour to the right). Colour coding key shows sediment class and corresponding national bottom-line (C/D) thresholds.

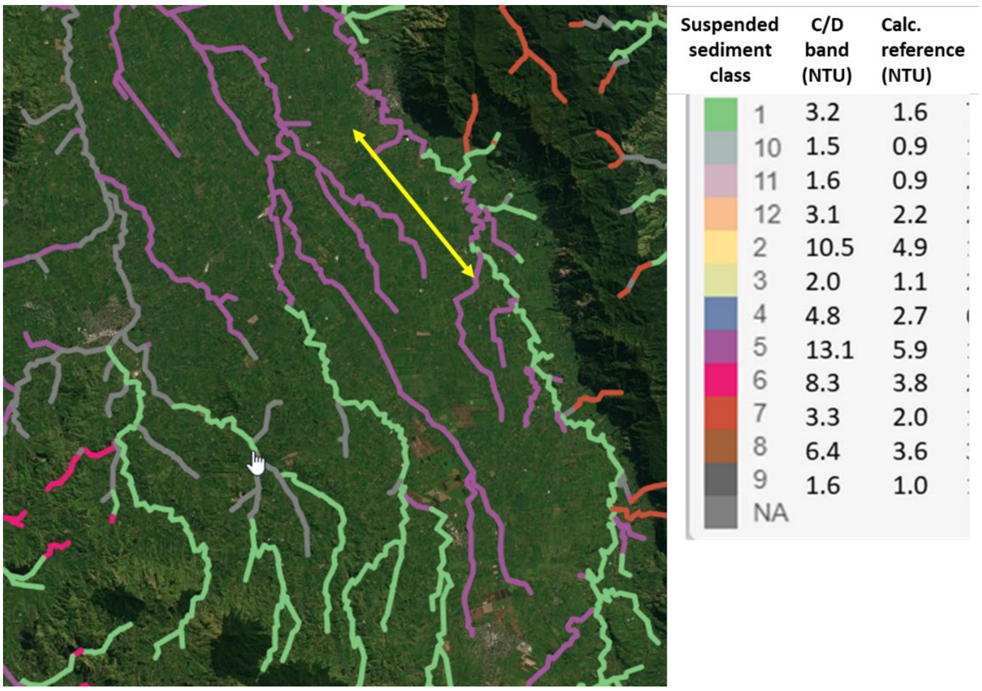


Figure A3.5 – Enlargement of the Hauraki suspended sediment class map shown as satellite image. Image highlights the frequency with which class 1 (green) flows into class 5 (purple) – the turbidity threshold for these two classes is 3.2 and 13.1 NTU, respectively. It is difficult to reconcile how these very different bottom-lines apply I seemingly similar landscapes. The yellow arrow highlights anomaly where the mainstem Waihou river goes from green to purple to green and back to purple (it goes back to green before discharging to the sea). Alternating bottom-lines of 3 and 13 NTU in the mainstream of the same river is unworkable.

2) The method used to derive the thresholds are problematic

Both suspended and deposited sediment thresholds used a newly developed methodology (not peer-reviewed) based on the deviation from reference using a bespoke 'community index'; fish and macroinvertebrate community indices were used for suspended and deposited fine sediment, respectively

National bottom-line (C/D band) thresholds are based on a 20% change (decrease) in the community index, relative to reference. The defined 'level of effect' is inconsistent with NPS-FM delineation of C/D band thresholds which attempts to define a point along an effect gradient where impacts move from 'moderate' (i.e. minimum acceptable state, or C-band) to 'major or severe' (i.e. unacceptable state, or D-band).

Importantly, the 20% deviation from reference state does not represent extirpation of species, and hence not necessarily a change in 'community composition'. For the fish community index, the term is misleading, as the index likely consists of 3-5 native fish (this data has not been provided, despite being request by the Ministry), and the bottom line merely define the turbidity (modelled) that corresponds to an average 20% reduction in the probability of catching the same subset of fish (at sites with that turbidity), relative to a model reference state value.

In this way, D-band states are arguably more consistent with an A/B band threshold, given that they effectively define a state that is 80% of reference condition.

This could explain why for several of the sediment classes the difference between modelled reference state and the national bottom-line is only 0.5 and 2 NTU respectively. This is well below effects-based thresholds in literature that indicate effects begin to occur between 5 to 10 NTU.

The result of the proposed bottom-line thresholds cause a large numbers of sites/catchment to be classified as D-band despite having median turbidity values less than current ANZECC trigger values, for example, the cumulative total of D-band sites with median turbidity values less than 3, 4 and 5 NTU is 36, 75 and 103 sites, respectively.

DairyNZ do not support the use of the untested and bespoke fish community index method as the basis for deriving thresholds for a limiting setting attribute in the NPS-FM. We note that the Stage 2 report (Section 7.3.2) did not support using this newly develop, and non-validated model as the basis for setting national bottom-lines for suspended sediment.[87]

If the Ministry continue to support thresholds based on fish community index for suspended sediment, we strongly recommend that the following steps be undertaken to at least respond to some of the method's many limitations, namely:

1. Clear articulation about what the bottom-line means – as currently proposed, the bottom-lines are defined by a modelled value that represents, on average, a 20% lower probability of capturing the <u>same group of fish</u> (between 3 and 7 fish species) at a site relative to a modelled reference site.
2. Peer review of method by technically qualified experts, including estimates of uncertainty that propagate through the many steps of the 'model-heavy' method.

3. Validation of the model output (e.g. suitability of -20% for bottom-line); and transparency about how final numbers are derived – for example, the number of fishes included in the index for each class, modelled probability of capture curves showing fit to measured presence/absence data and tabulated values of normalised probabilities for reference and impact conditions (Note: that this data is still an outstanding OIA request with the Ministry)
4. Sensitivity analysis / recalculation of thresholds with brown trout are removed (1 of 7 fish species used in the index). removal of brown trout (or at least understanding impact of its inclusion) is consistent with draft NPS-FM Fish IBI attribute that excludes salmonids.

DairyNZ emphasise the importance of having confidence in the thresholds, particularly bottom-line values which will drive limit setting. It is concerning that current bottom-line thresholds are not met in sub-catchments dominated by natural landcover (including DOC conservation estate land). This indicates that either the classification system and/or bottom-line thresholds are not robust, and highlights the uncertainty of using an untested, newly developed method.

3) Inclusion of water bodies that naturally exceed bottom-lines.

DairyNZ acknowledge the consideration of STAG to include an over-arching caveat that excludes any water body that naturally exceeds any attribute bottom-line; however, we believe it is important that the suspended sediment attribute is explicit about known river types that fall into this category. We note in the Stage 2 proposed table that the following caveats were included in the table footnote:[87]

- *highly coloured brown-water streams;*
- *glacial flour affected streams and rivers;*
- *selected lake-fed REC classes (particularly warm climate classes) where high turbidity may reflect autochthonous phytoplankton production (as opposed to inorganic sediment from the catchment).*

We also recommend the inclusion of peat drainage areas where iron pans result in the distinctive 'rust' coloured water caused by precipitated ferric oxide.

DairyNZ support the suspended attribute table being explicit about caveats to not meeting bottom-lines. We believe this will be provide clarity to communities, stakeholders and councils during plan changes and limit setting processes.

4) Further comments on deposited sediment

While acknowledging the importance of managing deposited sediment as a key driver of stream ecosystem health, we have concerns about the attribute as proposed. DairyNZ agree that deposited sediment should not be linked to requirement to set limits, but rather the requirement for an action plan. DairyNZ is relatively neutral as to whether deposited fine sediment sits better within the NPS-FM as an action plan attribute, or as a monitoring requirement - analogous to Policy CB3 for macrophytes in the 2017 amended NPS-FM. We note that this was an option being progressed by the Ministry. Our understanding is that given the uncertainty around reference state sites, and the inherent within site/reach variability, that its inclusion as a monitoring requirement would enable a more flexible and adaptable approach for deposited sediment.

DairyNZ strongly support the inclusion of deposited sediment in the NPS-FM as either an *action plan attribute*, or *monitoring requirement* (which would trigger requirement for similar action plan). Specific comments and recommendations regarding the proposed attribute include:

- Classification system – same comments apply as per suspended sediment above. The classification should reflect natural state variation in deposited sediment, and the classes require 'sense checking' to eliminate overlapping or similar classes. This is particularly important for deposited sediment which can only be determined (at best) in 5% intervals, but more realistically 10% intervals (Appendix Q, Stage 2 sediment report).[87]
- Accordingly, classes that differ by <10% deposited fine sediment are not able to be differentiated using either instream or bankside assessment methods. This effects more than half the proposed sediment classes - that is, it would be difficult to differentiate the like of Class 2, 4 and 15; and similarly 3, 7 and 9) – refer to Table 4.
- Band delineation - same comments apply as per fish community index, as this method was applied to macroinvertebrates. It is therefore important that the Ministry is satisfied that the decrease in community composition can be articulated and understood by communities (in limit setting / action plan processes). We note that band gaps for all deposited attribute classes are <10 (Table 4). As indicated above, the uncertainty in the measurement is likely to be greater than the band gap. This is problematic for reporting and meeting instream objectives

We note that the Stage 2 sediment report had a relatively simple process comprising 3 classes that corresponded to natural levels of fine sediment expected at each site – these were defined as 'low', medium' and 'high' – any site classified as 'low' had a national bottom-line value of 30% - which is consistent with the 20-30% thresholds reported elsewhere. This approach, while not perfect, is arguably a more workable, practical solution to managing for significant adverse effects of deposited fine sediment – which primarily relates to habitat degradation in hard-bottom streams (Clapcott 2011)[99].

[99] Clapcott et al. Clapcott, J.E., Young, R.G., Harding, J.S., Matthaei, C.D., Quinn, J.M. and Death, R.G. (2011) Sediment Assessment Methods: Protocols and guidelines for assessing the effects of deposited fine sediment on in-stream values. Cawthron Institute, Nelson, New Zealand.

Table 4 Proposed attribute band thresholds for deposited fine sediment cover (Table 1-1 from Stage 3 sediment report).

Attribute	Deposited fine sediment											
Attribute Unit	% fine sediment cover (percentage cover of the streambed in a run habitat determined by th											
Attribute State	SSC class[1]											
	1	2	3	4	5	6	7	8	9	10	11	12
	Site median[2]											
A	<84	<9	<42	<12	<80	<30	<41	<22	<48	<15	<76	<27
B	<90	<15	<50	<17	<86	<38	<48	<33	<54	<22	<82	<36
C	<97	<21	<60	<23	<92	<46	<56	<45	<61	<29	<89	<45
National Bottom Line[3]	≥97	≥21	≥60	≥23	≥92	≥46	≥56	≥45	≥61	≥29	≥89	≥45
D												

Turbidity	CDH					0.5	0.3	0.8	0.7	0.9	0.5	1.5	1.8	2
(NTU)	CDL					0.7	0.4	1.1	1.1	1.3	0.7	2.1	1.6	3
	CDLk					0.9	0.1	2.3		1.9	0.2	5.0		

Indicator	REC	20%ile	20%ile - CI	20%ile + CI	MDC 20%ile	Median	Median - CI	Median + CI	MDC Median	80%ile[1]	80%ile[1] - CI	80%ile[1] + CI	MDC 80%ile	Num sites for MDC
	CDM					1.4	0.4	2.8	1.0	2.9	0.8	6.2	1.6	1
	CWH					1.0	0.8	1.3	1.0	2.4	1.8	3.1	2.3	45
	CWL					1.2	0.8	1.7	1.2	2.3	1.5	3.3	2.4	21
	CWLk					0.8	0.5	1.3	1.3	1.3	0.7	2.0	2.4	5
	CWM					1.6	0.9	2.6	1.1	4.6	2.3	7.7	3.0	7
	CXH					0.7	0.4	1.1	0.8	2.1	1.2	3.2	2.5	12
	CXL					1.3	0.7	2.1	2.5	2.6	1.4	4.2	5.6	6
	CXLk					0.7	0.4	1.2	0.8	2.0	0.9	3.6	2.1	2
	CXM					1.3	0.5	2.6	1.5	3.5	1.0	7.4	4.9	3
	WDL					2.5	0.8	5.2		4.2	1.4	8.5		
	WWH					1.5	0.4	3.2	2.2	2.7	0.6	6.2	3.4	1
	WWL					2.3	1.6	3.3	1.9	5.2	3.3	7.5	4.7	9
	WWLk					2.1	0.6	4.3		3.9	1.2	8.0		
	WXH					1.9	0.6	3.8	0.9	6.9	1.9	14.9	5.8	1
	WXL					1.2	0.4	2.2		4.0	1.4	7.8		
Suspended														

Appendix 4:

Economic Impact of Regulatory Changes

This Appendix contains the technical papers that DairyNZ commissioned to assess the macroeconomic and microeconomic impacts of the Essential Freshwater policy proposals. The suite of papers comprises:

- **Paper 1***: Th**e Economywide Effects of Proposed Environmental Policies* (Sense Partners, 29 October 2019).

- **Paper 2:** *Economic Impacts of the Essential Freshwater Proposals on New Zealand Dairy Farms* (Dr Graeme Doole, 24 October 2019).

- **Paper 3:** *Regional and National Impacts of Proposed Environmental Policies on the New Zealand Dairy Sector* (Infometrics, October 2019).

The analysis builds on detailed farm modelling conducted by DairyNZ (outlined in Paper 2) which was used to inform three scenarios, plus anticipated Zero Carbon Bill effects, which were fed into Infometrics' ESSAM Computable General Equilibrium model of the New Zealand economy (See Paper 3). The resulting macroeconomic and flow-on effects to other sectors from changes to dairy sector production as a result of freshwater and emissions policies were captured and outlined in Paper 1.

DairyNZ

The economywide effects of proposed environmental policies

Final report to DairyNZ, 29 October 2019

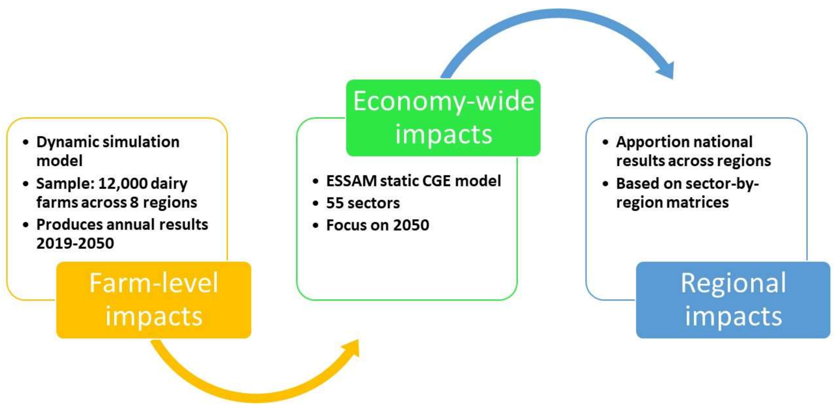
SENSE PARTNERS

DATA LOGIC ACTION

Key points

We link farm-level and economywide models to assess the economic impacts of freshwater and emissions policies

FIGURE A1: MODELLING APPROACH



SOURCE: SENSE PARTNERS

- We use highly detailed farm-level modelling conducted by DairyNZ (Doole, 2019b) to inform the scenarios fed into Infometrics' ESSAM Computable General Equilibrium (CGE) model of the New Zealand economy.
- This allows us to capture the macroeconomic and flow-on effects to other sectors from changes to dairy sector production as a result of freshwater and emissions policies. Regional economic impacts are estimated by filtering the national level outcomes through a sector-by-region matrix.

We consider three freshwater scenarios plus the Zero Carbon Bill

TABLE A1: OVERVIEW OF MODELLING SCENARIOS

Scenario	Key elements
Essential Freshwater Scenario 1	Shift existing fences on larger streams so average setback is 5m. Develop farm plan that is regularly audited and updated. Consent applications for farmers with an existing stand-off pad. Fencing of smaller streams under a farm plan. Capital expenditure according to activities under a farm plan, e.g. effluent pond sealing, culvert maintenance, laneways, races, etc.
Essential Freshwater Scenario 2	As per 1 **plus** introduction of catchment-specific nitrogen caps in a proposed collection of priority catchments; farms above 75th percentile of nitrogen loss required to reduce them to 75th percentile.
Essential Freshwater Scenario 3	As per 2 **plus** broadscale introduction of phosphorus and nitrogen leaching reductions to meet new proposed limits in monitored catchments.
Scenario 4: Essential freshwater plus Zero Carbon Bill	As per 3 **plus** 10% and 36% reduction in methane emissions by 2030 and 2050, respectively.

Stringent freshwater reforms see real GDP fall by $6 billion by 2050

- In Scenario 3, GDP is lower by 1.1%. In 2019/20 dollars, this is equivalent to a loss of $6.04 billion from a BAU real GDP of $549.32 billion.
- By way of comparison, OECD (2015) estimates the costs of climate change to be 1% to 2% of GDP by 2060 for New Zealand and Australia combined.
- In Scenario 3, total exports decline by 5.2% relative to business as usual (BAU) in 2050. In 2019/20 dollars, this is equivalent to a loss of $8.13 billion from a BAU export value of $156.31 billion.
- Real Gross National Disposable Income (RGNDI) rises marginally 0.2%. This is because falls in dairy output lead to fewer greenhouse gas emissions being generated. This in turn reduces the need to buy international emissions units, saving over $1 billion, and leads to better terms of trade.
- Dairy farm output and dairy processing output are both estimated to fall by a quarter relative to 2050 BAU. Employment in dairy farming is estimated to fall by 17% below 2050 BAU, with dairy processing employment falling 10% below BAU.

The Zero Carbon Bill further dampens economic activity

- When the Zero Carbon Bill is modelled alongside the stringent freshwater reform package from Scenario 3, exports and real GDP drop relatively sharply: by 6.5% and 1.3% below the 2050 BAU respectively.
- In 2019/20 dollars, this decrease in national export value is equivalent to a loss of $10.16 billion from a BAU export value of $156.31 billion.
- In 2019/20 dollars, this fall in the value of real GDP is equivalent to a loss of $7.14 billion from a BAU real GDP of $549.32 billion.
- Relative to the BAU, total emissions are almost 16% lower, largely driven by emissions of methane and nitrous oxide from agriculture which fall by 30% relative to BAU. This lowers the cost of purchasing international emission units, which nudges RNGDI up by 0.3%.
- Dairy farming and dairy processing production falls by around 27% below BAU in this scenario in the CGE model.[1]

However, water quality and emissions gains can still be made with less stringent reforms, at a minimal cost to the New Zealand economy

- The more moderate freshwater reform scenarios (1 and 2), in isolation, are not expected to have significant macroeconomic impacts.
- Real GDP is estimated to fall between 0.1% and 0.2% below the 2050 BAU, or $0.5 billion to $1 billion. Total exports fall around 0.7% below BAU in these scenarios.

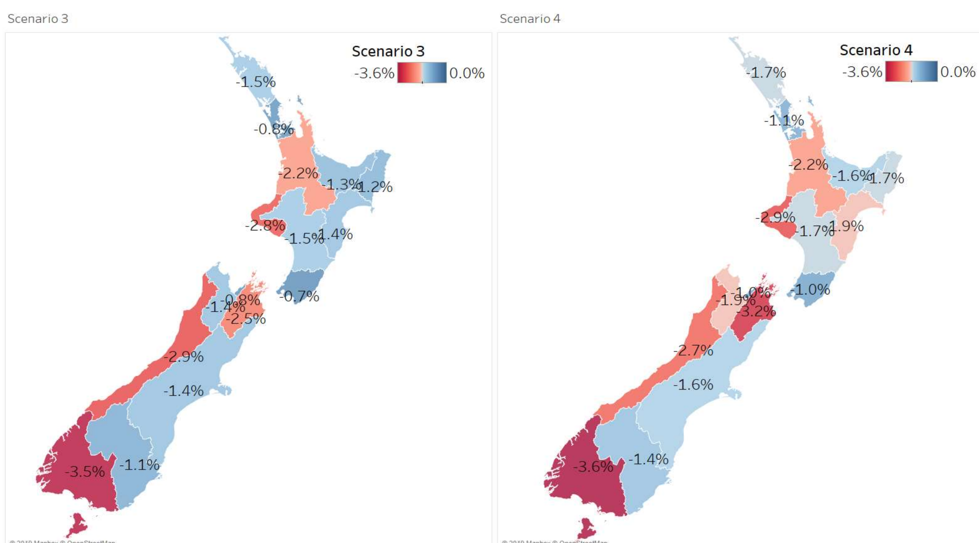
[1] The CGE modelling produces different results for falls in dairy production to the farm-level modelling. These are most pronounced in scenario 3 (24% in the CGE model compared to 31.6% in the farm-level model) and scenario 4 (28% compared to 60%). This is because the CGE model contains feedback loops (such as lower wages) that the farm-level modelling does not.

- This indicates that important steps could be taken towards improving water quality and reducing emissions without causing too much macroeconomic damage.

Regional economic impacts vary, but Southland, Taranaki, Marlborough and West Coast are likely to be most negatively affected

- Using a top-down regional apportioning matrix, the economic impacts of stringent freshwater reforms and the Zero Carbon Bill are most keenly felt in:
    - Southland (GDP falls by up to 3.6% below BAU by 2050)
    - Taranaki (GDP falls by up to 2.9%)
    - Marlborough (GDP falls by up to 3.2%)
    - West Coast (GDP falls by up to 2.9%).
- Regions with a lower dependence on dairy farming and processing, such as Wellington, Auckland and Nelson, suffer less. This is because they benefit from the downward pressure on wages, making labour cheaper across their economies.

FIGURE A2: REGIONAL ECONOMIC IMPACTS OF SCENARIOS 3 AND 4



SOURCE: SENSE PARTNERS, DRAWING ON INFOMETRICS ESTIMATES

These economic costs need to be compared against the largely unquantified potential benefits of emissions and freshwater policies

- Given New Zealand accounts for 0.17% of global greenhouse gas emissions, even significant domestic reductions are unlikely to deliver material benefits. However, if such actions can support or even catalyse wider global emissions reduction efforts, there will be benefits from limiting global temperature increases.
- These co-benefits "could include reduced congestion, health benefits, cleaner air, cleaner water, and improved biodiversity" (Infometrics 2018), and faster innovation (hence productivity growth) in response to emissions targets and prices.

- There are few quantified benefits, although "Victoria University and NIWA conservatively estimates that over 2007-2017, climate change-related floods and droughts have cost New Zealand at least $120 million from privately-insured damages from floods and $720 million for economic losses from droughts" (MFE, 2018). Some of these costs could be avoided if climate change policy reduces their incidence. The costs of replacing buildings near high water marks – estimated at up to $20 billion – could be reduced, for example (MFE, 2018).
- OECD (2015) estimates the costs of inaction on climate change could cost the New Zealand and Australian economies combined between 1% and 2% of GDP by 2060.
- The Interim Regulatory Impact Analysis of the Essential Freshwater package (MFE, 2019c, 2019d) presents very few quantified estimates of potential benefits, although they note this research is being developed further.
- Qualitatively, the potential benefits from improved water quality could include:
    - Positive impacts on farmer mental wellbeing through certainty, enhanced social license to operate
    - Improved planning could identify measures that would boost profitability while improving environmental outcomes
    - Potential gains in sustainability-conscious export markets
    - Enhanced recreational values
    - Enhanced national pride in natural environment
    - Animal health benefits
    - Reduced stock losses from drowning; reduced risks for farmers
    - Biodiversity enhancement gains
    - Reduced health risks from *E. coli* and other pathogens
    - Greater opportunities for eco-tourism
    - Cultural and inter-generational benefits.
- These are all worthy objectives, and ones which farmers support. The question then becomes what is the most efficient pathway to achieving them? Or alternatively, when does the marginal social cost of additional environmental regulations outweigh the marginal social benefit?
- We hope that the analysis presented here can contribute to a more informed debate about these costs and benefits.

1. Objectives and scope

The primary sector is facing a raft of regulatory changes…

The government is currently considering a series of regulatory changes that will have important costs and benefits for society, the economy and rural communities:

- **Essential freshwater reform** – a discussion document[2] has been released for consultation that seeks to stop further degradation of New Zealand's freshwater resources and make material improvements in water quality within five years; and reverse past damage to bring water quality back to a healthy state within a generation.
- **Addressing greenhouse emissions from agriculture** – consultation has recently been completed on the transition to pricing livestock emissions at the farm level by 2025. The government has recently announced that it will work with the agricultural sector to develop a farm-level pricing mechanism by 2025 at the latest.
- The government has also consulted on its **Climate Change Response (Zero Carbon) Amendment Bill** in recent months, with a decision expected by the end of 2019 around interim and final targets for key greenhouse gases and the use of forestry offsets for biogenic gases.
- **Capital adequacy ratios** – the Reserve Bank is exploring changes to its framework that defines the amount of capital that locally-incorporated registered banks in New Zealand are required to hold, with the aim of ensuring a sound and efficient financial system. Given the reliance of the dairy sector on bank lending, this is likely to have non-trivial implications for those who have borrowed to fund land and/or livestock purchases.

…of which there has been little formal modelling

Of these regulatory changes, only the Zero Carbon Bill has been subjected to economic modelling to demonstrate the potential impacts on the primary sector as well as the wider economy.[3] Yet all of them could have potentially material impacts on agricultural producers, and their cumulative impact – given that they are all potentially to be enacted concurrently – also needs to be considered.

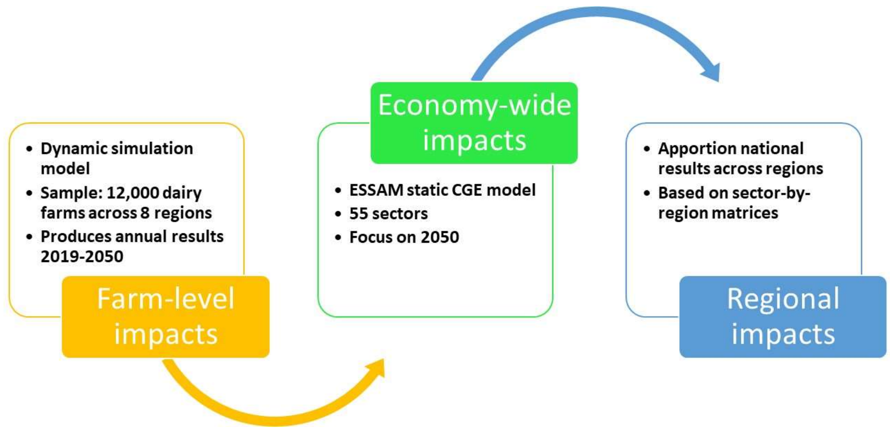
This report seeks to contribute to the public debate around weighing up the costs, benefits and distributional effects across regions and sectors of regulatory changes related to freshwater reform and the Zero Carbon Bill.

[2] Ministry for the Environment, 2019a.
[3] NZIER. 2018b.

2. Our approach

We link a detailed farm-level model with an economywide model…

FIGURE 2 OVERVIEW OF ECONOMIC IMPACT MODELLING METHODOLOGY



SOURCE: SENSE PARTNERS

Our economic modelling approach seeks to capture both microeconomic and macroeconomic impacts of regulatory changes on the New Zealand dairy sector:

- We use DairyNZ's **farm-level modelling** to assess the on-farm effects of regulatory changes. This bottom-up regional model explores farm-level impacts for 8 regions and assesses how regulatory changes will affect, *inter alia*, dairy farmers' revenue, costs and margins.[4]
- We take the outputs of the farm-level modelling to design scenarios to be fed into a **national-level economywide model** comprising 55 sectors. This Computable General Equilibrium (CGE) model allows us to evaluate the macroeconomic and wider sector impacts of the farm-level changes identified in the DairyNZ modelling.[5]
- As a last step, we use a **top-down approach to identify regional economic impacts**.

…which allows us to harness the strengths and mitigate the limitations of the two models

The farm-level model is designed to provide a highly granular microeconomic assessment of how dairy farmers respond to changes in their cost structures and incentives, but it cannot determine what these changes mean for the wider economy (GDP, exports, etc.).

In contrast, the national-level CGE model used here is well suited for estimating the macroeconomic and spillover impacts of changes in the dairy sector's performance following regulatory changes. Yet it cannot determine the size of the initial 'shocks' to the dairy sector – those have to be evaluated outside of the model and fed into it as scenarios.

[4] See Doole (2019a) for a detailed explanation of the farm-level model.
[5] See Appendix A for more technical detail on the CGE model.

We focus our attention here on the macroeconomic, sector and regional impacts of freshwater and emissions policies. A detailed analysis of the farm-level modelling can be found in Doole (2019a, 2019b).

Limitations

Any modelling exercise is subject to caveats, especially when considering such significant regulatory changes in a compressed consultation timeframe.

The farm-level modelling is subject to three key limitations (Doole, 2019a, 2019b):

1. A key variable is the forecast milk price and its variation, which is difficult to estimate in both theory and practice. We draw on historical trends and cycles to guide our estimates, which may not be reflective of future patterns.
2. Technical innovation at the farm-level is uncertain and is therefore excluded from the model. We would expect additional innovation in response to tighter environmental policy settings to partially offset the long-term impacts of these policies on profit and production.
3. The adoption of normal distributions as a basis for the econometric estimation of the dynamic equations has limited some of the variation described by the model. This approach serves to moderate some of the estimated costs on farms that are atypical relative to the rest of the population.

Computable general equilibrium (CGE) models such as the ESSAM model we use here for the economy wide modelling can only ever approximate the highly complex real economy, especially over the longer term when significant technological shifts are likely. Therefore, the results can only ever be indicative.

The interpretation of CGE results should centre on their direction (up or down) and broad magnitude (small, medium or large), rather than on the precise point estimates generated. Essentially we are modelling scenarios: such modelling "does not predict what *will* happen in the future. Rather, it is an assessment of what *could* happen in the future, given the structure of the models and input assumptions."[6]

For a detailed discussion of the limitations of CGE modelling, see NZIER (2018a, pp. 4-5) and NZIER and Infometrics (2009, pp. 3-6).

We only consider the *direct* effects of Essential Freshwater reforms on the dairy sector. We acknowledge that other sectors (sheep and beef, horticulture, etc.) will also face increased costs associated with these changes. However, we do not have detailed estimates of these sectors' likely costs at this stage.

We would expect that including these additional costs for other primary sectors would reduce the negative effects on the dairy sector. This is because other land-based sectors would also face higher production costs, which would reduce the relative negative competitiveness effects of the regulatory changes on dairy (i.e. lead to less land use change away from dairy due to relative price changes). The potential impacts on the wider economy are more difficult to assess, as they will

[6] Australian Treasury, 2008 (emphasis added).

depend both on the shift of resources within the primary sector and between the primary sector and the rest of the economy.

The regional economic analysis is not based on a bottom-up regional CGE model. Rather it takes the national level CGE modelling results and apportions them across regions using StatsNZ's IDI data. There is no movement of resources between regions. All sectors are assumed to have the same cost and productivity profile in all regions – that is, we do not take into account different regional characteristics of sectors; just their relative weight in the composition of each region.

All regulatory changes create costs and benefits. This report summarises existing material on the potential benefits from each regulatory change, against which the modelled economic costs can be compared. It does not purport to be a fully-fledged social and economic impact analysis, which was not feasible in the timeframe available.

3. Summary of modelling scenarios

We consider five CGE modelling scenarios:

- Business as Usual
- Three Essential Freshwater scenarios of increasing stringency
- A Zero Carbon Bill scenario.

The CGE modelling scenarios are based on the outputs of the farm-level modelling in Doole (2019a, 2019b), which also contain greater detail on the farm-level assumptions employed.

Business as Usual scenario

The CGE model is used to produce a Business as Usual (BAU) scenario for 2050. This is a theoretical construct of what the New Zealand economy might look like at a future point in time with existing policies to reduce greenhouse emissions in place and no change in freshwater policies. The function of the BAU scenario is purely to act as a point of comparison against which other scenarios can be compared.

Two key background assumptions for the CGE model's BAU scenario and all other scenarios are:

1. The New Zealand population is projected to be 6.135 million in 2049/50, based on StatsNZ's 50th percentile population projections.
2. The real oil price averages US$100/bbl over the period to 2049/50.

The CGE and DairyNZ BAU scenarios share the following characteristics:

- By 2050 the ETS carbon price is $150 per tonne of CO_2e, which is assumed to be in line with carbon prices in New Zealand's major trading partners.
- Free allocation for existing industries classified as CO_2 emissions-intensive and trade-exposed (EITE) is phased out at 1% pa from 2021 to 2030, 2% pa from 2031 to 2040 and 3% per annum from 2041 to 2050. Thus by 2050 free allocation is at 54.5% of the levels in 2020. This profile is in line with the government's current proposals.
- Agricultural emissions of CH_4 and N_2O enter the ETS around 2025 with 95% free allocation. At this stage nothing is known about how that might be phased out. We assume 75% free allocation remains by 2050. These assumptions are varied in Scenario 4.
- A reduction in emissions of CH_4 and N_2O per unit of agricultural output of 0.3% pa. Again, this is changed in Scenario 4.
- There are no other policies to reduce biogenic methane emissions. Explicit methane targets are not in the BAU but are also explored in Scenario 4.
- New Zealand is assumed to have a net zero emissions target by 2050 (although in practice this may apply only to long-lived gases). If this target is not achieved it is assumed that the deficit will be covered by the purchase of bona fide international units, at the world price of $150/tonne CO_2e.

- Net forestry emissions are negative (absorption): 45,000 kt in 2049/50. See Productivity Commission (2018).

Essential Freshwater Scenario 1

Scenario 1 is relatively small scale and comprises the following on-farm actions:

1. Shifting of existing fences on larger streams such that the average setback is 5m.
2. Development of a farm plan that is regularly audited and updated.
3. Consent applications for farmers with an existing stand-off pad.
4. Fencing of smaller streams under a farm plan.
5. Capital expenditure to improve the base system, according to activities under a farm plan. This could include things such as effluent pond sealing, culvert maintenance, laneways, races, etc.

Drawing on the farm-level modelling, the main input shock in the CGE model for this scenario is an increase in dairy farming's capital-output ratio of 19.4%. There is also a small reduction in labour productivity of 1.9%.

Essential Freshwater Scenario 2

This scenario comprises the Scenario 1 actions **plus** the introduction of catchment-specific nitrogen caps in a proposed collection of priority catchments around New Zealand. These caps require farms above a certain threshold for nitrogen leaching to reduce their leaching to that level.

In this analysis farms, above the 75th percentile of nitrogen loss are required to reduce their emissions to the 75th percentile level in these priority catchments.

Based on the farm-level modelling, the increase in the capital-output ratio for the CGE modelling is slightly larger than in Scenario1; 19.8%, but there are also minor changes in the composition of farm expenditure, notably relatively less on supplementary feed, fertiliser and grazing, and relatively more on repairs and maintenance. Labour productivity reduces by 3.6%.

Essential Freshwater Scenario 3

This is the most stringent freshwater reform scenario. It incorporates Scenario 2 **plus** the broadscale introduction of phosphorus and nitrogen leaching reductions to meet new proposed limits for Dissolved Phosphorus and Dissolved Inorganic Nitrogen in monitored catchments.

For the CGE modelling the main input shock is an increase in the capital-output ratio of 197%, accompanied by larger changes in the composition of farm expenditure than those in Scenario 2, and labour productivity which is 7.8% lower relative to BAU.

Scenario 4: Essential Freshwater plus Zero Carbon Bill

In Scenario 4 we add legislated methane emissions to the water quality policies. We model 10% and 36% emissions reductions by 2030 and 2050, respectively. The long-term goal is a midpoint between the lower and upper bounds provisionally set in the Zero Carbon Bill.

Commensurate with the methane reduction targets proposed under the Zero Carbon Bill, the farm-level modelling estimates that on-farm measures reduce methane emissions per unit of dairy output by 27%. Dairy herd size is estimated to fall by 49% and output by 60%.

As with Scenarios 1-3, the most important shocks to the CGE model are again an increase in capital intensity (246%) and a decrease in labour productivity (21%), plus changes in the composition of expenditure. Most notable are a 98% decline in spending on nitrogen fertiliser and a 94% decline in supplement expenditure.

The amount of free allocation for biogenic CH_4 and N_2O emissions is lowered from 75% in the BAU to 65% in this scenario.

4. CGE modelling results

4.1. Economywide impacts

The main macroeconomic results are summarised in Table 1, along with the impacts on the dairy farming and processing sectors.[7]

TABLE 1: SUMMARY OF KEY RESULTS

Percentage change relative to 2050 BAU

	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Macroeconomy				
Private consumption	0.1%	0.0%	0.1%	0.3%
Exports	-0.7%	-0.7%	-5.2%	-6.5%
Imports	-0.1%	-0.1%	-0.7%	-0.7%
GDP	-0.1%	-0.2%	-1.1%	-1.3%
RGNDI[8]	0.1%	0.0%	0.2%	0.3%
Real wage rate	-0.2%	-0.3%	-2.2%	-2.7%
Industry Gross Output	-0.2%	-0.3%	-2.0%	-2.6%
Dairy Farming				
Output	-3.1%	-3.2%	-24.0%	-27.7%
Employment	-1.2%	0.4%	-17.2%	-10.4%
Dairy Processing				
Output	-3.0%	-3.1%	-23.5%	-27.3%
Employment	-1.2%	-1.2%	-10.2%	-12.3%
Emissions[9]				
Gross emissions	76.2	76.1	70.4	65.0
Agricultural CH_4 & N_2O	37.0	37.0	31.6	26.3

SOURCE: INFOMETRICS ESSAM MODEL

Scenarios 1 and 2 do not have large economywide impacts

The more moderate freshwater reform scenarios (1 and 2), in isolation, are not expected to have significant macroeconomic impacts. Real GDP is estimated to fall between 0.1% and 0.2% below the 2050 BAU, with total exports falling around 0.7% below BAU.

This implies that the macroeconomic effects of the changes in the composition of on-farm expenditure due to this part of the Essential Freshwater policy are minimal. The dominant effect in

[7] The strength of the CGE model is in analysing differences between scenarios. Thus we omit discussion of the BAU here other than to say that the growth in GDP to 2050 averages 2.1% pa from 2018.

[8] Real Gross National Disposable Income is GDP adjusted for net offshore factor payments (such as interest and dividend flows) and for changes in the terms of trade. A higher level of RGNDI is generally consistent with a better standard of living.

[9] In the BAU scenario, gross emissions are 77.0 Mt CO_2e and agricultural emissions are 37.8 Mt CO_2e.

both scenarios is the change in dairy farming capital intensity – the additional investment that is required to meet the new water quality standards.

The dairy farming and processing sectors are more negatively affected than the wider economy, as would be expected. For Scenarios 1 and 2, output is estimated to fall by 3.0% to 3.2% below BAU in both farming[10] and processing.

Employment falls by around 1.2% in Scenario 1, and lifts a touch in Scenario 2. Labour expenditure per unit of output is similar across both scenarios, but total labour expenditure drops by around 3% in Scenario 2 in the farm-level model due to lower production as nitrogen limits are introduced. This effect is magnified in the CGE modelling as cheaper labour and land help dairy farmers mitigate some of the production drops predicted in the farm-level assessment.

Real Gross National Disposable Income (RGNDI) barely moves in these more moderate scenarios. This result reflects the balancing out of two effects. While GDP falls (reducing RGNDI), New Zealand buys fewer international emissions units due to reduced dairy production leading to a drop in greenhouse gas emissions (lifting RGNDI). RGNDI is also supported by an increase in the terms of trade as dairy exports move up the demand curve. That is, the dairy commodities and/or markets that earn least are the first to be abandoned when supply is lower.

More stringent freshwater reforms have a material economic impact

In Scenario 3, the macroeconomic results are directionally similar to, but more pronounced than, those in Scenarios 1 and 2. Exports decline by 5.2% relative to BAU and GDP is lower by 1.1%.

Private consumption and RGNDI rise marginally by 0.1% and 0.2% respectively, again thanks to the reduction in emissions (saving over $1 billion in the cost of purchasing international emission units) and better terms of trade.

For this scenario the capital intensity of dairy farming was raised by almost 200%, based on the additional capital expenditure required to meet tougher nitrogen and phosphorus limits in the farm-level modelling. The CGE model produces a dairy farming production decline of 24% below BAU, compared to 31.6% in the farm-level modelling.

From Scenario 2 it is clear that changes in on-farm expenditure help to mitigate the fall in output. In this more stringent freshwater reform simulated in Scenario 3, a stronger effect comes from the fall in exports which reduces the costs of factors of production (land and labour). Economywide real wage rates for example fall by 2.2% relative to BAU.

By assumption, rates of return on capital are fixed at the BAU levels, but part of that adjustment includes a reduction in land prices. This means that although negative profitability forces some dairy farmers into insolvency (as analysed specifically in the farm-level modelling) the associated land is still inherently profitable as a dairy farm provided it can be purchased at a lower price. Only about 5% of dairy land in the BAU is *not* used in dairy farming in Scenario 3, signifying the low relative profitability of alternative land uses in many of these areas.

---

[10] In the farm-level analysis (Doole, 2019b) the projected fall in production relative to BAU is 1% in Scenario 1. In the CGE model, however, the implied reduction in the rate of return to capital (profitability) is too large in the long run to sustain a fall in production of only 1% – the fall increases to 3.1%. In Scenario 2 this increases marginally to 3.2% in the CGE modelling, compared to a larger fall of 4.7% in the farm-level analysis. There would appear to be some ameliorative effect from changing the mix of on-farm expenditure.

These changes provide some offset to the decline in the competitiveness of dairy farming, preventing the substantial fall in production estimated by farm-level modelling.

Stringent freshwater reforms plus the implementation of the Zero Carbon Bill have more significant economic impacts still

When the effects of the Zero Carbon Bill are added to a stringent freshwater reform package, the results for Scenario 4 see exports and real GDP drop relatively sharply (by 6.5% and 1.3% below BAU respectively).

Relative to the BAU, total emissions are almost 16% lower, largely driven by emissions of methane and nitrous oxide from agriculture which together fall by 30% relative to BAU. The benefit of much lower emissions and hence lower cost of international emission units, flows straight through to higher private consumption, which is up by 0.3% on BAU.

Again, the CGE model has a smaller change in dairy farm output than suggested by the farm-level modelling: -28% compared to -60%. The former is still a significant reduction, but the difference from the farm-level modelling result is much larger than in Scenario 3.

Lower factor prices are again at play, but the main reason for the larger difference is that although Scenario 3 already includes a carbon price of $150/tonne CO_2e (albeit with 75% free allocation instead of the 65% in Scenario 4), there is no explicit target for methane reductions. Methane emissions do decline in Scenario 3, but that is a consequence of the freshwater reform policies, not the carbon price which is also in the BAU.

In contrast, in Scenario 4 the methane reduction target must be met. In the farm-level modelling this outcome has a high cost and there are many insolvencies. Again the CGE model suggests that much of the land can remain in dairy farming as it can be purchased by other farmers at lower cost or, more realistically if policies are announced with sufficient warning, such land sees less of an escalation in value by 2050 under Scenario 4 than under the BAU.

4.2. Sector and regional impacts

Table 2 overleaf shows how broad sector groups fare under Scenario 3 and 4 in terms of gross output.

Gross output differs from GDP in that it is simply the value of final production, whereas GDP (or value-added) subtracts the cost of intermediate inputs.

Sectors that gain (or lose less) when fewer resources are used in dairy farming include 'Other services' (such as education and medical services) and Construction.

Note that this is not a case of farmers becoming builders, or tractors being turned into equipment for medical research. Rather, it means that over the period to 2050 fewer people become farmers than under a scenario where there are no (or less stringent) freshwater or emissions policies. Similarly, more investment is directed into the education and medical sectors as opposed to fences and irrigation ponds.

The 28% decline in dairy output relative to 2050 BAU in Scenario 4 means that the industry grows at about 1% per year less under the proposed policies than it otherwise would.

TABLE 2: SUMMARY OF SECTOR RESULTS

Percentage change in gross output relative to 2050 BAU

	Scenario 3	Scenario 4
Dairy Farming	-24.0%	-27.7%
Meat Processing	-3.9%	-5.3%
Dairy processing	-23.5%	-27.3%
Fishing, Forestry, Mining	-0.3%	-0.7%
All Food Processing	-13.0%	-15.3%
Other Manufacturing	-1.1%	-2.0%
Electricity, Gas, Water	-1.0%	-1.2%
Construction	0.2%	0.4%
Trade & Transport	-1.3%	-1.6%
Other Services	-0.5%	-0.7%
Total economy	**-2.0%**	**-2.6%**

SOURCE: INFOMETRICS ESSAM MODEL

Table 3 presents estimated changes in GDP at the regional level for those two scenarios. This top-down split uses an industry-by-region matrix estimated from StatsNZ's IDI data for 2018.

TABLE 3: SUMMARY OF REGIONAL RESULTS

Percentage change in regional GDP relative to 2050 BAU

	Scenario 3	Scenario 4
Auckland	-0.8%	-1.1%
Bay of Plenty	-1.3%	-1.6%
Canterbury	-1.4%	-1.6%
Gisborne	-1.2%	-1.7%
Hawke's Bay	-1.4%	-1.9%
Manawatu-Wanganui	-1.5%	-1.7%
Marlborough	-2.5%	-3.2%
Nelson	-0.8%	-1.0%
Northland	-1.5%	-1.7%
Otago	-1.1%	-1.4%
Southland	-3.5%	-3.6%
Taranaki	-2.8%	-2.9%
Tasman	-1.4%	-1.9%
Waikato	-2.2%	-2.2%
Wellington	-0.7%	-1.0%
West Coast	-2.9%	-2.7%
New Zealand[11]	**-1.2%**	**-1.5%**

SOURCE: INFOMETRICS CALCULATIONS

[11] At the regional level GDP is valued at factor prices whereas nationally it is valued at market prices, which include some indirect taxes, so the total change across all regions is not exactly the same as the national change shown in Table 2.

In the farm-level modelling the regions that are most negatively affected are Taranaki and the combined Marlborough & Canterbury region. The CGE-based results in Table 3 show broadly similar results. Taranaki and Marlborough are amongst the worst-affected regions, but in Scenario 3 Southland and West Coast experience the largest falls in regional GDP. In Scenario 4 Southland and Marlborough are worst affected.

The regions that fare most poorly are those that do not have industries that become more competitive with the decline in dairying. Conversely regions such as Auckland and Wellington with little dairy farming are relative winners.

Although this top-down approach helps to assess the resilience of regions to freshwater and emissions polices, the CGE model lacks information on which regions have farms that are most exposed to such policies.

That is, the results suggest that Northland is more resilient than Waikato to cost-inducing regulatory changes in the dairy industry, but they do not take into account, for example, whether dairy farms in Northland produce more or fewer kilograms of nitrogen or greenhouse gas emissions per kilogram of milksolids than dairy farms in Taranaki – and thus which regions incur the sharpest initial shock.

The regional results here also do not consider where farmers are most at risk of insolvency, nor the extent to which land might remain in dairying.

5. Benefits of regulatory changes

5.1. Essential Freshwater

The table below summarises the key proposals from the Essential Freshwater discussion document relevant to the dairy sector. It also notes the expected benefits of each measure, drawing on the Ministry for the Environment's Interim Regulatory Impact Analysis for Consultation.[12]

The table shows that most potential benefits from freshwater reform have not yet been quantified, and as MFE (2019c, p.4) notes:

> *It is inherently difficult to accurately quantify environmental costs and benefits (and arguably it is not always necessary when the intrinsic value of the environment is acknowledged). It is often easier to quantify the economic cost of a policy intervention to an individual, yet harder to quantify the environmental benefit in the same terms.*

Many of the potential benefits are avoided costs associated with continuing the status quo regulatory settings. They are inherently challenging to monetise, particularly because there are many types of benefits and they are difficult to evaluate as a group. It is clear from the interim RIA that more work is to be done to quantify at least some of the benefits before final decisions are made.

In practice, it is common for community and/or policy makers to determine water-quality targets that are consistent with their goals for freshwater management (Doole and Connolly, 2017). This can involve, for example, limits for *E. coli* and suspended sediment consistent with societal aspirations for contact recreation.

Economists then can analyse the least-cost ways of reaching these targets (Doole, 2015a; Daigneault et al., 2017). This approach is pragmatic, especially given the issues of uncertainty, cost, partial view, and variation across spatial and temporal scales associated with survey-based studies that seek to monetise the benefits associated with environmental management (Rogers et al., 2013).

We note that while the proposals are presented separately in the RIA, they are designed to be a package, and will have overlapping costs and benefits. For example, we did not include specific sediment thresholds in the farm-level and CGE modelling; however, we would expect sediment levels to improve as a result of the initiatives that we did model, particularly the broadscale implementation of farm environment plans that target hotspot losses. MFE (2019d) expects monetised benefits of $5.4 billion – $21. 4 billion over 50 years from reduced erosion, more ETS credits, improved recreational values, etc.

[12] Ministry for the Environment, 2019c and 2019d.

TABLE 1 SUMMARY OF BENEFITS FROM PROPOSED CHANGES IN ESSENTIAL FRESHWATER

Proposed change description	**Key expected benefits**	**Quantified estimates (MFE, 2019d)**
Stock exclusion: shifting existing fences on larger streams such that the average setback is 5m.	• Improved water quality on farm for stock drinking • Reduced stock losses from drowning; reduced risks for farmers • Potential market access gains • Improved aesthetic and financial values of farms • Positive impacts on farmer mental wellbeing through certainty, enhanced social licence to operate • Biodiversity enhancement gains • Improved ecological and recreational values; reduced *E. coli* health risks • Greater opportunities for eco-tourism • Cultural and inter-generational benefits • Increased opportunities for food gathering	At least $983 million benefits from flat and rolling land. Ruamahanga modelling indicates that relative to the no-stock-exclusion scenario the option would deliver: • 2.2% reduction in nitrogen • 4.2% reduction in phosphorus • 7.3% reduction in sediment. Contributes to improved health outcomes from less exposure to *E. coli* of $10-$80 million annually.
Development of a farm plan that is regularly audited and updated.	• Help farmers become more resilient and better placed to tackle other environmental challenges • Assists building social licence to operate • Could identify measures that would boost profitability while improving environmental outcomes • Potential market access gains • Good audits can make it easier to borrow from banks • Better water quality and recreational values • Enhanced national pride in natural environment • Employment opportunities for agricultural support services	None yet presented.
Stock holding areas and feedlots: National Environmental Standard with consent requirements	• Clarity and certainty for farmers around containment risks • Improvement in farm productivity and discharge rates • Reduces inconsistencies between regions and plans	None presented; notes "Costs to meet minimum requirements may not translate

and permitted activity standards for land use, supported by the adoption of Farm Environment Plans.	• Contribution to halting water quality degradation; improved ecological, cultural and recreational values • Improved animal and human health outcomes	into economic benefits in the short term for farmers" (p.323).
Standards for intensive winter grazing on forage crops	• Farm production and animal health benefits • Assists building social licence to operate • Lower costs for Councils in plan preparation • Public confidence that high-profile activities affecting water quality are being addressed	None yet presented.
Reducing leaching on farms above the 75th percentile for N leaching to the 75th percentile in selected catchments.	• Some farms can reduce nitrogen and improve profitability; savings in fertiliser costs • Reduced costs to Councils as nitrogen discharges start falling • Up to 7% drop in leaching under most stringent cap proposal • Improved ecological health of rivers • Recreational benefits to river users • Accelerated water quality outcomes (1-5 years) relative to implementation solely through Regional Plans	None presented; notes "Medium [benefits] in high-N impacted catchments" (MFE, 2019d, p.308). MFE (2019c, p.39) reports "Reducing discharges to the 75th percentile was modelled to change annual profit by +$106 to -$541 per hectare on 10 case-study dairy farms in the Waikato, with an average of -$143".
Nutrient attributes for managing ecosystem health, specified in the NPS-FM	• Improved social cohesion of remaining local communities • Better mental health outcomes for farmers • Employment opportunities for agricultural support services • Reduced human health risks • Improved amenity values • Cultural and inter-generational benefits	None yet presented.

SOURCE: MINISTRY FOR THE ENVIRONMENT, 2019D

5.2. Benefits of Zero Carbon Bill

Given New Zealand accounts for 0.17% of global greenhouse gas emissions, even significant domestic reductions are – by themselves – unlikely to deliver material benefits to New Zealand. However, if such actions can support or even catalyse wider global emissions reduction efforts, there will be benefits from limiting global temperature increases.

There are few quantified benefits, although "Victoria University and NIWA conservatively estimates that over 2007-2017, climate change-related floods and droughts have cost New Zealand at least $120 million from privately-insured damages from floods and $720 million for economic losses from droughts" (MFE, 2018, p.53). Some of these costs could be avoided if climate change pressures lessen. The costs of replacing buildings near high water marks – estimated at up to $20 billion – could be reduced, for example (MFE, 2018).

OECD (2015) estimates the costs of inaction on climate change could cost the New Zealand and Australian economies combined between 1% and 2% of GDP by 2060.

Identified co-benefits of New Zealand transitioning to a lower-emissions economy "could include reduced congestion, health benefits, cleaner air, cleaner water, and improved biodiversity" (Infometrics 2018), and faster innovation (hence productivity growth) in response to emissions targets and prices.

6. Conclusions

This report has provided new empirical evidence on the scale and distribution of economic impacts across sectors and regions of proposed freshwater and emissions policies as they pertain to the dairy farming sector.

We find that stringent freshwater reforms that involve phosphorus and nitrogen leaching reductions to meet new proposed limits for Dissolved Phosphorus and Dissolved Inorganic Nitrogen in monitored catchments have significant macroeconomic impacts.

Total exports decline by 5.2% relative to business as usual (BAU) in 2050 and real GDP is lower by 1.1%, or $6 billion in 2019/20 dollars. Dairy farming production falls by 24% below BAU.

When the impacts of the Zero Carbon Bill, and its assumed reductions in methane are also considered alongside stringent freshwater reforms, GDP falls by 1.3% below BAU by 2050, or $7.1 billion in 2019/20 dollars. Dairy farming production falls by 28% below BAU.

These are not trivial costs. They need to be carefully weighed up against the – as yet – largely unquantified benefits that would result from improved water quality and lower greenhouse gas emissions.

Appendix A Overview of CGE model

ESSAM model

The ESSAM (Energy Substitution, Social Accounting Matrix) model is a general equilibrium model of the New Zealand economy. It considers the main inter-dependencies in the economy, such as flows of goods from one sector to another, plus the passing on of higher costs in one sector into prices and thence the costs of other sectors.

The ESSAM model has previously been used to analyse the economy-wide and sector specific effects of a wide range of issues, including:

- Analysis of the New Zealand Emissions Trading Scheme and other options to reduce greenhouse gas emissions
- Changes in import tariffs
- Public investment in new technology
- Funding regimes for roading and wider economic benefits
- Release of genetically modified organisms.

Features of ESSAM model

Some of the model's features are:

- 55 sector groups, as detailed in the table below.
- Substitution between inputs into production - labour, capital, materials, energy.
- Four energy types: coal, oil, gas and electricity, between which substitution is also allowed.
- Substitution between goods and services used by households.
- Social accounting matrix (SAM) for tracking financial flows between households, government, business and the rest of the world.

The model's output is extremely comprehensive, covering the standard collection of macroeconomic and sector variables:

- GDP, private consumption, exports and imports, employment, etc.
- Demand for goods and services by sector, government, households and rest of the world.
- Sector data on output, employment, exports etc.
- Import-domestic shares.
- Fiscal effects.

Model closure

The following model closure rules are adopted for the alternative scenarios, consistent with generally accepted modelling practice:

1. The current account balance is fixed as a percentage of GDP. This means for example that if New Zealand needs to purchase international emissions units to meet an emissions responsibility target, that liability cannot be met simply by borrowing more from offshore with indefinitely deferred repayment.
2. The post-tax rate of return on investment is unchanged between scenarios, so for example if agricultural profitability is adversely impacted by clean water policies, profitability must eventually be restored. This acknowledges that New Zealand is part of the international capital market and ensures consistency with the preceding closure rule.
3. Any change in the demand for labour is reflected in changes in wage rates, not changes in employment. This prevents the long run level of total employment being driven more by environmental policy than by the forces of labour supply and demand, which is unlikely.
4. The fiscal balance is fixed across scenarios. This means for example that if the government needs to purchase overseas emission units it must ensure that it has matching income. If it earns insufficient income from the sale of domestic emission units (because of free allocation for example) it would have to adjust tax rates.

   We assume that net household effective income tax rates are the default equilibrating mechanism, although changing government expenditure or other tax rates are alternative options that could be used.

Model structure

Production functions

These equations determine how much output can be produced with given amounts of inputs.

For most sectors a two-level standard translog specification is used which distinguishes four factors of production – capital, labour, and materials and energy, with energy split into coal, oil, natural gas and electricity.

Intermediate demand

A composite commodity is defined which is made up of imperfectly substitutable domestic and imported components - where relevant. The share of each of these components is determined by the elasticity of substitution between them and by relative prices.

Price determination

The price of sector output is determined by the cost of factor inputs (labour and capital), domestic and imported intermediate inputs, and tax payments (including tariffs).

World prices are not affected by New Zealand purchases or sales abroad.

Consumption expenditure

This is divided into Government Consumption and Private Consumption. For the latter eight household commodity categories are identified, and spending on these is modelled using price and income elasticities in an AIDS framework. An sector by commodity conversion matrix translates the demand for commodities into sector output requirements and also allows import-domestic substitution.

Government Consumption is usually either a fixed proportion of GDP or is set exogenously. Where the budget balance is exogenous, either tax rates or transfer payments are assumed to be endogenous.

Stocks

The sector composition of stock change is set at the base year mix, although variation is permitted in the import-domestic composition. Total stock change is exogenously set as a proportion of GDP, domestic absorption or some similar macroeconomic aggregate.

Investment

Sector investment is related to the rate of capital accumulation over the model's projection period as revealed by demand for capital in the horizon year. Allowance is made for depreciation in a putty-clay model so that capital cannot be reallocated from one sector to another faster than the rate of depreciation in the source sector.

Rental rates or the service price of capital (analogous to wage rates for labour) also affect capital formation. Investment by sector of demand is converted into investment by sector of supply using a capital input- output table. Again, import-domestic substitution is possible between sources of supply.

Exports

These are determined from overseas export demand functions in relation to world prices and domestic prices inclusive of possible export subsidies, adjusted by the exchange rate. It is also possible to set export quantities exogenously.

Supply-demand identities

Supply-demand balances are required to clear all product markets. Domestic output must equate to the demand stemming from consumption, investment, stocks, exports and intermediate requirements.

Balance of Payments

Receipts from exports plus net capital inflows (or borrowing) must be equal to payments for imports; each item being measured in domestic currency net of subsidies or tariffs.

Factor market balance

In cases where total employment of a factor is exogenous, factor price relativities (for wages and rental rates) are usually fixed so that all factor prices adjust equi-proportionally to achieve the set target.

Income-expenditure identity

Total expenditure on domestically consumed final demand must be equal to the income generated by labour, capital, taxation, tariffs, and net capital inflows. Similarly, income and expenditure flows must balance between the five sectors identified in the model – business, household, government, foreign and capital.

Sector classification

The 55 sectors identified in the standard ESSAM model are defined on the following page. Sector definitions are according to Australian and New Zealand Standard Industrial Classification (ANZSIC06).

Input-output table

The model is based on Statistics New Zealand's latest input-output table which relates to 2012/13.

Model Sectors

1	HFRG	Horticulture and fruit growing
2	SBLC	Sheep, beef, livestock and cropping
3	DAIF	Dairy and cattle farming
4	OTHF	Other farming
5	SAHF	Services to agriculture, hunting and trapping
6	FOLO	Forestry and logging
7	FISH	Fishing
8	COAL	Coal mining
9	OIGA	Oil and gas extraction, production & distribution
10	OMIN	Other Mining and quarrying
11	MEAT	Meat manufacturing
12	DAIR	Dairy manufacturing
13	OFOD	Other food manufacturing
14	BEVT	Beverage, malt and tobacco manufacturing
15	TCFL	Textiles and apparel manufacturing
16	WOOD	Wood product manufacturing
17	PAPR	Paper and paper product manufacturing
18	PRNT	Printing, publishing and recorded media
19	PETR	Petroleum refining, product manufacturing
20	CHEM	Other industrial chemical manufacturing
21	FERT	Fertiliser
22	RBPL	Rubber, plastic and other chemical product manufacturing
23	NMMP	Non-metallic mineral product manufacturing
24	BASM	Basic metal manufacturing
25	FABM	Structural, sheet and fabricated metal product manufacturing
26	MAEQ	Machinery and other equipment manufacturing
27	OMFG	Furniture and other manufacturing
28	EGEN	Electricity generation
29	EDIS	Electricity transmission and distribution
30	WATS	Water supply
31	WAST	Sewerage, drainage and waste disposal services
32	CONS	Construction
33	TRDE	Wholesale and retail trade
34	ACCR	Accommodation, restaurants and bars
35	ROAD	Road transport
36	RAIL	Rail transport
37	WATR	Water transport
38	AIRS	Air Transport
39	TRNS	Transport services
40	PUBI	Publication and broadcasting
41	COMM	Communication services
42	FIIN	Finance and insurance
43	HIRE	Hiring and rental services
44	REES	Real estate services
45	OWND	Ownership of owner-occupied dwellings
46	SPBS	Scientific research and computer services
47	OBUS	Other business services
48	GOVC	Central government administration and defence
49	GOVL	Local government administration
50	SCHL	Pre-school, primary and secondary education
51	OEDU	Other education
52	MEDC	Medical and care services
53	CULT	Cultural and recreational services
54	REPM	Repairs and maintenance
55	PERS	Personal services

Appendix B References

Australian Treasury. (2008). *Australia's low pollution future: the economics of climate change mitigation*. Online at http://www.treasury.gov.au/lowpollutionfuture/report/default.asp

Daigneault, A.J., Dymond, J., and Basher, L. (2017a). *Kaipara Harbour sediment mitigation study: catchment economic modelling*, Landcare Research Contract Report LC2905.

DairyNZ (2019). *DairyNZ economic farm survey 2018/19*, DairyNZ, Hamilton.

Doole, G.J. (2015a). A flexible framework for environmental policy assessment at the catchment level. *Computers and Electronics in Agriculture* 114, 221–230.

Doole, G.J. (2015b). Efficient mitigation of nitrogen leaching in pasture-based dairy systems, *Nutrient Cycling in Agroecosystems* 101, 193-209.

Doole, G.J., and Connolly, J. (2017). *An accessible framework for using Benefit-Cost Analysis in environmental decision-making*, Ministry for the Environment, Wellington.

Doole, G.J. (2019a). *Economic impacts of the Zero Carbon Bill on New Zealand dairy farms*, DairyNZ, Hamilton.

Doole G.J (2019b). *Economic impacts of the Essential Freshwater proposals on New Zealand dairy farms.* DairyNZ, Hamilton.

Infometrics. (2018). *Zero Carbon Bill Economic Analysis: A synthesis of economic impacts*. Produced to support the Our Climate, Your Say discussion document.

Livestock Improvement Corporation (LIC)/DairyNZ (2018). *New Zealand dairy statistics 2017/2018*, LIC/DairyNZ, Hamilton.

Ministry for the Environment (MFE) (2018). *Zero Carbon Bill Regulatory Impact Statement*. MFE, Wellington.

Ministry for the Environment and Ministry for Primary Industries (MFE/MPI) (2018). *Essential Freshwater: healthy water, fairly allocated*, MFE/MPI, Wellington.

Ministry for the Environment (MFE) (2019a). *Action for healthy waterways – A discussion document on national direction for our essential freshwater*, MFE, Wellington.

Ministry for the Environment (MFE) (2019b). *Action on agricultural emissions: A discussion document on proposals to address greenhouse gas emissions from agriculture*, MFE, Wellington.

Ministry for the Environment (MFE) (2019c). *Interim regulatory impact analysis for consultation: Essential Freshwater, Part I* MFE, Wellington.

Ministry for the Environment (MFE) (2019d). *Interim regulatory impact analysis for consultation: Essential Freshwater*, *Part II* MFE, Wellington.

Ministry for Primary Industries (MPI) (2019). *Situation and outlook for Primary Industries: September 2019*, MPI, Wellington.

New Zealand Institute of Economic Research (NZIER) (2018a). *Economic impact analysis of 2050 emissions targets: A dynamic Computable General Equilibrium analysis.* Report to Ministry for the Environment, NZIER, Wellington.

New Zealand Institute of Economic Research (NZIER) (2018b). *Economic impact of meeting 2050 emissions targets: Stage 2 modelling'.* Report to Ministry for the Environment, NZIER, Wellington.

New Zealand Institute of Economic Research (NZIER) (2018c). *An analysis of the flow-on benefits of dairy's revenue generation*, NZIER, Wellington.

NZIER and Infometrics (2009). *Economic modelling of New Zealand climate change policy.* Report to Ministry for the Environment, May 2009.

New Zealand Productivity Commission (2018). *Low-emissions economy: Final report.* Available from www.productivity.govt.nz/low-emissions.

OECD (2015). *The Economic Consequences of Climate Change.* OECD, Paris.

Pickering, A. (2018). *Methodology for calculation of New Zealand's agricultural greenhouse gas emissions*, Ministry for Primary Industries Technical Paper No: 2018/69, Wellington.

Productivity Commission (2019). *New Zealand, technology, and productivity*, Productivity Commission, Wellington.

Rogers, A.A., Kragt, M.E., Gibson, F.L., Burton, M.P., Petersen, E.H. and Pannell, D.J. (2013). Non-market valuation: Usage and impacts in environmental policy and management in Australia, *Australian Journal of Agricultural and Resource Economics* 57, 1-15.

SENSE PARTNERS

DATA LOGIC ACTION

Economic impacts of the *Essential Freshwater* proposals on New Zealand dairy farms

Dr Graeme Doole

Date: 24 October 2019

Disclaimer

The information contained within this report should not be taken to represent the views of DairyNZ. While all reasonable endeavours have been made to ensure the accuracy of the investigations and the information contained in the report, DairyNZ expressly disclaims any and all liabilities contingent or otherwise to any party other than DairyNZ Incorporated or DairyNZ Limited that may arise from the use of the information.

Acknowledgements

The authors of this report would like to acknowledge the important contributions of: Darran Austin, John Ballingal, Kay Brown, David Burger, Craig Depree, Ross Kingwell, Jennifer Leslie, David McCall, Richard McDowell, Paul Melville, Mark Neal, Ina Pinxterhuis, Alvaro Romera, David Silva-Villacorta, Adolf Stroombergen, Christophe Thiange, Aslan Wright-Stow, and Justine Young.

Executive Summary

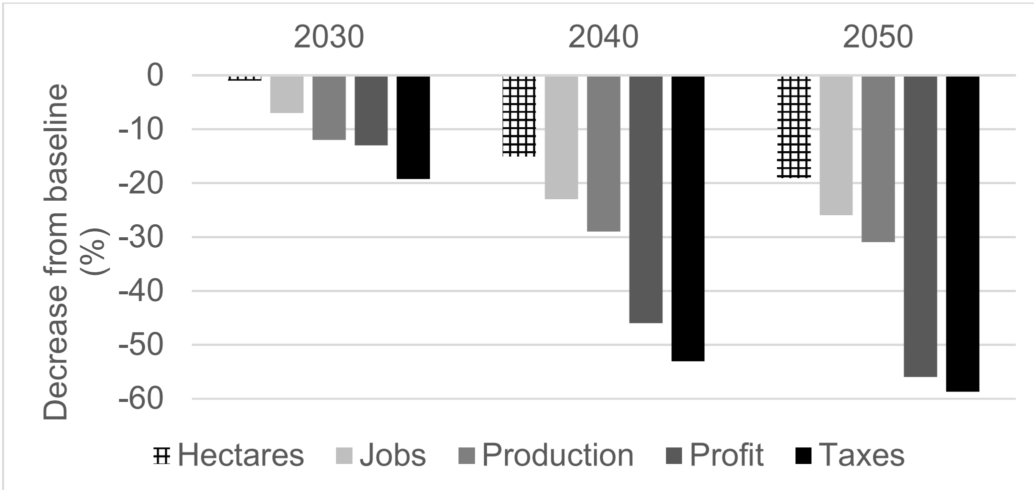
The dairy sector is a critical part of the New Zealand economy. In the last financial year, dairy constituted nearly a third of national merchandise exports. Further, it is a major source of jobs and incomes in regional New Zealand. The dairy sector is the top-income earner in the Waikato, West Coast, Taranaki, and Southland regions, and second earner in Manawatu-Whanganui and Northland.

The *Essential Freshwater* package proposes a broad set of responses to address the losses of contaminants including nutrients (principally nitrogen and phosphorus), pathogens, and sediment from New Zealand primary sectors. However, no comprehensive economic assessment has been performed that outlines the cost of this package to the dairy sector and the corresponding impacts on the broader economy.

This assessment employs a detailed model of the New Zealand dairy sector to evaluate the impact of the *Essential Freshwater* package. It models the evolution of individual farms within the sector over the 2019-50 period, to identify the financial and management impacts of the proposed policy. Multiple components of the policy are modelled, but the introduction of stringent limits for Dissolved Inorganic Nitrogen and Dissolved Reactive Phosphorus are found to have the greatest impact on farm profitability and solvency.

The key findings of the research are identified in Figure S1, which reports the extent of deviation from a baseline situation, where no *Essential Freshwater* package is implemented. The *Essential Freshwater* programme is forecast to have a significant economic impact on the New Zealand dairy sector, particularly in the long term as the limits become more stringent (Figure S1). Milk output is predicted to decrease by approximately 30% by 2040,and operating profit is predicted to halve by this time. Taxes paid by the dairy sector are predicted to halve by 2040 as well, while jobs in the sector decrease by nearly a quarter. These changes in production and profit constitute substantial business risk for New Zealand dairy farms, with the number of insolvent farms across the study period forecast to jump from 2% to 11% because of the *Essential Freshwater* policy package.

Figure S1. The forecast national impact of the *Essential Freshwater* package on dairy farm area, jobs, production, operating profit, and taxes in 2030, 2040, and 2050.



The regional economic impact of *Essential Freshwater* is also substantial. Dairy profits are predicted to be negative in the Northland and Taranaki regions by 2045-50. Further; profit is forecast to fall by 70% in the Waikato and by 50% in both Canterbury and Southland in the same period. Waikato, Canterbury, and Southland experience a predicted decline in production of around 33%, 50%, and 35%, respectively, by 2045-50.

Operating expenses per unit of output do not change much under *Essential Freshwater*. This is because decreases in expenditure on nitrogen inputs is offset by increases in costs associated with the uptake of mitigation assets. Yet, significant declines in production constitute a serious threat to the global competitiveness of the New Zealand dairy sector. Further, *Essential Freshwater* potentially compromises the vitality of regional communities, given the importance of processing jobs and because both farm profits and expenses are an important source of revenues for other firms.

Overall, this work identifies that policy makers should judiciously consider the impacts of the *Essential Freshwater* package on the dairy sector and regional and national economies, especially in the long term.

Contents

1. Introduction

The dairy sector remains a pivotal part of the New Zealand economy. MPI (2019) identified that dairying generated $18.1 billion of $46.4 billion of primary-sector exports in the last year, an increase of 9% compared to the year before. Further, dairy is the source of nearly a third of the value of merchandise exports each year (NZIER, 2018). There is a strong causal relationship between export performance and economic growth (Alcala and Ciccone, 2004). Accordingly, the significance of the dairy sector to the economy cannot be understated. Its importance is enhanced when the regional distribution of economic activity is considered. The dairy sector is the top-income earner in the Waikato, West Coast, Taranaki, and Southland regions, and second in Manawatu-Whanganui and Northland (NZIER, 2018). The sector employs around 46,000 people, many of these in regional New Zealand. The sector's importance is enhanced given the limited relative performance of other industries in these areas (NZIER, 2018). Further, poor productivity improvement in the national economy (Productivity Commission, 2019) suggest that it will take time to establish viable alternative sources of economic growth, especially at scale. Options available to stimulate national economic activity through monetary policy are also becoming increasingly constrained by the maintenance of very low Official Cash Rates.

Nevertheless, the environmental footprint of rural and urban land use in New Zealand is of societal concern, becoming a major election issue in recent years. Central Government has announced their objective, "to build a productive, sustainable and inclusive economy that supports the wellbeing of all New Zealanders." (MFE, 2019a). This was a major driver for the *Climate Change Response (Zero Carbon) Amendment Bill 2019* and discussion document for managing agricultural greenhouse-gas emissions (GHG-e) (MFE, 2019b) earlier this year. Further, the recent release of the "Action for healthy waterways" (MFE, 2019a) document proposes an *Essential Freshwater* (EF) programme for managing water resources. The EF package proposes a broad set of responses to address the loss of contaminants including nutrients (principally nitrogen and phosphorus), pathogens, and sediment from New Zealand primary sectors, particularly dairy farming (MFE/MPI, 2018; MFE, 2019a). Nevertheless, no comprehensive economic assessment has been conducted that outlines the cost of this package to the dairy sector and the corresponding impacts on the broader economy. An Interim Regulatory Impact Statement has been presented (MFE, 2019c), but it constitutes a set of partial-measurement exercises that are not combined in a systematic way. This is a critical gap because of the many ways that the EF package will impact dairy farms and the importance of the New Zealand dairy sector to regional and national economies.

The primary objective of this analysis is to provide an economic assessment of the EF policy package on New Zealand dairy farms, including draft proposals included within the *National Policy Statement for Freshwater Management 2019* (hereafter *NPS-FM*) and the *National Environmental Standard for Freshwater 2019* (hereafter *NES*).

In this report, a detailed model of the dairy-farm population of New Zealand is developed and applied to explore the implications of the EF framework. Overall, this research identifies the significant long-term cost, in terms of both lost production and profit, of the proposed EF policy package to the New Zealand dairy sector. Forecast impacts on farm profit are calculated to have a serious effect on farm solvency, with 11% of dairy farms predicted to become insolvent by 2050 under the EF proposals. The detrimental economic effects of the EF package are found to be further compounded by policies aimed at reducing GHG-e within the sector.

2. Methods

This research involves the application of a statistical simulation model that describes how key elements of farm management and performance, both biophysical and financial, evolve over time for the New Zealand dairy sector. An individual model is developed for each farm present in the initial population of 11,590 dairy farms (LIC/DairyNZ, 2018) for the base year of 2019/20. The biophysical, environmental, and financial performance of each farm is then forecast for each milking season between the base year and 2049/50.

The model is data driven, with statistical data used to define realistic levels of diversity across farms, between and within regions, as well as defining how each farmer responds to variation in climate and milk price across time. This specification for the model allows the distributional impacts of the policy package, across both farms and regions, to be estimated. This is important given that management, biophysical resources, and farm financial position determine, at least partly, the cost of mitigation across a population (Doole, 2012). Further, the transitional impacts of key management variables can be explicitly represented and considered in a model of this kind. The interplay between spatial and temporal variability is also critical to determining the impact of a policy; thus, this also appears as a key feature of the modelling framework (Doole and Pannell, 2012).

The model contains several key features, each described in a subsequent subsection. It is constructed using the R software package (R Core Team, 2019). This software framework is ideal for a model of this kind, given its efficiency, the diversity of statistical techniques applied within the model, and its broad accessibility (Leemis, 2016).

2.1 Initial conditions

A set of key performance metrics for each farm in the base year is generated in a statistically consistent manner to represent realistic levels of inter-farm heterogeneity. A sample of data for 1,200 dairy farms located across diverse regions of New Zealand is isolated from other records. Extreme outliers in terms of farm size, milk production per hectare, and stocking rate are then removed.[1] The inclusion/exclusion of farms within each regional set is then adjusted until the average farm size, milksolids per cow, and stocking rate for the sample closely matches the regional averages for these variables published in LIC/DairyNZ (2018). This matching is performed through a similar process to that used to generate the sample of farms for the DairyNZ Economic Farm Survey (DairyNZ, 2019), but is automated through use of a binary-optimisation procedure to solve a multiple-objective minimisation problem. This minimisation exercise is closely

---

[1] An outlier is defined using the standard statistical rule that an extreme observation is one that sits 1.5 times the interquartile range below the first quartile or above the third quartile (Verbeek, 2017).

equivalent to minimising squared error across the three target variables in each regional implementation. This procedure leads to very close matching between sample data and reported averages, with a mean goodness of fit across the eight simulated regions of around R^2=98%.

Regional distributions of key performance metrics are then estimated from the sample data. These distributions are not required to be normal distributions. Rather, they are allowed to have diverse means, variance, skewness, kurtosis, minima, and maxima. Further, there are meaningful relationships between many of the individual variables that are studied. For this reason, covariances between the set of variables is also estimated. The distributions are generated for farm size, milk production per cow, stocking rate, asset value per hectare, equity per hectare, and various components of operating profit defined per unit of output. Various components of operating expenses estimated are those for depreciation, grazing, labour, livestock, miscellaneous items, nitrogen fertiliser, non-nitrogen fertiliser, repairs and maintenance, supplement, and overheads. Also, a base value of non-milk revenue defined per unit output is estimated.

Individual values for each of these elements is then generated for each farm present within each region. The total number of farms present in each region is taken from LIC/DairyNZ (2018). Each random variable for the individual farm is generated in an integrated manner using the method of Fleishman (1978), which accounts for the respective regional means, variances, covariances, skewness, kurtosis, minima, and maxima identified in the earlier estimation stage.

2.2 Dynamic equations in the model

Climate and milk-price variation are key sources of business risk on New Zealand dairy farms. Annual milk price is a key driving variable within the simulation model—thus, the model requires the *a priori* specification of a milk-price trajectory for the study period. A milk price defined for each year in the simulation drives a farm-specific response across key variables in the model. The annual milk price can be defined deterministically or generated randomly. If the latter is selected, then the model should be run multiple times using Monte-Carlo methods.

The evolution of these key variables is governed through dynamic equations estimated through econometric methods involving panel-data estimation (Woolridge, 2010). The dataset studied involves a balanced panel of 115 owner-operator farms, for the 2010-18 period. A random-effects model is estimated for each equation, to allow for more-straightforward generation of farm-specific coefficients relative to a fixed-effects model (Verbeek, 2017). Potentially, this decision could introduce inconsistency in the model specification if some explanatory variables are correlated with the (unobserved) farm-level random effect (Baltagi, 2013). This limitation is overcome through the application of an error-components model based on the Hausman-Taylor estimator (Hausman and Taylor, 1981) that has been adjusted to account for dynamic equations (Kripfganz and Schwarz, 2019). This approach deals with the inherent temporal autocorrelation—where the past values of the dynamic variable influence its current value—that is a feature of these dynamic equations. The covariance matrix estimated for each equation is adjusted to account for heteroscedasticity and cross-sectional autocorrelation using the approach of Arellano (1987).

The model includes a number of dynamic variables, with a goodness of fit between the regression and sample data ranging from 19% to 58%, with a mean of 37%.[2] These regressions indicate that there is a strong level of fit across key measures of farm performance—including stocking rate, milksolids per cow, supplement, and fertiliser—given that these each have a higher average of around 50%. The descriptive capacity of the dynamic equations sometimes declines for those elements of operating expenditure that are composed of a number of diverse measures and/or respond to a variety of effects that are difficult to capture in an econometric model. Nevertheless, these measures of

[2] Goodness-of-fit measures range between 0% and 100%, with 0% representing no relationship between a set of explanatory variables and the dynamic variable and 100% representing a perfect correlation.

model adequacy remain sufficient, given the low goodness-of-fit inherent to the process of fitting dynamic equations (Wooldridge, 2010), the statistical significance of each model identified using an F-test of model adequacy (Baltagi, 2013), and because all estimated coefficients are statistically significant at the 5% level. Additionally, any randomness that is not described by the explanatory variables is still represented in the simulation model through its explicit inclusion of the random errors identified through the estimation process.

The estimation results for each dynamic equation are used to generate a farm-specific version of each equation for each individual farm. Each statistical estimation identifies the distribution of each coefficient within the population, combined with a distribution of random effects. In the model, the values of these coefficients are drawn randomly from these distributions, accounting for their means, variance, covariance, minima, and maxima. These coefficients are then fixed across the study period for each farm, signifying stable management ability and preferences across time. In contrast, the distribution of the idiosyncratic-error term generated during the estimations is used to generate random disturbances that differ across years and perturb any deterministic effect described by the non-random part of the dynamic equation.

An important component of farm financial management is deferring costs when output prices are low and addressing these expenditures when output prices recover. One example is the use of phosphate fertiliser to help build reserves of phosphorus in the soil when milk prices are high, and drawing on these stocks by cutting expenditure on fertiliser when milk prices are low. Another involves repairs and maintenance, given that maintenance expenditure may decrease during low milk-price years and subsequently be increased when higher milk prices are realised (DairyNZ, 2019). The dynamic equations defined within the model add substantial realism as they capture these important relationships, subject to variation across both farms and time.

The dependent variables described in the dynamic equations change across time in response to changes in the milk price, levels of the variable computed in past periods, and/or other drivers, some defined within the dynamic equations and others not. Novel statistical methods discussed throughout this section are employed to ensure that the multiple issues present in the sample data are sufficiently overcome to allow a robust description of how farmers strategically modify their farming system over time in response to internal and external drivers. The use of these methods allows important sources of heterogeneity between farms to be described. One example is how supplement and nitrogen-fertiliser use respond to changes in the milk price. Another is how changes in these variables depend on the stocking rate. Further, the explicit estimation of different types of errors allows randomness arising from both management (i.e. individual errors) and other sources, particularly the climate, (i.e. idiosyncratic errors) to be represented in a cohesive way.

2.3 Farm insolvency

Land is the key physical asset of most farms. Land typically does not depreciate and accrues capital gains; thus, land prices are often very high, when considered alongside the annual cash flow they generate (Oltmans, 1995). This provides persistent challenges to maintain cash flows that are sufficient to cover debt and expenses. The significance of debt dynamics is emphasised because loanable funds can help to maintain a smooth level of consumption over time (Lawes and Kingwell, 2012).

The initialisation of the model involves the generation of assets and equity per hectare for each farm in the population (Section 2.1). The generation of these two variables allows the computation of the level of liabilities per hectare for each farm. It is critical to represent the dynamics of assets, debt, equity, interest, tax, and solvency in a realistic way that is tied to farm profitability and its variation across both farms and time. This is done through the embedding of the DairyNZ Equity Tool (Bird, 2019) in the economic model. The DairyNZ Equity Tool is a spreadsheet model that allows a farmer to sketch out how assets, debt, and equity will evolve across time under different assumptions. The average interest rate on borrowed funds assumed across the farm population is 6% in this analysis.

An average annual rate of capital gain of 2.5% is assumed, as well. This is one-third of the historical rate observed across the last 30 years, which is estimated using the time-trend approach of Enders (2015). This moderation of the historical rate of appreciation is appropriate given anecdotal evidence that suggests that many of the capital gains accruing to New Zealand dairy production have already been realised given a convergence of milk prices internationally. It is also consistent with the economic theory that the price of land reflects its productive value (Muller and Neal, 2019) and this could be substantially moderated in the medium- to long-term through the impacts of environmental regulation on dairy-farm profitability (Doole, 2019).

Farm solvency is based on general criteria to classify non-performing loans (NPL) used by the Reserve Bank of New Zealand. These criteria are (Dunstan et al., 2015):

1. Farm cashflow is negative when the current management plan is evaluated at the average milk price.
2. Farm cashflow is negative in the current season.
3. The Debt-to-Asset ratio is greater than 90%.

The risk of foreclosure is of most interest here. The criteria listed above concern non-performing loans and it is highly uncertain what proportion of these farms with NPL will eventually foreclose. It is assumed that foreclosure will occur when items 1 and 2 listed above are satisfied, and a Debt-to-Asset ratio of 95% or above is observed. This updated set of criteria recognises the aversion of a lender to foreclosure (Hargreaves and Williamson, 2011), while also providing a sound indication of unviable firms.

This representation of farm insolvency within the model provides unique insight into the probability that a farm is not financially viable, under different future scenarios. Nevertheless, several relationships are not considered that could affect this probability.

First, there is a chance that growing levels of insolvency could lead to a downward spiral for land prices, which could further accelerate the rate at which firms become unviable. High levels of insolvency can lead to an excess supply of land, which can decrease land price. Most of the asset value of a dairy farm accrues to its land. Thus, a lower land price can decrease asset value, thereby increasing the Debt-to-Asset ratio for an operation. Through this mechanism, higher levels of insolvency can erode the general equity position of the sector, with the potential to further promote observed rates of foreclosure.

Second, though variation in asset value is represented, the model contains an assumption that all farms have a consistent life that is equal to the length of the study period. This assumption allows a concise, straightforward depiction of the farm population. Yet, it also introduces several caveats. One is that farms with high levels of equity often constitute farmers who have been farming for longer. Upon their retirement, they are typically replaced by younger farmers who carry higher levels of debt. Another caveat is that farmer ability will change across time, due to experience, learning (Gonzalez and Dutt, 2011), and manager turnover. Experience and learning are difficult to incorporate in dynamic economic models (Verspagen, 2009), particularly in a structured and meaningful way. Additionally, representing a change in management across time has been outside the scope of this research. Representing this dynamic in the model is worthy of further attention.

The consistent-life assumption stated above means that insolvent farms remain in the population as dairy farms. Such farms could be replaced by other land uses. However, economy-wide modelling undertaken by Infometrics identifies that a lack of profitable alternative enterprises means that many of these farms could be expected to remain in dairy production (Stroombergen, 2019). This aligns with the results of other economic assessments of water-quality improvement that show that despite some rationalisation of area, intensity, and production with environmental regulation, the New Zealand dairy sector should remain an important source of income and jobs, particularly in regional economies (Doole, 2018; Doole et al., 2016; LGNZ, 2019; McDonald, 2015; McDonald and Doole, 2016).

A move away from dairy to some other land use is not represented in the model. Land is withdrawn from dairy farming if the uptake of other mitigations is insufficient to reach farm-specific targets (see Section 3.1). Nevertheless, the value of profits earned from this land from the time it is removed from dairy production is not evaluated here. This approach is motivated by a focus on the dairy sector and a lack of evidence pertaining to the relative profitability of other land uses under the EF programme. In particular, the limited consultation period available has made it difficult to estimate the scale of these costs ourselves. It is possible to include these costs in future work, if/when appropriate information becomes available.

Overall, it is expected that the existing assumptions provide pragmatic insight into the risk of insolvency that unfolds under different future scenarios. Indeed, it appears in the following that the failure to represent an insolvency spiral associated with land-price effects is adequately moderated by the consistent-manager assumption.

2.4 Environmental footprint

Metamodels that link farm production and environmental management are estimated from case-study data collected over the last decade by DairyNZ. The variation defined within the estimated equations are used to define farm-level and temporal variation within the model. This follows a near-identical process to that discussed for the dynamic equations above in Section 2.2.

All relationships are estimated using robust-regression methods to robustly discount any potential bias arising from outlier observations (Wilcox, 2017). The robust-regression methodology applied in this research is based on the four-step SMDM approach developed by Koller and Stahel (2011). These authors identify this methodology as superior to standard methods of robust regression, particularly in the presence of small sample sizes.

Several key procedures are notable.

First, soil type is randomly allocated to each farm depending on regional distributions and production intensity.

Second, average rainfall is randomly allocated to each farm depending on regional distributions.

Third, nitrogen leaching is determined as a function of imported-nitrogen input, soil, and rainfall. Imported-nitrogen input captures the nitrogen entering the farming system in the form of nitrogen fertiliser and supplement. This formulation is pragmatic and also bypasses the complexity associated with estimating nitrogen fixation at different levels of nitrogen-conversion efficiency (Pinxterhuis and Edwards, 2018).

Fourth, a mitigation protocol is introduced for nitrogen leaching. This protocol draws together a significant literature that involves the determination of a pragmatic, ordinal approach to the adoption of mitigation strategies. Representative examples of applications within this literature are: de Klein et al. (2017), Doole (2015, 2016), Matheson et al. (2018), Monaghan and de Klein (2014), Monaghan et al. (2008, 2016), Moran et al. (2017), Muirhead et al., (2016), Parsons et al. (2015), and Vibart et al. (2015). A high number of mitigation actions are defined across the protocol. Actions include, but are not limited to, improved effluent management, improved fertiliser management, improved pasture management, low-nitrogen supplement, reductions in nitrogen fertiliser, reductions in supplement, improved effluent infrastructure, and restricted grazing to reduce urine deposition on pasture. Additionally, stocking-rate reductions are observed as key nitrogen inputs are removed. Mitigation activities impact on nitrogen conversion efficiency—that is, they allow a farmer to produce more product for a given level of imported nitrogen—or adjust the level of nitrogen imported to the farm system. An example of the former is improving the timing and application rates of effluent and nitrogen fertiliser, to improve pasture response to these additions (de Klein et al., 2017; Monaghan et al., 2008). An example of the latter is a reduction in the amount of supplement imported to the milking platform (Matheson et al., 2018). The definition of the model across time allows the adoption and efficacy of alternative mitigations to vary across the study period (Doole et al., 2019). Notably, this mitigation protocol contains the explicit capacity for farmers to reduce nitrogen loss through improvements in pasture-management capability

(Doole, 2019), with the degree to which this is possible varying among farmers according to their management capability.

A feature of the EF package is that diverse nitrogen limits are defined for each farm. Accordingly, the economic model allows each farm to move various distances along the mitigation protocol. The initiation of each step of the protocol depends on comparison of the moving average of nitrogen loss in each period and the target level of nitrogen leaching required for that farm.

Fifth, reductions in phosphorus loss are also required for some farms. A mitigation protocol and associated level of abatement cost is defined for phosphorus based on data within Monaghan et al. (2012, 2016). Notably, the actions contained in this protocol have little effect on production, with most of their impact being on operating expenses.

Last, GHG-e are determined using a methodology based on that of Pickering (2018).

Overall, the environmental models possess a strong capacity to describe linkages between farm management and environmental outcomes. This is evident in moderate to high goodness-of-fit measures, the statistical significance of each model identified using an F-test of model adequacy (Baltagi, 2013), and all estimated coefficients being statistically significant at the 5% level.

2.5 Scenarios

The study period extends from 2019-20 to 2049-50. The length of this time horizon is selected because:

1. It incorporates the proposed transition time discussed in the EF policy package.
2. It permits an adequate period of time for meaningful insight into business liquidity.
3. It corresponds to the provisional timeframes defined within the Zero Carbon Bill (ZCB).

The price trajectory for the study period involves repetition of the last ten-year cycle of milk prices three times. This approach is selected: to improve the consistency of the price series with base model data, because of a lack of alternative information, reduce the computational burden associated with the adoption of stochastic price sets and Monte Carlo simulation, to remove any distortion in policy assessment that could arise from atypical price series, and help ameliorate the high level of inherent uncertainty in price forecasting, especially over a long time period.

2.5.1 Baseline

The baseline situation represents a continuation of the current state, but without any implementation of limits associated with the *National Policy Statement for Freshwater Management 2014*. This assumption is pragmatic—particularly since this research involves modelling applied at the national scale—and is justified by the fact that the introduction of environmental limits based on this legislation is highly localised and not yet occurring at scale. This decision aligns with those presented in LGNZ (2019). It is also an appropriate yardstick for comparison given that existing policies will have to give effect to the updated set of regulations contained in the EF package.

2.5.2 Scenario 1

This section describes the assumptions underlying Scenario 1. This scenario represents the combined impacts of Farm Environment Plans (FEPs), stock exclusion, consents for stand-off pads, and actions associated with FEPs.

The cost to generate a new FEP is estimated to be $3,500/farm. The FEPs areassumed to be present by 2025, with the plan enacted by 2030. A new plan is generated every ten years. This is the average cost determined for dairy farms in the AgFirst Waikato study (Journeaux, 2016). Auditing is carried out every two years at a cost of $2,500 per audit (MFE, 2019a).

The cost of implementing a FEP is assumed to be $50,000/farm. One-tenth of this total is assumed to be spent every year for the first decade, at $5,000 per year. This estimate of $50,000 is the average cost spent by dairy farms in the AgFirst Waikato study (Journeaux, 2016). These represent generic costs for drain improvement, upgrading of races, culvert maintenance, effluent-pond sealing, sumps, crossings, cultivation, reducing hotspot losses, and so on.

The Sustainable Dairying: Water Accord states that the length of Accord fencing is 24,249 km, of which 98% is fenced. The total length of Accord streams in dairy land in New Zealand is assumed to be 68% of the sum of Accord and non-Accord stream length (Doole, 2015). This gives a total length of 35,660 km on New Zealand dairy farms, which implies that 11,411 km of non-Accord length is present across dairy farms. This is allocated across farms according to their location and size.

The assumed type of stream fencing involves a 3-wire electric fence with 2.5 mm wire, quarter-round posts, and 7.5 m spacing to keep cattle out of streams. A per-metre cost of $5 for 10 m post spacing was recommended by Duncan Kervell (Northland Regional Council) in past work (Doole, 2015). This is also the midpoint of the range of cost for a 3-wire fence ($4.50/m–$5.50/m) estimated by Bala Tikkisetty from the Waikato Regional Council and also stated in Doole (2015). No cost for water provision is represented, given that average dairy farms have an adequate number of current troughs and do not rely generally on stream water for stock watering. The total cost is therefore $5/m for stream fencing on dairy farms, the same cost assumption as that present in Agribusiness Group (2016). This cost is annualised to $0.44/m, which is an annual payment determined at a discount rate of 6% over a 20-year period. This is split evenly between labour and materials.

The costs of shifting an existing fence are assumed to consist of both labour and material costs. This activity is costed as $0.29/m, two-thirds of the total cost of a new fence. Two-thirds of this cost is allocated to labour, while one-third is allocated to materials.

For Accord streams, exclusion requires a 1 m minimum and 5 m average setback across each property by 2021 for existing dairy farms. We use the assumption that an additional 4 m of setback, on average, is required to meet these targets. This is assumed to lead to a loss of 1% of the total effective area of the farm.

A cost of $3,000 for a consent (MFE, 2019a) for farms with a stand-off pad is assumed. Farms with an existing stand-off pad are assumed to apply for a consent in 2020 and then each decade after that.

2.5.3 Scenario 2

This scenario is additional to Scenario 1.

The EF package involves the introduction of interim measures to reduce nitrogen loss. Three options are being considered:

1. A catchment-specific nitrogen cap. MfE are seeking feedback on where the threshold should be set. Farmers above the given percentile limit for nitrogen loss will be required to reduce their level of leaching until they are at this limit. This proposal involves limits set between the 70th and 90th percentiles. For example, for a 75th percentile limit, farms above this limit would be required to reduce their leaching losses until they are equivalent to or below the 75th percentile (Doole et al., 2016).
2. A national limit on nitrogen-fertiliser use.
3. Addressing nitrogen losses through FEPs.

Only option #1 is modelled in this investigation. The 75th percentile is used as an indicative threshold, based on its adoption in the proposed Waikato Plan Change 1 policy framework (Doole et al., 2016).

Option #1is required in a range of proposed Schedule 1 catchments in which nitrogen loss is currently elevated. These are:

1. Taharua River (Hawke's Bay),
2. Waipao Stream (Northland),
3. Mataura River (Southland),
4. Oreti River (Southland),
5. Waimatuku Stream (Southland),
6. Aparima River (Southland),
7. Waihopai River (Southland),
8. Waingongoro River (Taranaki),
9. Motupipi River (Tasman Region),
10. Piako River (Waikato Region),
11. Waihou River (Waikato Region),
12. Parkvale Stream (Wellington), and
13. Upper Rangitaiki and Otangimoana Rivers (Bay of Plenty).

The DairyNZ Catchment Accounting Framework is used to identify the farms that are located in these Schedule 1 catchments. The degree to which each farm is required to reduce their nitrogen-leaching level to reach the 75^{th} percentile, if at all, is then determined using the baseline level of leaching estimated for each farm in the model (Section 2.4). The amount of mitigation that each farm is required to do varies because of the diversity in the baseline levels of nitrogen-leaching loss described within the modelling framework.

2.5.4 Scenario 3

This scenario is additional to Scenario 2.

The EF policy package involves new bottom lines for Dissolved Inorganic Nitrogen and Dissolved Reactive Phosphorus where instream concentrations exceed the proposed national bottom line. The DairyNZ Catchment Accounting Framework is used to determine which farms are required to make reductions in which region and by how much. Some farms are required to reduce only nitrogen, some farms are required to reduce only phosphorus, while some must reduce both. There is a broad diversity of the stringency of these limits, particularly regionally. The EF package proposes that these goals for water-quality outcomes must be met over a generation, of 20-30 years length (MFE, 2019a). In the model, the nitrogen-leaching protocol defined therein is based on an assumption that a 25-year transition period is most likely.

2.5.5 Scenario 4

This scenario is additional to Scenario 3.

The purpose of this scenario is to represent the cumulative impact of targeting greenhouse-gas emissions (GHG-e) alongside the EF package. This is particularly relevant given the recent release of the *Climate Change Response (Zero Carbon) Amendment Bill 2019* and discussion document for managing agricultural GHG-e (MFE, 2019b).

Zero Carbon Bill (ZCB) goals for methane are assumed to be a 10% reduction by 2030 and 36% by 2050. The 36% reduction is a midpoint between the lower and upper bounds of 24% and 47%, respectively, that are currently provisionally set within the legislation. These goals are required to be met across each farm.

A protocol for mitigating methane is defined for each farm. It is structured such that the economic model allows each farm to move different distances along the mitigation protocol, given diversity in baseline losses of methane. The initiation of each step of the protocol depends on a comparison of the moving average of methane loss in each period and the target level of methane reduction required for that farm.

It is assumed that agriculture does not enter into the New Zealand Emissions Trading Scheme until 2025. In 2025, agriculture receives a 90% level of free allocation that declines at the rate of 1% a year until the end of the study period. Base allocation is based on the farm-specific level of GHG-e in the first year of the study period.

A schedule of carbon prices is incorporated as an exogenous variable. The linear schedule of carbon prices is defined such that it incorporates 2020, 2030, and 2050 prices of $25, $70, and $150 per tonne of carbon, respectively. These carbon prices are based on those broadly adopted by Infometrics in BERG (2018) and Dorner et al. (2018).

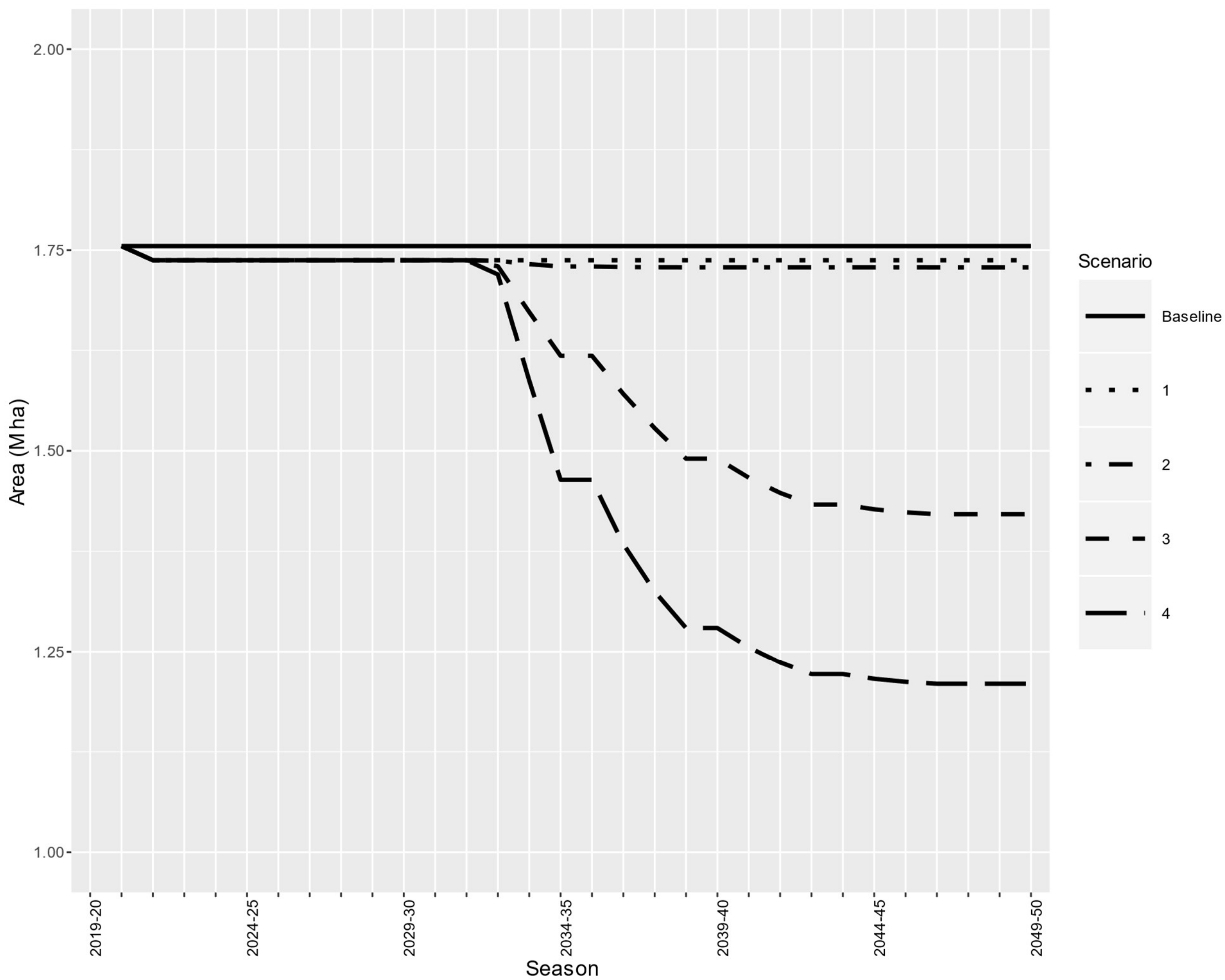
Operating profit for each farm increases/decreases through carbon revenue/payments when the farmer holds a surplus/deficit of entitlements to emit.

3. Results and Discussion

3.1 Essential Freshwater greatly impacts dairy area, cow number, and production

Figure 1 shows the impact of the five scenarios on the area of land used for dairy farming within New Zealand. It contains several notable points. First, the amount of area present in the baseline remains constant across time. Second, only around 1% of land is lost from production within Scenarios 1 and 2. This loss of land is associated with the greater use of setbacks across the sector. In contrast, there is a marked decrease in the land area under dairy observed in the long term with the full EF package (Scenario 3) and when GHG-e policy is considered alongside it (Scenario 4). These decreases in area reflect the need to remove land from dairy production to achieve sufficient reductions in methane and nitrogen loss, once the supply of more cost-effective forms of mitigation are exhausted. These losses in land area are reasonably gradual, given the period specified for transition. Nevertheless, dairy area in 2050 falls by around 20% and 30% in Scenarios 3 and 4, respectively, relative to current hectares.

Figure 1. The impacts of the five scenarios on the area of land area utilised for dairy production.



This model is focused solely on the dynamics of the New Zealand dairy sector. Land that is taken out of dairy production (Figure 1) thereby represents a loss of income, without it being offset through land-use change. This discarded land could be utilised for other activities, such as sheep and beef production. Indeed, LGNZ (2019) show that this form of farming can be a valuable alternative land use on dairy land, if environmental limits lead to sufficient falls in income. This value would help to offset some of the lost income in the dairy sector that is identified in this report. Nonetheless, an accurate assessment of the opportunity cost of discarded land requires detailed modelling of how alternative land uses perform, both from an environmental and financial perspective, under environmental limits across time. The resources required to undertake such an analysis have been unavailable in the context of this research, particularly given the regional and national scale of this assessment. Accordingly, this analysis retains a sole focus on how the dairy sector performs under different regulatory regimes.

Figure 2 demonstrates the impact of the five scenarios on the national herd size. The herd in the initial year of model output is 5,403,833 cows. This is 8% above the baseline amount of 4,992,914 cows in the year (2017/18) that the model is calibrated to represent (LIC/DairyNZ, 2019). Such a deviation from the baseline cow number is to be expected, given that the total cow number is a random variable computed through aggregation of thousands of random variables. This deviation and that discussed below are deemed to be of minor significance because of this justification, its minor size, and as this baseline is used as a basis for comparison across all scenarios.

Figure 2 contains a few key findings. First, cow numbers do not fall substantially within Scenarios 1 and 2 given the lesser incidence of stringent reductions in nitrogen and/or phosphorus losses. Second, in comparison, cow numbers start to fall steadily within the first decade for both Scenarios 3 and 4. Early reductions reflect a decrease in key nitrogen inputs, principally nitrogen fertiliser and supplement, into the farming system. Third, losses in cow numbers start to steady after a point, reflecting stability in land area towards the beginning of the last modelled decade (2041-2050). Last, the losses in cow number are predicted to be significant under Scenarios 3 and 4. The national herd size in 2050 falls by around 25% and 50% in Scenarios 3 and 4, respectively, relative to current herd size.

Figure 2. The impacts of the five scenarios on the number of cows in the New Zealand dairy sector.

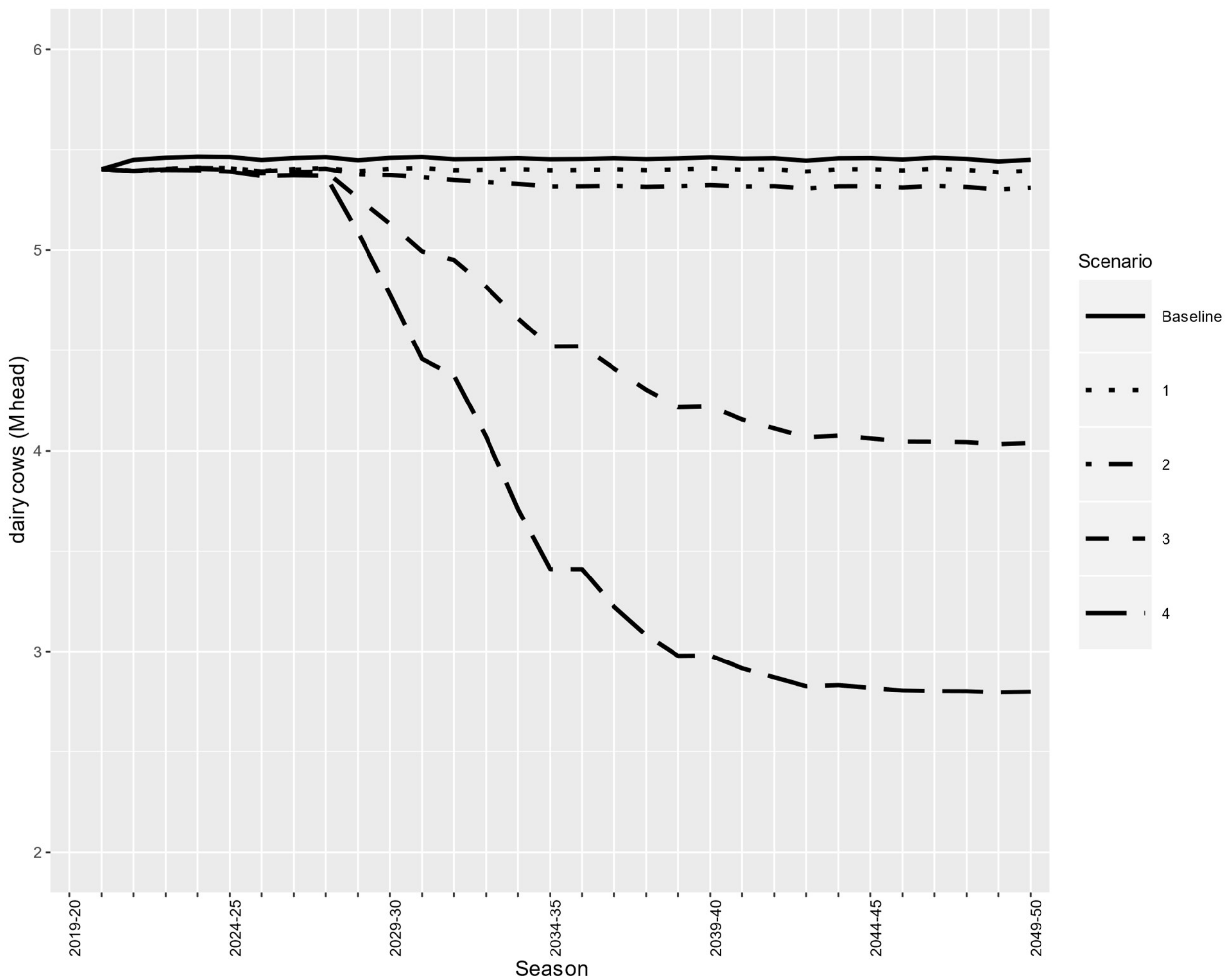
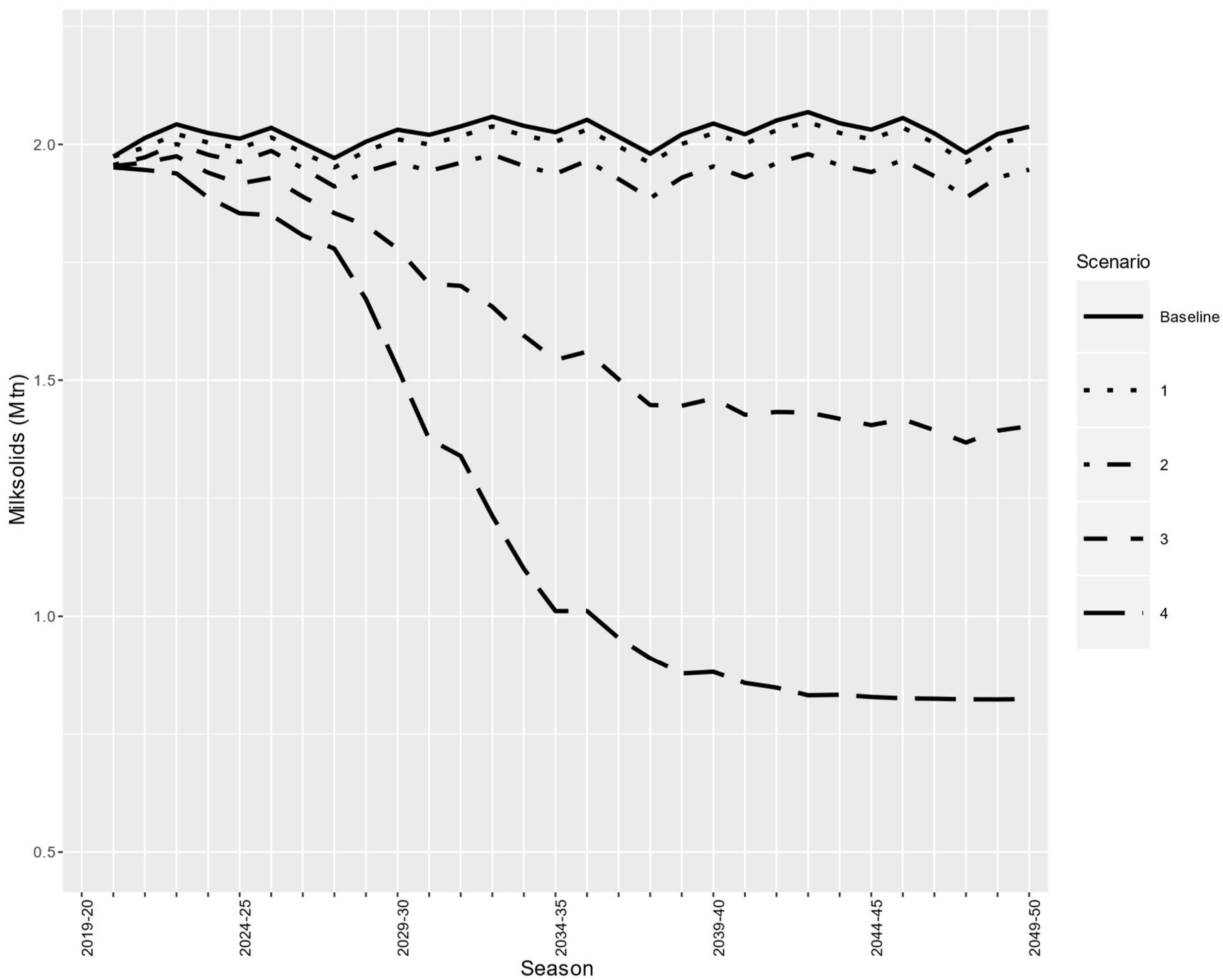


Figure 3 highlights the associated decrease in milk production for each of the evaluated scenarios. The national level of milk production in the initial year of model output is 1,974,341 M tonnes of milksolids. This is 7% above the baseline amount of 1,839,714 M tonnes of milksolids present in the year (2017/18) that the model is calibrated to represent (LIC/DairyNZ, 2019). Such a deviation is expected, given that total milk production is generated through the aggregation of thousands of random variables. These changes reflect substantial decreases in nitrogen inputs, farm area, and cow number. The impacts of Scenarios 3 and 4 are, once again, dramatic relative to the current state (Figure 3).

Production falls by 8, 23, and 28% by 2030, 2040, and 2050, respectively, in Scenario 3. In comparison, it falls by 30, 55, and 58% by 2030, 2040, and 2050, respectively, in Scenario 4. Scenario 3 requires large reductions on a significant proportion of dairy farms, but on top of this Scenario 4 requires changes across all farms. Accordingly, losses in production grow as limits for GHG-e are introduced on top of those proposed in the EF package (Figure 3).

Figure 3. The impacts of the five scenarios on the total level of milk production in the New Zealand dairy sector.



3.2 Essential Freshwater greatly affects regional dairy sectors, but in diverse ways

Figure 4 presents the regional distribution of average-annual operating profit for 2025-30 (top graph) and 2045-50 (bottom graph)[3]. Figure 4 shows that all scenarios impose a loss of profit, relative to the baseline. Additionally, most of these results conform to economic theory that suggests that profit falls at a faster rate as the stringency of environmental limits increases (Tietenberg and Lewis, 2009; Doole, 2012).

Significant reductions are observed under the full EF package (Scenario 3) by 2025-30, but are magnified by 2045-50 when the decreases in production intensity are more-fully pronounced (Figure 5). Regional differences are very evident. Operating profit decreases by around half in the Waikato region and by around a quarter in the Canterbury and Southland regions in the first decade under the EF package. The long-term impacts are larger in magnitude. Dairy-farming profit is forecast to disappear in the Northland and Taranaki regions by 2045-50 in Scenario 3. Further, profit is predicted to fall by 70% in the Waikato region and by 50% in both Canterbury and Southland by 2045-50 within Scenario 3. These results emphasise the significant medium- and long-term effects of the EF package on the nation's primary dairying regions.

These losses have significant impact on tax revenue. The EF package represented in Scenario 3 leads to a loss of tax revenue from the New Zealand dairy sector of approximately 20%, 50%, and 60% in 2030, 2040, and 2050, respectively. Nevertheless, some part of this would be able to be offset through the uptake of agricultural/horticultural production on land that drops out of dairy farming (Figure 1).

---

[3] The use of these two periods is to provide short-term and long-term snapshots—these are 2030 and 2050, respectively. Means are used to mediate some of the variation arising from climate and milk-price variation over each five-year period.

Figure 4. The impacts of the five scenarios on the regional distribution of annual operating profit in the New Zealand dairy sector in 2025-30 (top graph) and 2045-50 (bottom graph). Regional data is presented for: Northland (NLD), Waikato (WAI), Bay of Plenty (BOP), Taranaki (TAR), Lower North Island (LNI), West Coast-Tasman (WCT), Canterbury-Marlborough (CAN), and Otago-Southland (SLD). National profit is allocated the NAT label.

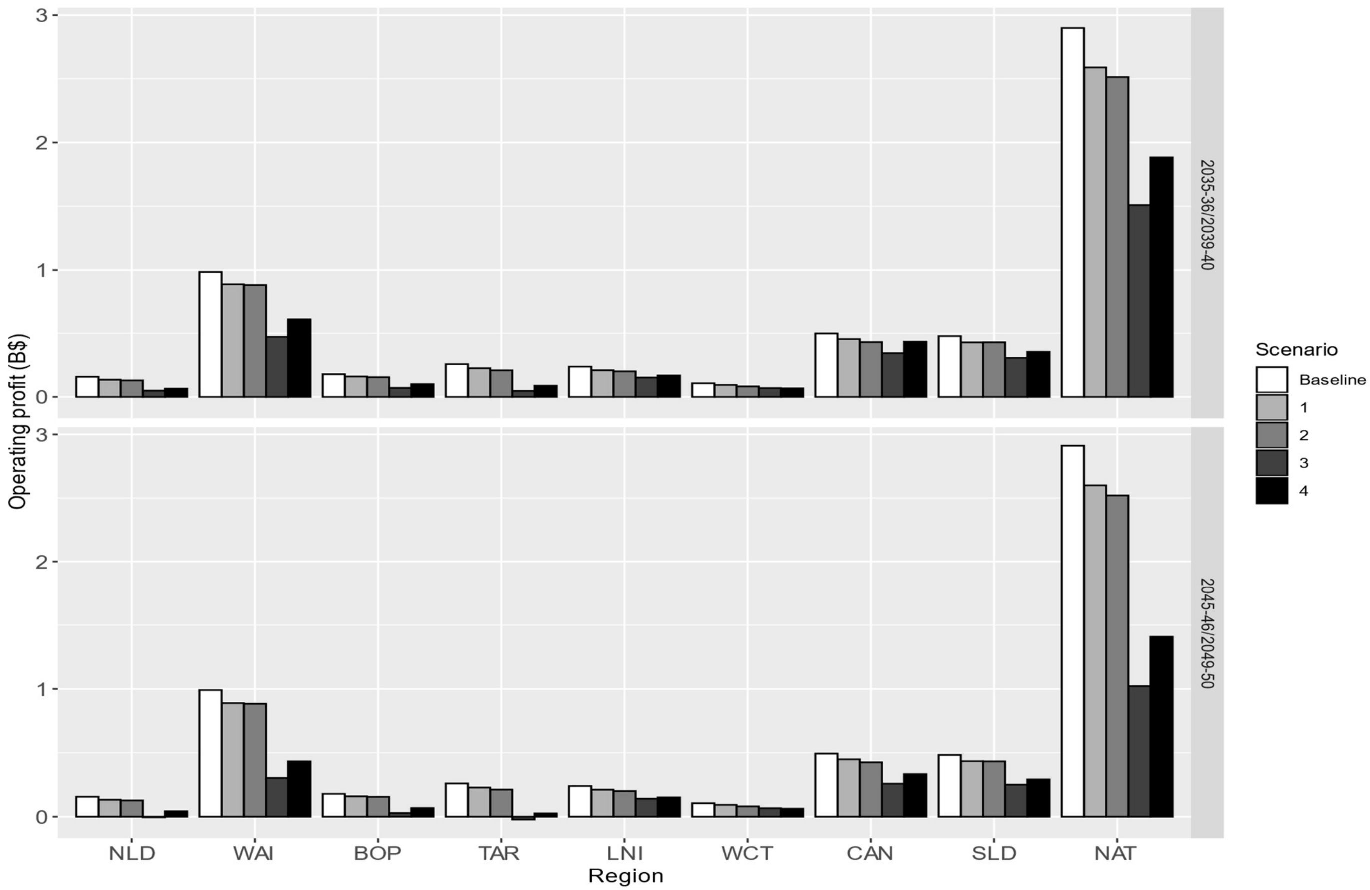
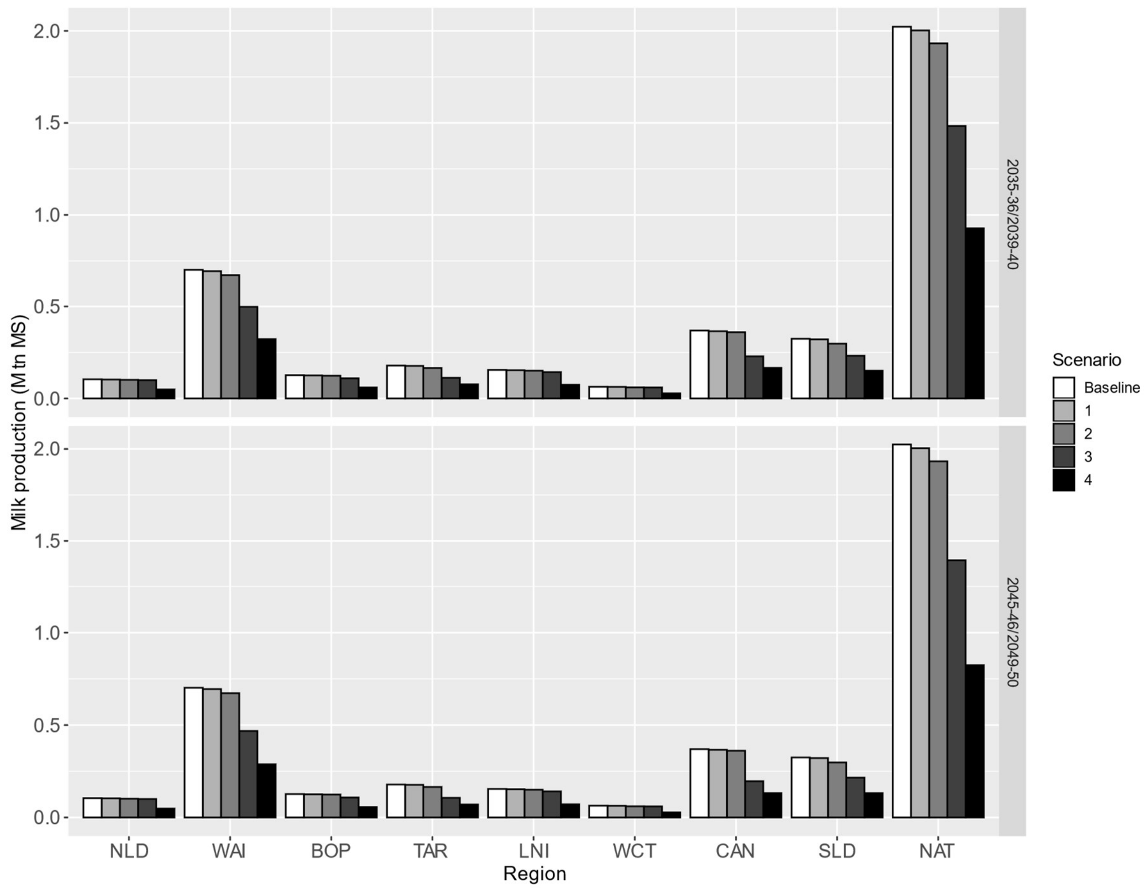


Figure 5 presents the regional distribution of average-annual milk production for 2025-30 (top graph) and 2045-50 (bottom graph). Figure 5 shows that all scenarios impose a loss in production, relative to the baseline. The largest production impacts are observed for Scenarios 3 and 4, reflecting a need to address methane and nitrogen losses at scale within the sector under the simulated policy instruments. The primary dairy regions experience significant decreases in production as a result of the EF package. Waikato, Canterbury, and Southland experience a decline of around 30%, 40%, and 28%, respectively, in Scenario 3 in 2025-30. Further, they experience a decline of around 33%, 50%, and 35%, respectively, under Scenario 3 by 2045-50. These declines in production experienced across all regions are magnified by policy aimed at reducing GHG-e within the dairy sector. This is shown where production more than halves within each region by 2045-50 in Scenario 4. Marked decreases in milk production are important from a community perspective, given that dairy-processing companies provide jobs and income in regional economies (NZIER, 2018).

Notably, it is possible within Scenario 3 for some regions to experience a large decline in operating profit (Figure 4), but not to experience large associated declines in milk production (Figure 5). One example is Northland, another is Bay of Plenty. This outcome reflects regional differences in the relative importance of limits targeted at nitrogen and phosphorus. Production and operating profit both experience significant declines within the Waikato and Canterbury regions under the EF package (Scenario 3), reflecting a strong focus on both nitrogen and phosphorus in these areas. In comparison, phosphorus limits are much more prominent in the Northland and Bay of Plenty regions. Accordingly, the EF package has a greater impact on profit than production in the Northland and Bay of Plenty areas, relative to those in areas in which nitrogen is also a primary issue. Regardless, it is possible to have significant reductions in operating profit and not production even when limits are not stringent with respect to nitrogen loss, particularly in years in which a low milk price is observed (Doole, 2015; Doole and Romera, 2019). Overall, these results further emphasise the significant medium- and long-term effects of the EF package on the nation’s primary dairying regions.

Figure 5. The impacts of the five scenarios on the regional distribution of annual milk production in the New Zealand dairy sector in 2025-30 (top graph) and 2045-50 (bottom graph). Regional data is presented for: Northland (NLD), Waikato (WAI), Bay of Plenty (BOP), Taranaki (TAR), Lower North Island (LNI), West Coast-Tasman (WCT), Canterbury-Marlborough (CAN), and Otago-Southland (SLD). National production is allocated the NAT label.



Scenario 2 is different from Scenario 1 in that it involves the assumption that farms above the 75th percentile of nitrogen loss in a catchment are required to reduce their leaching losses to this threshold (Section 2.5.3). It is notable from Figures 4 and 4 that Scenario 2 provides some negative economic impact over and above Scenario 1, particularly in Waikato and Southland. However, overall, these effects are not large, particularly relative to the extent of the changes that occur when more-stringent nitrogen and phosphorus targets are incorporated in Scenario 3. This is evident for several reasons. First, the 75th percentile limits are highly localised across the total population. Second, requiring the highest-leaching farms to decrease to the 75th percentile also statistically does not have a major impact on average losses. Indeed, this generally corresponds to a reduction in mean leaching across the total population of around 4-6%, depending on the distribution of nitrogen loss (Doole et al., 2016). This serves to reduce the abatement costs associated with such a policy. Last, the cost of abatement per unit of nitrogen abated has been found in the past to be lower for the highest-leaching farms (Doole, 2012; Doole and Pannell, 2012). This is apparent in recent research (Ledgard et al., 2017) that showed that 60% of the case-study farms that reduced leaching to a 75th percentile limit experienced costs less than 3% of baseline operating profit. Generally, this is due to the greater scope these more-intensive farms have for improving the efficiency with which imported nitrogen is utilised (Doole and Pannell, 2012; de Klein et al., 2017).

3.3 Essential Freshwater reduces average profit, compromising financial viability

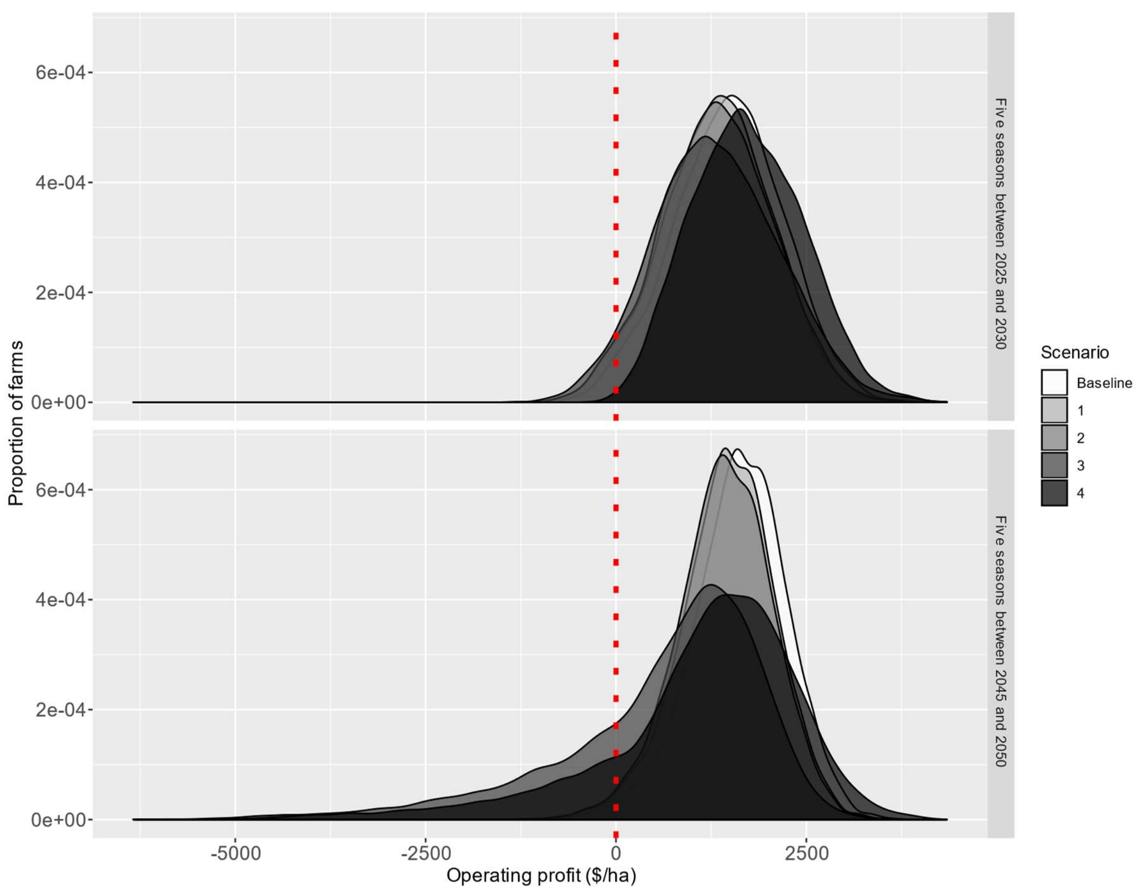
Figure 6 shows the distribution of annual-average[4] operating profit per hectare across the dairy-farm population in 2025-30 (top graph) and 2045-50 (bottom graph). A characteristic of the EF package is that a transition period of 20-30 years is proposed. This also applies to the greenhouse-gas limits proposed within the ZCB. Accordingly, annual-average operating profit is reasonably equivalent in 2025-30 across all scenarios (Figure 6, top

---

[4] It is necessary to define an annual average in Figure 4 because annual operating profit is a random variable within the model, given the broadscale representation of both spatial variation in management ability and temporal variation in climate and prices.

graph). One interesting difference is that the proportion of farmers earning a negative level of operating profit per hectare grows under Scenario 3. Another is that these losses are less evident in Scenario 4 because of the opportunity for dairy farmers to sell carbon. This opportunity arises because decreases in intensity necessary to meet limits for methane and nitrogen create a surplus of entitlements for GHG-e under the assumed allocation policy. Selling this surplus helps to partially offset the losses accruing due to decreases in production intensity, at least in the short term.

Figure 6. The impacts of the five scenarios on the distribution of annual operating profit per hectare in the New Zealand dairy sector. The top graph presents the annual-average operating profit per hectare across 2025-30, while the bottom graph presents the annual-average operating profit per hectare across 2045-50. The dotted vertical line denotes an operating profit of $0/ha.



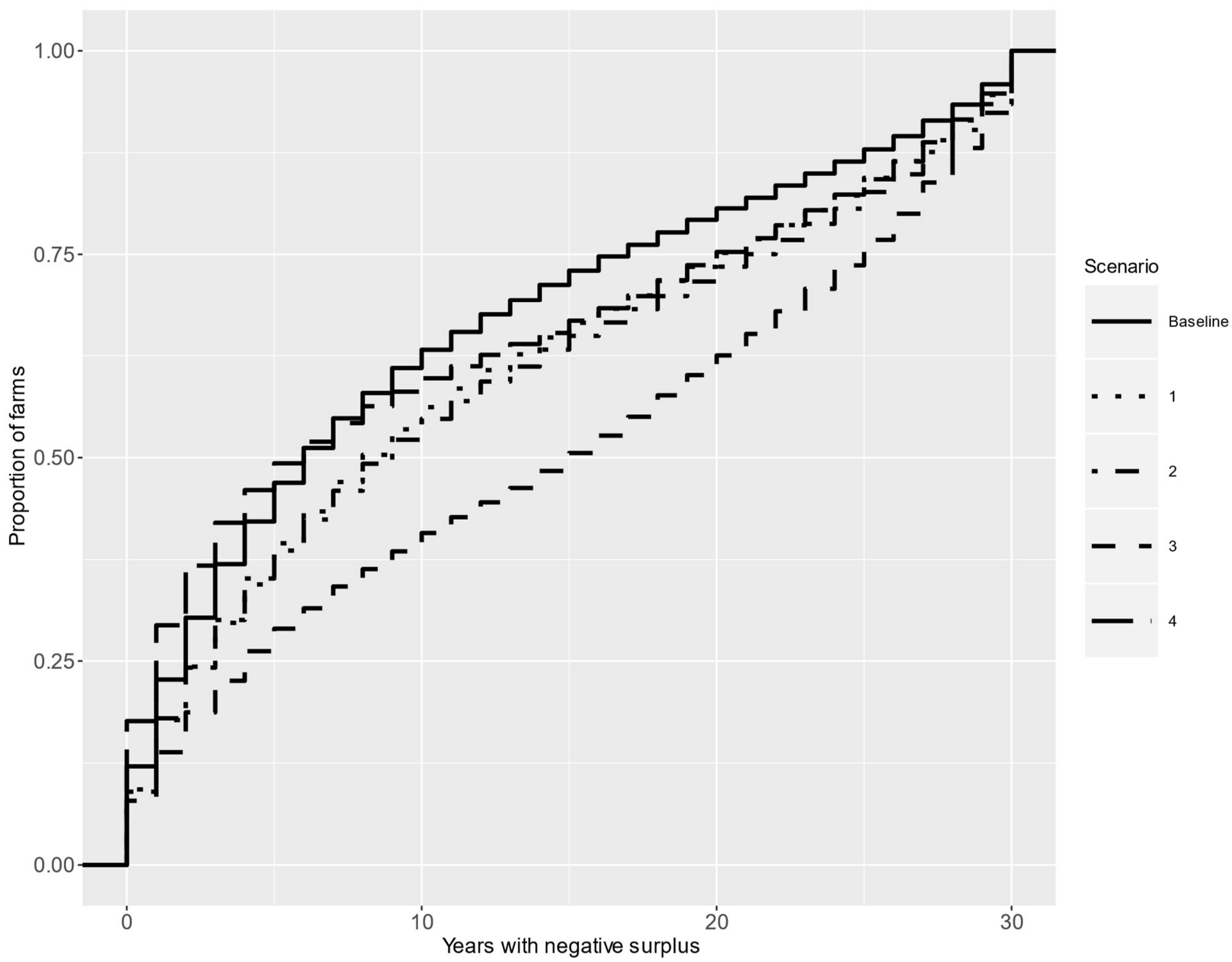
Annual-average operating profit is more disparate across all scenarios in 2045-50 (Figure 6, bottom graph). Larger required reductions in intensity mean that by 2045-2050 a moderate proportion of farms now earn a negative level of operating profit across both Scenarios 3 and 4. This is evident in that the distributions of operating profit for Scenarios 3 and 4 move away from being bell-shaped curves in 2025-30, to possessing long tails on the left-hand side of the dotted vertical line—which denotes an operating profit of $0/ha—by 2045-50.

Figure 7 presents the number of years that farms earn a negative surplus under each of the five scenarios. This surplus corresponds to the level of money left to the farmer after interest and tax have been subtracted from operating profit.[5] Each line of the graph represents a cumulative distribution function. Accordingly, a lower line for a scenario signifies that more farms experience more years with a negative surplus, relative to a scenario with a higher line. An example is illustrative: Assume we are interested in the results observed for half of the farming population across the study period—this corresponds to 50% or 0.5 on the vertical axis labelled “Proportion of farms”. If we move directly right from this number on the vertical axis until we hit the solid line denoting the result for the Baseline, we see it corresponds to a value of around six on the horizontal axis. This tells us that 50% of the farmers in the Baseline earn a negative surplus in six years or less across the 30-year period of interest. In comparison, if we move directly right from the 0.5 value on the vertical axis until we hit the dashed line denoting Scenario 3, it corresponds to a value of 15 on the horizontal axis. This shows that under the EF package, 50% of farmers instead earn a negative surplus over half of the study period under this policy. Similarly, three-quarters of farmers earn a negative surplus in 13 years or less in the Baseline, relative to 25 years or less in the EF case. Overall, these factors highlight how the proposed policy impacts farm profit, increasing the number of years in

[5] The level of operating profit utilised here includes adjustments for management and family labour; thus, it explicitly includes the consideration of drawings, as well.

which people earn negative levels of surplus and are thereby unable to service drawings, interest, and tax.

Figure 7. Impacts of each scenario on the number of years that farms earn a negative surplus. Surplus is what money is left after interest and tax are taken out of farm profit.

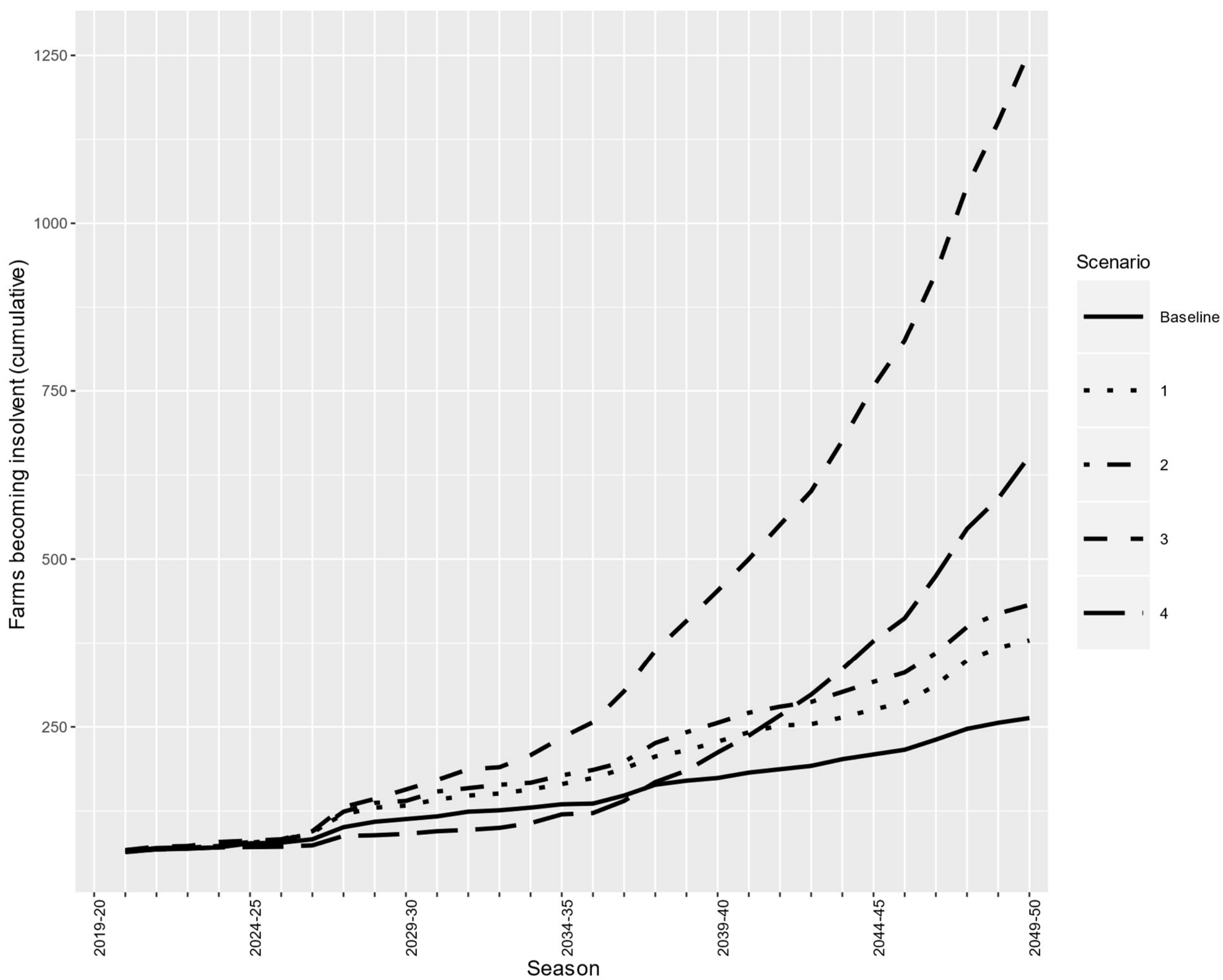


3.4 Essential Freshwater renders many farms insolvent

Figure 8 presents the cumulative sum of farms that are rendered insolvent across time due to an inability to meet debt obligations. Insolvency occurs when: (a) farm cashflow is negative at the average milk price, (b) farm cashflow is negative in the current season, and (c) the Debt-to-Asset ratio is greater than 95% (Hargreaves and Williamson, 2011;

Dunstan et al., 2015). Environmental regulations are forecast to greatly increase the risk of insolvency. Just over 2% of farms present in the initial year become insolvent by 2050 within the Baseline scenario. This increases to 11% of the total modelled population under the EF package defined in Scenario 3. Likewise, around 6.5% of the initial population are predicted to become insolvent under Scenario 4.

Figure 8. The cumulative number of farms that are rendered insolvent across time under each scenario.



3.5 Essential Freshwater greatly reduces the competitiveness of the dairy sector

The competitiveness of New Zealand dairy farms is determined by their capacity to remain profitable and solvent in the long term (Doole and Te Rito, 2018). The dairy sector is competitive if it survives and grows its share of global output markets across time (Sharples, 1990). The export-supply curve describes the international competitiveness of the New Zealand dairy sector, as determined by the nation's market share relative to the rest of the world. It represents the relationship between operating expenses per unit output and national milk production. An improvement in competitiveness is observed as a shift of the export-supply curve to the right, as this signifies a capacity to reduce the cost of producing a given quantity of output and increases market share. Likewise, any effect that shifts it to the left is consistent with reducing competitiveness.

Figure 9 presents pairs of average operating expenses per unit of milksolids and the corresponding level of total production for each of the five modelled scenarios for 2030-50[6]. Each pair represents a single year of data. The right-hand side of Figure 9 shows that the supply curves for the Baseline (labelled *Sbase*), Scenario 1 (*S1*), and Scenario 2 (*S2*) are broadly equivalent. However, as farms are required to impose higher levels of mitigation for nitrogen loss and methane emissions across time, milk production begins to fall dramatically (Figure 3). Those outcomes incorporating such dramatic reductions in milk production correspond to the supply curves for the full EF case (*S3* in Figure 9) and that present when greenhouse-gas regulation is considered too (*S4* in Figure 9). However, while production falls greatly, the level of operating expenses expressed per

[6] Technically, a supply curve should describe sector-level marginal costs of production. However, it is typical to report them in terms of average cost (IFCN, 2019), given the high uncertainty of marginal cost associated with the presence of complex feedbacks within grazing systems (Romera and Doole, 2015). This inconsistency between marginal and average cost highlights a gap between theory and practice and, hence, a need for care in interpretation.

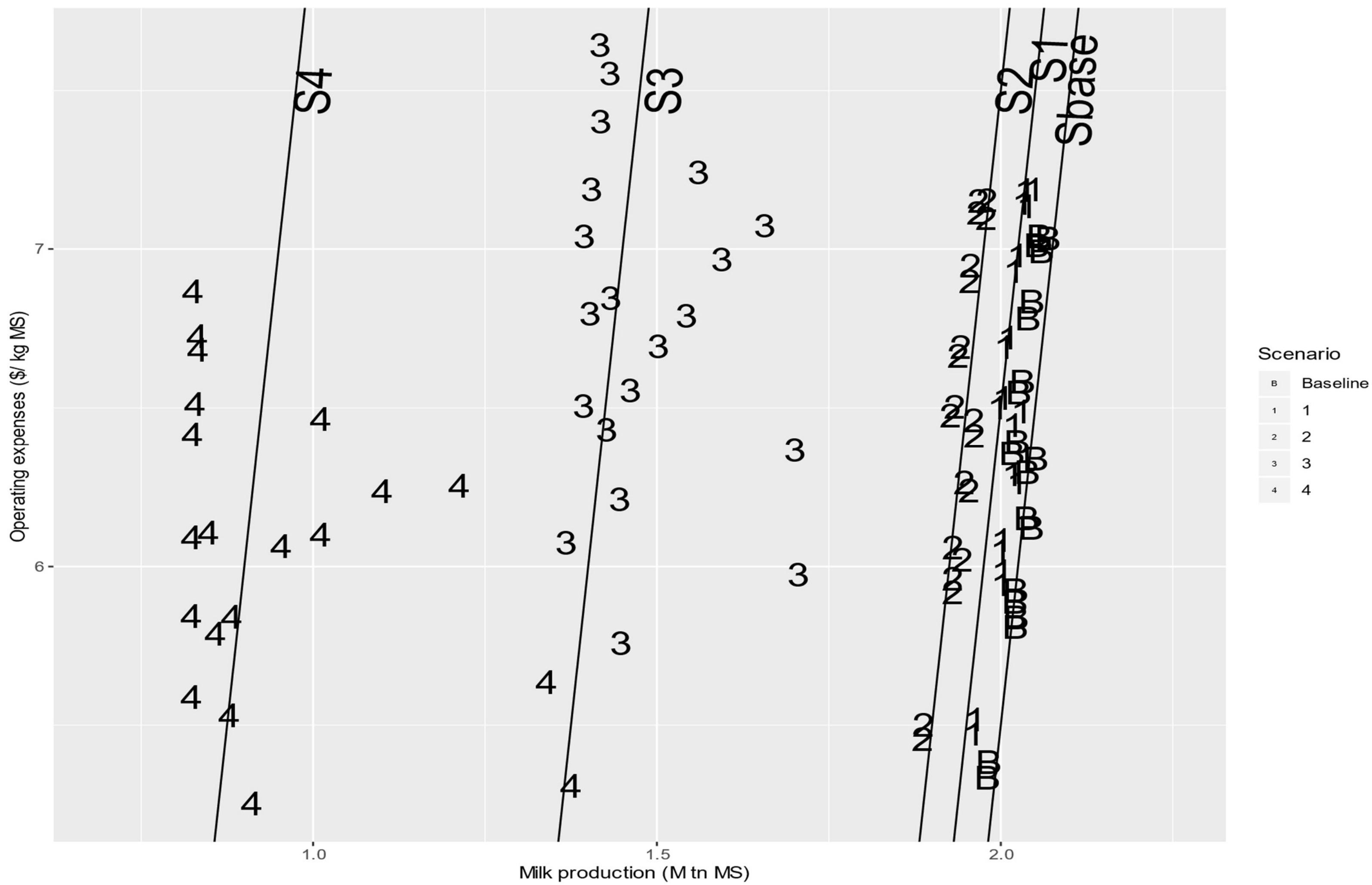
unit of output increases only marginally for Scenario 3 and stays relatively constant for Scenario 4 (Figure 9). Accordingly, the slope of the supply curves are maintained as equivalent across the five supply curves in Figure 9 labelled *Sbase* to *S4*.

The level of stability in operating expenses in Figure 9 hides a subtle, but intuitive, shift in its composition (Table 1). The proportion of expenses consisting of intensifying inputs, such as supplement and nitrogen fertiliser, falls markedly. Meanwhile, depreciation increases significantly in response to additional investment in mitigation capital, such as improved effluent systems and stand-off pads.

Table 1. The average percentage of operating expenses associated with different elements of cost for the Baseline (Base) and Scenario 3 (Sc3) for four equidistant milking seasons across the study period. For example, the value of 17% for supplement for the Base scenario in 2019-20 highlights that, on average across the farm population, 17% of operating expenses were attributable to supplement in that year in the model.

Variable	**2019-20**		**2029-30**		**2039-40**		**2049-50**	
	Base	**Sc3**	**Base**	**Sc3**	**Base**	**Sc3**	**Base**	**Sc3**
Supplement	17	16	17	11	17	12	18	13
Nitrogen fertiliser	6	6	5	3	5	4	5	4
Other fertiliser	3	3	5	5	5	4	5	5
Grazing	11	11	12	11	12	10	11	10
Labour	20	20	19	21	19	19	19	19
Livestock	8	8	8	8	7	7	7	7
Repairs and maintenance	7	7	6	6	6	6	6	6
Depreciation	8	9	9	14	9	18	9	19
Overhead	7	6	8	7	8	7	7	6
Other	12	12	13	13	13	12	13	12

Figure 9. Relationship between average operating expenses per unit of output and milk production for 2030-50. 20 numbers are present for each scenario, each representing a single year of data.



The leftward shifts of the export-supply curve under Scenarios 3 and 4 in Figure 9 denote a substantial decrease in the long-term global competitiveness of the New Zealand dairy sector. Technological change and innovation could potentially help to mediate these effects (Verspagen, 2009; van den Bergh and Kallis, 2013), particularly given the length of the transition period inherent to the policy instrument. A reduced level of dairy production could help motivate investment in efficiency improvements, mitigation research and uptake, and value-add strategies (Sauvage, 2014). These strategies may be particularly valuable if they help to open markets or build market share. For example, dairy farmers and/or manufacturers could potentially differentiate products, to pass costs associated with more-stringent environmental regulation of GHG-e along the value chain to consumers. Nonetheless, empirical evidence suggests that the strength of this relationship is relatively modest (Jaffe et al., 1995; Woods and Coleman, 2012), with recent work highlighting that regulation still often imposes a net cost on the regulated population (Dechezlepretre and Sato, 2017). Indeed, many studies fail to show a significant linkage between environmental regulation and industry competitiveness (Arlinghaus, 2015; Sense Partners, 2018; Naegele and Zaklan, 2019). This result is intuitive given that value-add strategies are: (a) difficult to maintain at high levels of production—which is a feature of New Zealand dairy production, even after the effects of EF are fully expressed (Figure 3); (b) expensive to develop given that they require large capital investment that can depreciate rapidly as a niche disappears through saturation (Grant, 2016); and (c) could be challenging to fund given that serious economic costs imposed on the sector due to environmental policy could erode investor confidence.

The capacity of value-add strategies to offset the losses accruing to the EF package is further limited in this case given the extent of the costs facing the sector. Indeed, an average real milk price of $7.74/kg MS—a price that is 25% higher than the current decadal average of $6.15/kg MS—is required for all milk produced by dairy farms in New Zealand in 2049-50 if the sector is to breakeven under EF. The emergence of potential substitutes for milk products derived from grazing cows—particularly those emerging from plant-based sources—will provide a persistent challenge to a sector seeking to attain higher output prices.

4. Conclusions

A mathematical model of the New Zealand dairy sector is utilised to explore the implications of the *Essential Freshwater* policy package. This analysis is important given that no cohesive economic assessment has been done which determines its impact on this important component of the New Zealand economy.

The *Essential Freshwater* policy package is predicted to have a profound detrimental impact on the New Zealand dairy sector, particularly once its impacts are fully realised at the end of its implementation phase.

Milk production is predicted to fall by around a third in the national dairy sector by 2040-50, while profits and tax revenue are forecast to halve by this time. The impacts of environmental regulation on milk production are further magnified when methane restrictions through the Zero Carbon Bill are simulated. In this case, milk production is forecast to fall by around 60% by the end of the study period. Yet, the introduction of a carbon price and free allocation helps to offset the costs of the EF program by allowing a proportion of dairy farmers to sell their carbon surplus. Notably, these costs do not include those accruing to policy aimed at the reallocation of irrigation water, which could be expected to further increase the burden of such mechanisms on the dairy sector.

The economic impact of *Essential Freshwater* is significant at the regional level, though the exact impact varies. Dairy profits are predicted to be negative in the Northland and Taranaki regions by 2045-50. Further, profit is predicted to fall by 70% in the Waikato region and by 50% in both Canterbury and Southland in this period. Waikato, Canterbury, and Southland experience a decline in production of around 33%, 50%, and 35%, respectively, by 2045-50.

Reduced milk production and the cost of mitigation activity with the *Essential Freshwater* package fundamentally change the distribution of operating profit within the New Zealand dairy sector. The proportion of the farmer population earning a positive level of profit decreases, while the proportion of farmers losing money, on average, grows. For example, the proportion of farmers unable to cover their interest and tax obligations for half of the 30-year period nearly doubles under the *Essential Freshwater* package. Reduced operating profit is forecast to lead to a significant increase in the probability of a farm becoming insolvent under the *Essential Freshwater* policy package. The number of insolvent farms is forecast across the study period to grow from 2% to 11%, due to the implementation of the *Essential Freshwater* package.

The impact of a policy regime on export competitiveness depends on its impacts on total production and to what degree the cost of production is affected. Here, it is predicted that operating expenses expressed per unit of milk output are unlikely to change substantially due to regulation. This is because decreases in expenditure arising from reduced production intensity are compensated for by increases in repairs and maintenance and depreciation associated with the uptake of capital assets for the purposes of mitigation. On the other hand, large reductions in milk production are forecast to accrue to the *Essential Freshwater* package. These signify a shift in the export-supply curve to the left for the New Zealand dairy sector, and hence suggest substantial erosion in its future global competitiveness.

References

Agribusiness Group. (2016). Stock exclusion costs report, Ministry of Primary Industries Technical Paper 2017/11, Wellington.

Alcala, F., and Ciccone, A. (2004). Trade and productivity, *Quarterly Journal of Economics.* 119, 613-646.

Arellano, M. (1987). Computing robust standard errors for within-groups estimators, *Oxford Bulletin of Economics and Statistics.* 49, 431-434.

Arlinghaus, J. (2015). Impacts of carbon prices on indicators of competitiveness: A review of empirical findings, OECD Environment Working Paper 2015/87, Paris.

Baltagi, B.H. (2013). Economic analysis of panel data, Wiley, New York.

Biological Emissions Reference Group. (BERG) (2018). Final report of the BERG, Ministry of Primary Industries, Wellington.

Bird, P. (2019). DairyNZ equity tool, DairyNZ, Hamilton.

DairyNZ. (2019). DairyNZ economic farm survey 2018/19, DairyNZ, Hamilton.

de Klein, C.A.M., Monaghan, R.M., Alfaro, M., Cameron, J.P., Gourley, C., Oenema, O.D., and Powell, J.M. (2017). Nitrogen performance indicators for dairy production systems, *Soil Research.* 55, 479-488.

Dechezlepretre, A., and Sato, M. (2017). The impacts of environmental regulations on competitiveness, *Review of Environmental Economics and Policy.* 11, 183-206.

Doole, G.J. (2012). Cost-effective policies for improving water quality by reducing nitrate emissions from diverse dairy farms: an abatement-cost perspective, *Agricultural Water Management.* 104, 10-20.

Doole, G.J., and Pannell, D.J. (2012). Empirical evaluation of nonpoint pollution policies under agent heterogeneity, *Australian Journal of Agricultural and Resource Economics.* 56, 82-101.

Doole, G.J. (2015). Efficient mitigation of nitrogen leaching in pasture-based dairy systems, *Nutrient Cycling in Agroecosystems.* 101, 193-209.

Doole, G.J. (2016). Description of mitigation options defined within the economic model for the Healthy Rivers Wai Ora Project, Waikato Regional Council report HR/TLG/2015-2016/4.6, Hamilton.

Doole, G.J., Quinn, J., Wilcock, B., and Hudson, N. (2016). Simulation of the proposed policy mix for the Healthy Rivers Wai Ora process, Waikato Regional Council report HR/TLG/2016-2017/4.5, Hamilton.

Doole, G.J. (2018). Economic assessment of allocating nitrogen based on sector ranges and Land Use Capability classifications in the Lake Rotorua catchment, DairyNZ, Hamilton.

Doole, G.J., and Te Rito, R. (2018). Assessing the competitiveness and resilience of the New Zealand dairy sector, DairyNZ, Hamilton.

Doole, G.J. (2019). Economic impacts of the Zero Carbon Bill on New Zealand dairy farms, DairyNZ, Hamilton.

Doole, G.J., and Romera, A.J. (2019). Benchmarks for farm financial performance in the New Zealand dairy sector, DairyNZ, Hamilton.

Doole, G.J., Kaine, G., and Dorner, Z. (2019). The optimal diffusion of mitigation options for environmental management, *Australian Journal of Agricultural and Resource Economics.* 63, 354-382.

Dorner, Z., Djanibekov, U., Soliman, T., Stroombergen, A., Kerr, S., Fleming, D.A., Cortes-Acosta, S., and Greenhalgh, S. (2018). Land-use change as a mitigation option for climate change, BERG report 18398, Wellington.

Dunstan, A., Skilling, H., Newman, M., and Mounsey, Z. (2015). An updated assessment of dairy sector vulnerabilities, Reserve Bank of New Zealand Bulletin 78(8), Wellington.

Enders, W. (2015). Applied econometric time series, Wiley, New York.

Fleishman, A. (1978). A method for simulating non-normal distributions, *Psychometrika.* 43, 521-532.

Gonzalez, C., and Dutt, V. (2011). Instance-based learning: integrating sampling and repeated decisions from experience, *Psychological Review.* 118, 523-551.

Grant, R.M. (2016). Contemporary strategic analysis, Wiley, New York.

Hargreaves, D., and Williamson, G. (2011). Stress testing New Zealand banks’ dairy portfolios, Reserve Bank of New Zealand Bulletin 74(2), Wellington.

Hausman, J.A., and Taylor, W.E. (1981). Panel data and unobservable individual effects, *Econometrica.* 49, 1377-1398.

International Farm Comparison Network (IFCN). (2019). Dairy report 2018: for a better understanding of the dairy world, IFCN, Kiel.

Jaffe, A.B., Peterson, S.R., Portney, P.R., and Stavins, R.N. (1995). Environmental regulation and the competitiveness of US manufacturing: What does the evidence tell us?, *Journal of Economic Literature.* 33, 132-163.

Journeaux, P. (2016). Farm environment plan project, AgFirst, Hamilton.

Koller, M. and Stahel, W.A. (2011). Sharpening Wald-type inference in robust regression for small samples, *Computational Statistics and Data Analysis.* 55, 2504-2515.

Kripfganz, S., and Schwarz, C. (2019). Estimation of linear dynamic panel data models with time-invariant regressors, *Journal of Applied Econometrics.* 34, 526-546.

Lawes, R.A., and Kingwell, R.S. (2012). A longitudinal examination of business performance indicators for drought-affected farms, *Agricultural Systems.* 106, 94-101.

Ledgard, S., Mapp, N., and Bartlett, N. (2017). Understanding nutrient losses on Waikato case study farms and the effectiveness of selected mitigation options, AgResearch Client Report RE 450/2017/072, Hamilton.

Leemis, L. (2016). Learning base R, Ingram, La Vergne.

Livestock Improvement Corporation (LIC)/DairyNZ. (2018). New Zealand dairy statistics 2017/2018, LIC/DairyNZ, Hamilton.

Local Government New Zealand (LGNZ). (2019). Initial economic advisory report on the Essential Freshwater package, LGNZ, Wellington.

Matheson, L., Djanibekov, U., Bird, B., and Greenhalgh, S. (2018). Economic and contaminant loss impacts on farm and orchard systems of mitigation bundles to address sediment and other freshwater contaminants in the Rangitāiki and Kaituna-Pongakawa-Waitahanui water management areas, Ministry for the Environment, Wellington.

McDonald, G. (2015). Economic impacts of the Healthy Rivers Wai Ora initiative—Freshwater Management Unit, regional, and national assessment, Healthy Rivers Wai Ora report HR/TLG/2015-2016/5.1, Auckland.

McDonald, G., and Doole, G.J. (2016). Regional- and national-level economic impacts of the proposed Waikato Regional Plan Change No. 1—Waikato and Waipa River Catchments, Waikato Regional Council report HR/TLG/2016-2017/4.5a, Hamilton.

Ministry for the Environment and Ministry of Primary Industries (MFE/MPI). (2018). Essential Freshwater: healthy water, fairly allocated, MFE/MPI, Wellington.

Ministry for the Environment (MFE). (2019a). Action for healthy waterways – A discussion document on national direction for our essential freshwater, MFE, Wellington.

Ministry for the Environment (MFE). (2019b). Action on agricultural emissions: A discussion document on proposals to address greenhouse gas emissions from agriculture, MFE, Wellington.

Ministry for the Environment (MFE). (2019c). Interim regulatory impact analysis for consultation: Essential Freshwater, MFE, Wellington.

Ministry of Primary Industries (MPI). (2019). Situation and outlook for primary industries: September 2019, MPI, Wellington.

Monaghan, R.M., de Klein, C.A.M., and Muirhead, R.W. (2008). Prioritisation of farm-scale remediation efforts for reducing losses of nutrients and faecal indicator organisms to waterways: a case study of New Zealand dairy farming, *Journal of Environmental Management.* 87, 609-622.

Monaghan, R.M., and de Klein, C.A.M. (2014). Integration of measures to mitigate reactive N losses to the environment from grazed pastoral dairy systems, *Journal of Agricultural Science.* 152, S45–S56.

Monaghan, R., McDowell, R., and Muirhead, R. (2012). Generalised estimation of mitigation performance and costs, Ministry for the Environment, Wellington.

Monaghan, R., McDowell, R., and Muirhead, R. (2016). Generalised estimation of mitigation performance and costs, Ministry for the Environment, Wellington.

Moran, E., Pearson, L.K., and Couldrey, M. (2017). The Southland economic project: agriculture and forestry, Environment Southland, Invercargill.

Muirhead, R., Monaghan, R., Smith, C., and Stantiall, J. (2016). Modelling farm-scale mitigation options for the Ruamahanga Whaitua collaborative modelling project, Ministry of Primary Industries, Wellington.

Muller, C.F., and Neal, M.B. (2019). The impact of nutrient regulations on dairy farm land values in Southland, *New Zealand Journal of Agricultural Research.* 62, 457-475.

Naegele, H., and Zaklan, A. (2019). Does the EU ETS cause carbon leakage in European manufacturing?, *Journal of Environmental Economics and Management.* 93, 125-147.

New Zealand Institute of Economic Research (NZIER). (2018). An analysis of the flow-on benefits of dairy's revenue generation, NZIER, Wellington.

Oltmans, A.W. (1995). Why farmland cannot, will not, and should not pay for itself, *Journal of American Society of Farm Managers and Rural Appraisers.* 95, 57-67.

Parsons, O.J., Doole, G.J., and Romera, A.J. (2015*).* On-farm effects of diverse allocation mechanisms in the Lake Rotorua catchment, BOPRC/DairyNZ, Hamilton.

Pickering, A. (2018). Methodology for calculation of New Zealand's agricultural greenhouse gas emissions, Ministry of Primary Industries Technical Paper No: 2018/69, Wellington.

Pinxterhuis, J.B., and Edwards, J.P. (2018). Comparing nitrogen management on dairy farms—Canterbury case studies, *Journal of New Zealand Grasslands.* 80, 201-206.

Productivity Commission. (2019). New Zealand, technology, and productivity, Productivity Commission, Wellington.

R Core Team. (2019). R: A language and environment for statistical computing, R Foundation for Statistical Computing, Vienna.

Romera, A.J., and Doole, G.J. (2015). Optimising the interrelationship between intake per cow and intake per hectare, *Animal Production Science.* 55, 384-396.

Sauvage, J. (2014). The stringency of environmental regulations and trade in environmental goods, OECD working paper 2014/3, Paris.

Sense Partners. (2018). Countervailing forces: Climate targets and implications for competitiveness, leakage*,* and innovation, Sense Partners, Wellington.

Sharples, J. (1990). Cost of production and productivity in analysing trade and competitiveness, *American Journal of Agricultural Economics.* 72, 1278-1282.

Stroombergen, A. (2019*).* Regional and national impacts of proposed environmental policies on the New Zealand dairy sector, Infometrics, Wellington.

Tietenberg, T., and Lewis, L. (2009). Environmental and natural resource economics, Addison-Wesley, Boston.

van den Bergh, J.C.J.M., and Kallis, G. (2013). A survey of evolutionary policy: normative and positive dimensions, *Journal of Bioeconomics.* 15, 281-303.

Verbeek, M. (2017). A guide to modern econometrics, Wiley, New York.

Verspagen, B. (2009). The use of modelling tools for policy in evolutionary environments, *Technological Forecasting and Social Change.* 76, 453-461.

Vibart, R., Vogeler, I., Dennis, S., Kaye-Blake, W., Monaghan, R., Burggraaf, V., Beautrais, J., and Mackay, A. (2015). A regional assessment of the cost and effectiveness of mitigation measures for reducing nutrient losses to water and greenhouse gas emissions to air from pastoral farms, *Journal of Environmental Management.* 156, 276-289.

Wilcox, R.R. (2017). Introduction to robust estimation and hypothesis testing, Academic Press, San Diego.

Woods, D., and Coleman, A. (2012). Price, quality, and international agricultural trade, Motu Working Paper No. 12-08, Wellington.

Wooldridge, J.M. (2010). Econometric analysis of cross section and panel data, MIT Press, Cambridge.

Appendix 1. Economic impacts of an alternative nitrogen limit (3.8 g/m^3)

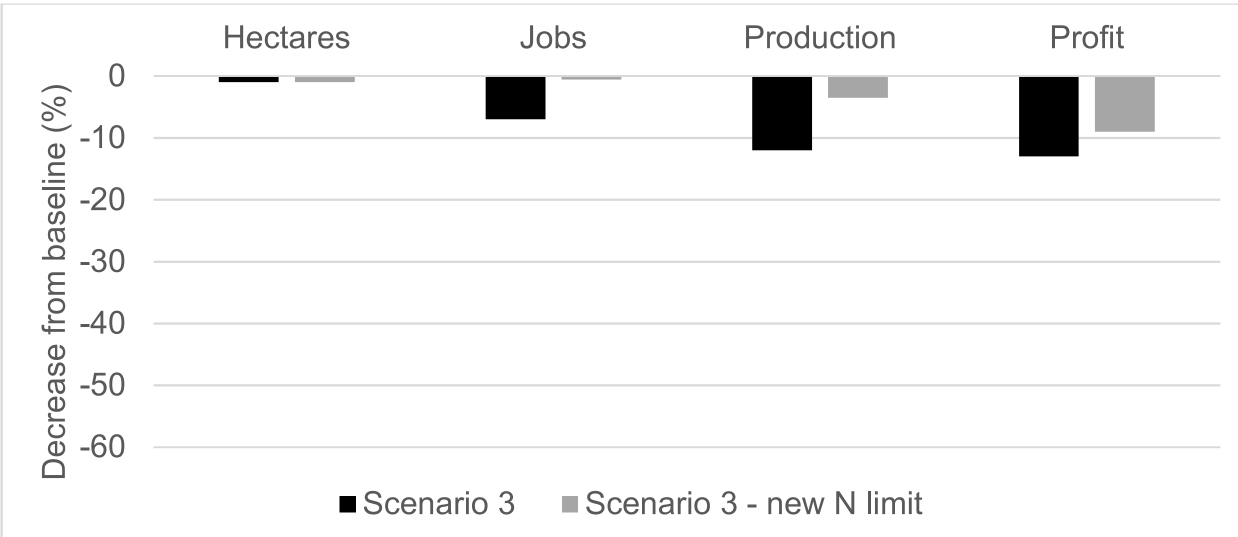
Scenario analysis reported in Section 3 identifies that it is the limits for Dissolved Inorganic Nitrogen (DIN) and Dissolved Reactive Phosphorus (DRP) within the *Essential Freshwater* package that incur the largest economic impacts on the dairy sector. An alternative is to continue to focus efforts on implementing the periphyton attribute, and developing site- or catchment-specific, targeted action plans to improve ecosystem health.

With respect to national bottom-lines, a more-robust and defensible proposition is to lower the nitrate toxicity bottom-line so that it is protective (with respect to chronic, non-lethal effects) of 90% of aquatic species—better providing for even the most-sensitive native fish and invertebrates. This increased protection for native aquatic fauna corresponds to a median nitrate concentration of 3.8 g/m^3. The economic impacts of this new limit is modelled, with key output presented below. As DRP is not directly toxic, there is no separate attribute (and hence limit) simulated for DRP here. The preferred method for managing trophic effects from DIN and DRP is via a limit-setting process for the periphyton attribute, or via the proposed 'action plan' attributes, such as macroinvertebrates and dissolved oxygen, which may require more-stringent management of nutrients.

Figure A1 compares the impact of the standard set of regulations simulated for the *Essential Freshwater* package in this report (Scenario 3) and an alternative scenario in which this new nitrogen limit replaces those for DIN and DRP (Scenario 3 – new N limit). This graph compares the impact of these scenarios on baseline dairy farm area, jobs, production, and operating profit in 2030. Figures A2 and A3 present the same data for 2040 and 2050, respectively.

Figure A1 shows that the short-term reductions in farm area, jobs, and production are much reduced for the new nitrogen limit, relative to the standard Scenario 3. Nevertheless, notable losses in operating profit are evident across both scenarios, with both incurring around a 10% loss in baseline profit across the sector.

Figure A1. The forecast national impact of the *Essential Freshwater* package, both without (labelled Scenario 3) and with the new proposed nitrogen limit (labelled Scenario 3 – new N limit). Impacts are presented for dairy farm area, jobs, production, and operating profit in 2030.



Figures A2 and A3 demonstrate that the growing stringency of the DIN and DRP limits in Scenario 3 mean that losses in hectares, jobs, production, and operating profit relative to the baseline grow across the simulated transition period. In contrast, though these costs do grow across time when Scenario 3 is updated to include the new nitrogen limit, the rate of growth is so slow that the costs are essentially stable across time. Indeed, losses in hectares, jobs, production, and operating profit relative to the Baseline remain around 2%, 2%, 5%, and 10% across the study period for the new scenario (Figures A1-A3).

These outcomes reflect the lower number of farms that are required to reduce their baseline leaching under the updated set of regulations, together with an overall reduction in the stringency of the limits placed on those farms where it is necessary to mitigate.

Figure A2. The forecast national impact of the *Essential Freshwater* package and a proposed variant. Impacts are presented for dairy farm area, jobs, production, and operating profit in 2040.

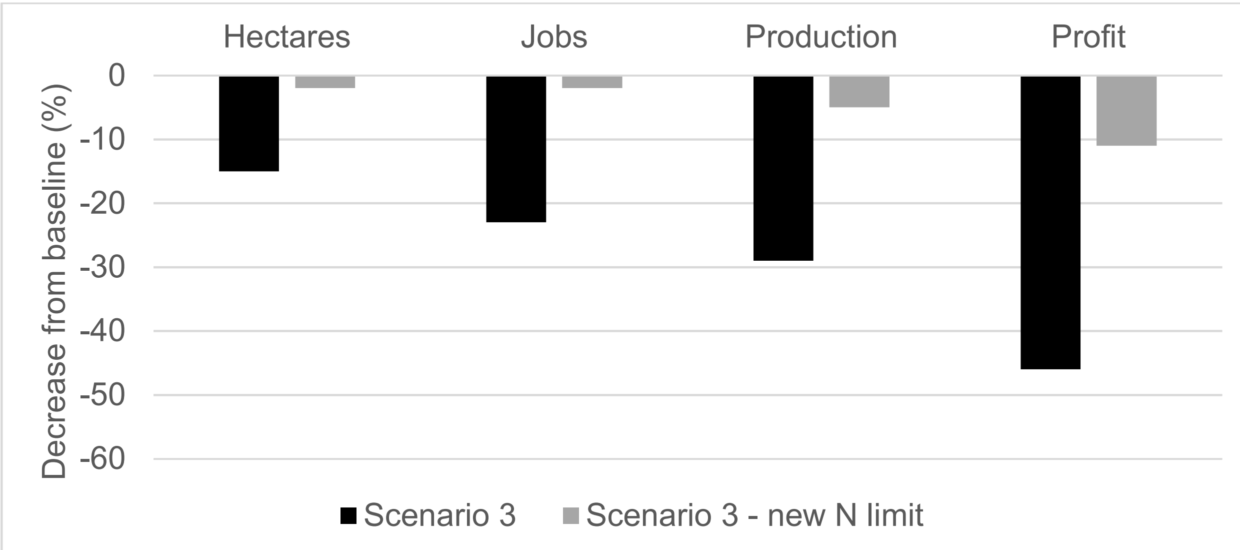
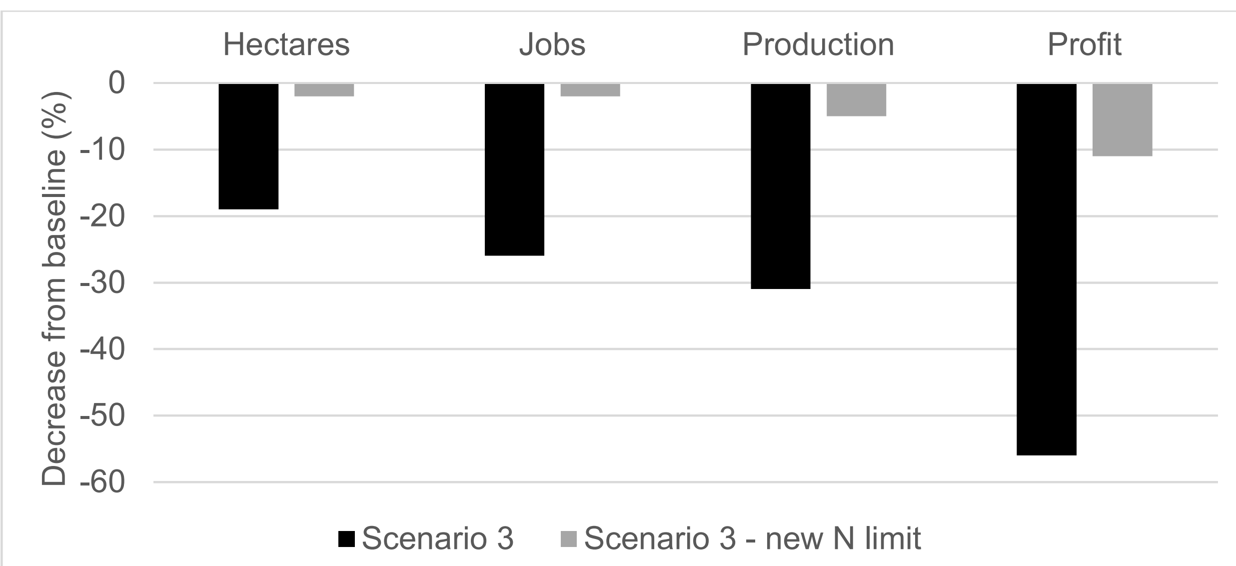


Figure A3. The forecast national impact of the *Essential Freshwater* package and a proposed variant. Impacts are presented for dairy farm area, jobs, production, and operating profit in 2050.



Regional and National Impacts of Proposed Environmental Policies on the New Zealand Dairy Sector

for DairyNZ

October 2019

Infometrics

Economics put simply

Authorship

This report has prepared by Adolf Stroombergen.

Email:

adolf.stroombergen@infometrics.co.nz

Table of contents

1. Introduction

Infometrics has been requested by DairyNZ to investigate the economic effects of two sets of environmental policies that will affect dairy farming:

- Essential Freshwater package
- Emissions targets for biogenic methane

We use a computable general equilibrium (CGE) model of the New Zealand economy to assess how these industry policies affect the wider economy and whether there are any feedback effects on dairy farming.

It is beyond the scope of this report to assess the health and recreational benefits of cleaner water, so such benefits should be compared to any macroeconomic costs of the proposed policies as estimated in this report.

With regard to lower GHG emissions, the direct benefit to New Zealand is of course negligible, but there may be reputational benefits that translate into more tangible economic effects such as increased trade and tourism opportunities. These effects are not captured in the analysis. We do, however, capture the main direct benefit which is the saving in the cost of purchasing international emission units, should New Zealand adopt such a strategy as part of a future international emissions responsibility target.

In summary we find mixed results at the macroeconomic level. The tighter versions of the clean water policies lead to lower exports and a smaller gross domestic product relative to 'business as usual' (BAU), but there are no losses or very small gains in private consumption and real national disposable income.

Emissions fall under the policies, leading to less expenditure on international emission units (assuming constant forestry), thereby releasing a greater share of national income for private (household) consumption. A further positive effect comes from a lift in the international terms of trade consequent to fewer sales of lower value dairy products and fewer sales of any products in low value markets. Such products and markets are the first to be abandoned when supply falls.

In general the CGE model suggests that the reductions in dairy farm output relative to BAU are not as severe as indicated by the DairyNZ model. This is unsurprising as the latter is a partial-equilibrium model that does not consider feedback effects such as changes in the cost of labour and land. The proposed policies may lead to insolvency for some dairy farmers, but this does not mean that the associated land is inherently unprofitable if used for dairy farming, provided it is purchased at a lower price.

At a regional level the CGE results are reasonably similar to those from the DairyNZ model. The CGE model helps to identify which regions are more resilient to the effects of shocks to the dairy industry, but implicitly assumes that dairy farms in one region are as exposed to environmental policies as dairy farms in any other region.

2. Methodology

We use the ESSAM general equilibrium model of the New Zealand economy to investigate the national costs and benefits of applying regulations on water quality and methane emission to dairy farming.

ESSAM Model

The ESSAM (Energy Substitution, Social Accounting Matrix) model is a multi-industry computable general equilibrium (CGE) model of the New Zealand economy. An outline is provided in Appendix A.

As with any model, CGE models can only approximate the highly complex real economy. Therefore the results can only ever be indicative. The interpretation of CGE results should centre on their direction (up or down) and broad magnitude (small, medium or large), rather than on the precise point estimates that the model produces. Essentially we are modelling scenarios: such modelling "does not predict what will happen in the future. Rather, it is an assessment of what could happen in the future, given the structure of the models and input assumptions."[1]

Business as Usual Scenario

The model is used to produce a Business as Usual (BAU) scenario for 2050. These are theoretical constructs of what the economy might look like at a future point in time with existing policies to reduce greenhouse emissions – or at least as best we can extrapolate them, and without any other major changes in policy or large exogenous economic shocks. The function of the BAU scenario is purely to act as a point of comparison against which other scenarios can be compared.

Two key background assumptions for the BAU scenario and all other scenarios are:

1. New Zealand population is projected to be 5.152 million in 2029/30 and 6.135 million in 2049/50. (StatsNZ 50th percentiles).
2. Real oil price is US$100/bbl in 2029/30 and remains there (on average) over the period to 2049/50.

More detail on the assumptions is given in the section on scenario specification.

Model Closure

The following model closure rules are adopted for the alternative scenarios, consistent with generally accepted modelling practice applied to long run scenarios:

1. The current account balance is fixed as a percentage of GDP. This means for example that if New Zealand needs to purchase international emissions units to meet an emissions responsibility target, that liability cannot be met simply by borrowing more from offshore with indefinitely deferred repayment.

[1] Australian Treasury. (2008). *Australia's low pollution future: the economics of climate change mitigation*. Online at http://www.treasury.gov.au/lowpollutionfuture/report/default.asp

2. The post-tax rate of return on investment is unchanged between scenarios, so for example if agricultural profitability is adversely impacted by clean water policies, profitability must eventually be restored. This acknowledges that New Zealand is part of the international capital market and ensures consistency with the preceding closure rule.

3. Any change in the demand for labour is reflected in changes in wage rates, not changes in employment. This prevents the long run level of total employment being driven more by environmental policy than by the forces of labour supply and demand, which we consider unlikely.

4. The fiscal balance is fixed across scenarios. This means for example that if the government needs to purchase overseas emission units it must ensure that it has matching income. If it earns insufficient income from the sale of domestic emission units (because of free allocation for example) it would have to adjust tax rates. We assume that net household effective income tax rates are the default equilibrating mechanism, although changing government expenditure or other tax rates are alternative options that could be used.

Scenarios

Specification

The BAU scenarios share the following characteristics:

1. By 2050 the ETS carbon price is $150 per tonne of CO_2e, which is assumed to be in line with carbon prices in New Zealand's major trading partners.
2. Free allocation for CO_2 emissions-intensive trade-exposed (EITE) industries is phased out at 1% pa from 2021 to 2030, 2% pa from 2031 to 2040 and 3% per annum from 2041 to 2050. Thus by 2050 free allocation is at 54.5% of the levels in 2020. This profile is in line with the government's current proposals.
3. Agricultural emissions of CH_4 and N_2O enter the ETS around 2025 with 95% free allocation. At this stage nothing is known about how that might be phased out. We assume 75% free allocation remains by 2050. These assumptions are varied in Scenario 4.
4. Reduction in emissions of CH_4 and N_2O per unit of agricultural output of 0.3% pa.[2] Again this is changed in Scenario 4.
5. There are no other policies to reduce biogenic methane emissions. Explicit methane targets are not in the BAU, but are explored in Scenario 4 too.
6. New Zealand is assumed to have a net zero emissions target by 2050 (although in practice this may apply only to long-lived gases). If this target is not achieved it is assumed that the deficit will be covered by the purchase of *bona fide* international units, at the world price of $150/tonne CO_2.
7. Net forestry emissions are negative (absorption): 45,000 kt in 2049/50. See Productivity Commission (2018).[3]

The DairyNZ scenarios have all of the above features unless otherwise specified in the scenarios below.

Scenario 1

Scenario 1 is relatively small scale and comprises the following on-farm actions:

1. Shifting of existing fences on larger streams such that the average setback is 5m.
2. Development of a farm plan that is regularly audited and updated.
3. Consent application for farmers with an existing stand-off pad.
4. Fencing of smaller streams under a farm plan.

[2] Based on work for the Biological Emissions Reference Group report: https://www.mpi.govt.nz/protection-and-response/environment-and-natural-resources/biological-emissions-reference-group/

[3] New Zealand Productivity Commission (2018) Low-Emissions Economy.

5. Capital expenditure to improve the base system, according to activities under a farm plan. This could include things such as effluent pond sealing, culvert maintenance, laneways, races, etc.

For CGE modelling the main input shock is an increase in the capital-output ratio of 19.4%. There is also a small reduction in labour productivity of 1.9%.

Scenario 2

As in Scenario 1 plus the introduction of catchment-specific nitrogen caps in a proposed collection of priority catchments around New Zealand. These caps require farms above a certain threshold for nitrogen leaching to reduce their leaching to that level. In this analysis farms that are above the 75th percentile of nitrogen loss are required to reduce their emissions to the 75th percentile level in these priority catchments.

The increase in the capital-output ratio is almost the same as in Scenario1; 19.8%, but there are also some minor changes in the composition of farm expenditure, notably relatively less on supplementary feed, fertiliser and grazing, and relatively more on repairs and maintenance. Labour intensity increases by 3.6%.

Scenario 3

As in Scenarios 1 and 2 plus broadscale introduction of phosphorus and nitrogen leaching reductions to meet new proposed limits for Dissolved Phosphorus and Dissolved Inorganic Nitrogen in monitored catchments.

For CGE modelling the main input shock is an increase in the capital-output ratio of 197%, accompanied by larger changes in the composition of farm expenditure than those in Scenario 2, including labour intensity which is higher by 7.8% compared to BAU.

Scenario 4

In Scenario 4 the focus is changed from water quality to methane emissions, but modelled as being in addition to the effects of water quality policy simulated in Scenario 3.

Two methane targets are modelled; a 10% reduction by 2030 and a 36% reduction by 2050. The long-term goal is a midpoint between the lower and upper bounds provisionally set in the Zero Carbon Bill.

Commensurate with the methane reduction targets proposed under the Zero Carbon Bill a number of on-farm measures are expected to reduce methane emissions per unit of output by 27%. Herd size is estimated to fall by 49% and output by 60%. As with Scenarios 1-3, the most important shocks to the model are again increases in capital and labour intensity; 246% and 21% respectively, plus changes in the composition of expenditure. Most notable are a 98% decline in spending on nitrogen fertiliser and a 94% decline in supplement expenditure.

The amount of free allocation for biogenic CH_4 and N_2O emissions is lowered from 75% in the BAU to 65%.

For further detail on any of the scenarios see Doole (2019).[4]

[4] Doole G (2019) *Economic impacts of the Essential Freshwater proposals on New Zealand dairy* farms, DairyNZ, Hamilton.

Main Results

The strength of the model is in analysing differences between scenarios. Thus we omit discussion of the BAU other than to say that the growth in GDP to 2050 averages 2.1% pa from 2018. The main results are summarised in Table 1, concentrating on a number of key measures.

Gross domestic product (GDP) is the value of all final goods and services in an economy. It is a primary measure of economic activity in an economy and a positive/negative change in GDP indicates economic growth/shrinkage.

Private consumption indicates how much money households spend on goods and services. It accounts for around 60% of GDP.

Real Gross National Disposable Income (RGNDI) is GDP adjusted for net offshore factor payments (such as interest and dividend flows) and for changes in the terms of trade. A higher level of RGNDI is generally consistent with a better standard of living.

The *real wage rate* is the average inflation-adjusted level of wages in the economy. It helps to denote at a general level how a given shock to the model impacts on the price of an important economic input, labour.

Table 1: Summary of Key Results

	BAU	Scen 1	Scen 2	Scen 3	Scen 4
Macroeconomy			Change on BAU		
Private consumption		0.1%	0.0%	0.1%	0.3%
Exports		-0.7%	-0.7%	-5.2%	-6.5%
Imports		-0.1%	-0.1%	-0.7%	-0.7%
GDP		-0.1%	-0.2%	-1.1%	-1.3%
RGNDI		0.1%	0.0%	0.2%	0.3%
Real wage rate		-0.2%	-0.3%	-2.2%	-2.7%
Industry Gross Output		-0.2%	-0.3%	-2.0%	-2.6%
Dairy Farming					
Output		-3.1%	-3.2%	-24.0%	-27.7%
Employment		-1.2%	0.4%	-17.2%	-10.4%
Dairy Processing					
Output		-3.0%	-3.1%	-23.5%	-27.3%
Employment		-1.2%	-1.2%	-10.2%	-12.3%
Emissions			CO_2e (Mt)		
Gross emissions	77.0	76.2	76.1	70.4	65.0
Agricultural CH_4 & N_2O	37.8	37.0	37.0	31.6	26.3

Scenario 1

In the DairyNZ analysis (Doole, 2019) the projected fall in production relative to BAU is 1%. In the CGE model, however, the implied reduction in the rate of return to capital (profitability) is too large in the long run to sustain a fall in production of only 1% – the fall increases to 3.1%.

With the decline in dairy output there is an accompanying decline in GHG emissions of 0.8%, but most of the macroeconomic effects are too small to be statistically significant. Exports fall by 0.7% and GDP falls by 0.1%. The latter does not translate into a decline in RGNDI, which actually increases marginally due to the lower demand for international emission units, and an increase in the terms of trade as dairy exports move up the demand curve. That is, the dairy commodities and/or markets that earn least are the first to be abandoned when supply is lower.

Scenario 2

The macroeconomic results are almost identical to those for Scenario 1, implying that the aggregate effects of the changes in the composition of on-farm expenditure due to this part of the Essential Freshwater policy are minimal. The dominant effect in both scenarios is the change in dairy farming capital intensity – the additional investment that is required to meet the new water quality standards.

The fall in milk production is 3.2%, compared to a fall of 4.7% estimated by the DairyNZ model. Thus in contrast to Scenario 1, the CGE model now produces a smaller decline in production than the DairyNZ model. There would appear to be some ameliorative effect from changing the mix of on-farm expenditure.

Scenario 3

At the macroeconomic level the results are directionally similar to, but more pronounced than those in Scenarios 1 and 2. Exports decline by 5.2% and GDP is lower by 1.1%. Private consumption and RGNDI rise by 0.1% and 0.2% respectively, again thanks to the reduction in emissions (saving over $1,000m in the cost of international emission units) and better terms of trade.

For this scenario the capital intensity of dairy farming was raised by almost 200% (based on output from the DairyNZ model), which in that model is associated with a 31.6% fall in production. However, the CGE model produces a somewhat smaller decline in of 24%.

From Scenario 2 it is clear that changes in on-farm expenditure help to mitigate the fall in output, but in Scenario 3 a stronger effect comes from the fall in exports which exerts negative pressure on factor prices, with real wage rates for example falling by 2.2% relative to BAU. Rates of return on capital are fixed at the BAU levels (closure assumption 2), but part of that adjustment includes a reduction in land prices. This means that although negative profitability forces some dairy farmers into insolvency (as analysed specifically in the DairyNZ model) the associated land is still inherently profitable as a dairy farm provided it can be purchased at a lower price. Only about 5% of dairy land in the BAU is not used in dairy farming in Scenario 3, signifying the low relative profitability of alternative land uses in many of these areas.

These changes provide some offset to the decline in the competitiveness of dairy farming, preventing the substantial fall in production estimated by the DairyNZ model – which is of course a partial equilibrium model and thus does not capture feedback effects from the rest of the economy.

Scenario 4

The results for Scenario 4 continue the trend set by the previous scenarios. The reductions in exports (-6.5%) and GDP (-1.3%) are worse than in Scenario 3, while the benefit of much lower emissions and hence lower cost of international emission units, flows straight through to higher private consumption, which is up by 0.3% on BAU.

Relative to the BAU, total emissions are almost 16% lower, largely driven by emissions of methane and nitrous oxide from agriculture which fall by 30% relative to BAU.

Again the model has a smaller change in dairy farm output than suggested by the DairyNZ model; -28% compared to -60%. The former is still a significant reduction, but the difference from the DairyNZ result is much larger than in Scenario 3. Lower factor prices are again at play, but the main reason for the larger difference is that although Scenario 3 already includes a carbon price of $150/tonne CO_2e (albeit with 75% free allocation instead of the 65% in Scenario 4), there is no explicit target for methane reductions. Methane emissions do decline in Scenario 3, but that is a consequence of the clean water policies, not the carbon price which is also in the BAU.

In contrast, in Scenario 4 the methane reduction target must be met. In the DairyNZ model this outcome has a high cost and there are many insolvencies. Again the CGE model suggests that much of the land can remain in dairy farming as it can be purchased by other farmers at lower cost or, more realistically if policies are announced with sufficient warning, such land sees less of an escalation in value by 2050 under Scenario 4 than under the BAU.

Industry and Region

Table 2 shows how broad industry groups fare under Scenario 3 and 4 in terms of gross output, while Table 3 presents estimated changes in GDP at the regional level for those two scenarios.

Table 2: Industry Gross Output

	Scen 3	Scen 4
	Change on BAU	
Dairy Farming	-24.0%	-27.7%
Meat Processing	-3.9%	-5.3%
Dairy processing	-23.5%	-27.3%
All Agriculture	-11.6%	-15.0%
Fishing, Forestry, Mining	-0.3%	-0.7%
All Food Processing	-13.0%	-15.3%
Other Manufacturing	-1.1%	-2.0%
Electricity, Gas, Water	-1.0%	-1.2%
Construction	0.2%	0.4%
Trade & Transport	-1.3%	-1.6%
Other Services	-0.5%	-0.7%
Total	-2.0%	-2.6%

Industries that gain (or lose less) when fewer resources are used in dairy farming include services (such as Education and Medical Services) and Construction. Note that this is not a case of farmers becoming builders, or tractors being turned into equipment for medical research. Rather, it means that over the period to 2050 fewer people become farmers than under a scenario where there are no (or less stringent) clean water or emissions policies. Similarly, more investment is directed into the education and medical sectors as opposed to fences and irrigation ponds.

The 28% decline in dairy output relative to BAU in Scenario 4 (Table 1) means that the industry grows at about 1% pa less under the proposed polices than it otherwise would.

Table 3: GDP Effects by Region

	Scen 3	Scen 4
	Change on BAU	
Auckland	-0.8%	-1.1%
Bay of Plenty	-1.3%	-1.6%
Canterbury	-1.4%	-1.6%
Gisborne	-1.2%	-1.7%
Hawke's Bay	-1.4%	-1.9%
Manawatu-Wanganui	-1.5%	-1.7%
Marlborough	-2.5%	-3.2%
Nelson	-0.8%	-1.0%
Northland	-1.5%	-1.7%
Otago	-1.1%	-1.4%
Southland	-3.5%	-3.6%
Taranaki	-2.8%	-2.9%
Tasman	-1.4%	-1.9%
Waikato	-2.2%	-2.2%
Wellington	-0.7%	-1.0%
West Coast	-2.9%	-2.7%
Total NZ[5]	-1.2%	-1.5%

In the DairyNZ model the regions that are most negatively affected are Taranaki and the combined Marlborough & Canterbury region. The CGE results in Table 3 also show broadly similar results. Taranaki and Marlborough are amongst the worst affected regions, but in Scenario 3 Southland and West Coast experience the largest falls in regional GDP. In Scenario 4 Southland and Marlborough are worst affected.

The numbers in Table 3 are based on a top-down approach that uses an industry by region matrix estimated from StatsNZ IDI data for 2018. Hence the regions that fare most poorly are those that do not have industries that become more competitive with the decline in dairying. Conversely regions such as Auckland and Wellington with little dairy farming are relative winners.

Although this top-down approach helps to asses the resilience of regions to clean water and emissions polices, the CGE model lacks information on which regions have farms that are most exposed to such policies. That is, the results suggest that Northland is more resilient than Waikato to adverse events in the dairy industry, but they do not take into account, for example, whether dairy farms in Northland produce more or fewer kilograms of nitrogen or greenhouse gas emissions per kilogram of milksolids than dairy farms in Taranaki – and thus which regions incur the sharpest initial shock. The results also do not consider where farmers are most at risk of insolvency, nor the extent to which land might remain in dairying.

[5] At the regional level GDP is valued at factor prices whereas nationally it is valued at market prices, which include some indirect taxes, so the total change across all regions is not necessarily exactly the same as the national change.

Appendix A: ESSAM Model

The ESSAM (Energy Substitution, Social Accounting Matrix) model is a general equilibrium model of the New Zealand economy. It takes into account the main inter-dependencies in the economy, such as flows of goods from one industry to another, plus the passing on of higher costs in one industry into prices and thence the costs of other industries.

The ESSAM model has previously been used to analyse the economy-wide and industry specific effects of a wide range of issues. For example:

- Analysis of the New Zealand Emissions Trading Scheme and other options to reduce greenhouse gas emissions
- Changes in import tariffs
- Public investment in new technology
- Funding regimes for roading and wider economic benefits
- Release of genetically modified organisms

Some of the model's features are:

- 55 industry groups, as detailed in the table below.
- Substitution between inputs into production - labour, capital, materials, energy.
- Four energy types: coal, oil, gas and electricity, between which substitution is also allowed.
- Substitution between goods and services used by households.
- Social accounting matrix (SAM) for tracking financial flows between households, government, business and the rest of the world.

The model's output is extremely comprehensive, covering the standard collection of macroeconomic and industry variables:

- GDP, private consumption, exports and imports, employment, etc.
- Demand for goods and services by industry, government, households and the rest of the world.
- Industry data on output, employment, exports etc.
- Import-domestic shares.
- Fiscal effects.

Model Structure

Production Functions

These equations determine how much output can be produced with given amounts of inputs. For most industries a two-level standard translog specification is used which distinguishes four factors of production – capital, labour, and materials and energy, with energy split into coal, oil, natural gas and electricity.

Intermediate Demand

A composite commodity is defined which is made up of imperfectly substitutable domestic and imported components - where relevant. The share of each of these components is determined by the elasticity of substitution between them and by relative prices.

Price Determination

The price of industry output is determined by the cost of factor inputs (labour and capital), domestic and imported intermediate inputs, and tax payments (including tariffs). World prices are not affected by New Zealand purchases or sales abroad.

Consumption Expenditure

This is divided into Government Consumption and Private Consumption. For the latter eight household commodity categories are identified, and spending on these is modelled using price and income elasticities in an AIDS framework. An industry by commodity conversion matrix translates the demand for commodities into industry output requirements and also allows import-domestic substitution.

Government Consumption is usually either a fixed proportion of GDP or is set exogenously. Where the budget balance is exogenous, either tax rates or transfer payments are assumed to be endogenous.

Stocks

The industry composition of stock change is set at the base year mix, although variation is permitted in the import-domestic composition. Total stock change is exogenously set as a proportion of GDP, domestic absorption or some similar macroeconomic aggregate.

Investment

Industry investment is related to the rate of capital accumulation over the model's projection period as revealed by demand for capital in the horizon year. Allowance is made for depreciation in a putty-clay model so that capital cannot be reallocated from one industry to another faster than the rate of depreciation in the source industry. Rental rates or the service price of capital (analogous to wage rates for labour) also affect capital formation. Investment by industry of demand is converted into investment by industry of supply using a capital input- output table. Again, import-domestic substitution is possible between sources of supply.

Exports

These are determined from overseas export demand functions in relation to world prices and domestic prices inclusive of possible export subsidies, adjusted by the exchange rate. It is also possible to set export quantities exogenously.

Supply-Demand Identities

Supply-demand balances are required to clear all product markets. Domestic output must equate to the demand stemming from consumption, investment, stocks, exports and intermediate requirements.

Balance of Payments

Receipts from exports plus net capital inflows (or borrowing) must be equal to payments for imports; each item being measured in domestic currency net of subsidies or tariffs.

Factor Market Balance

In cases where total employment of a factor is exogenous, factor price relativities (for wages and rental rates) are usually fixed so that all factor prices adjust equi-proportionally to achieve the set target.

Income-Expenditure Identity

Total expenditure on domestically consumed final demand must be equal to the income generated by labour, capital, taxation, tariffs, and net capital inflows. Similarly, income and expenditure flows must balance between the five sectors identified in the model – business, household, government, foreign and capital.

Industry Classification

The 55 industries identified in the standard ESSAM model are defined on the following page. Industries definitions are according to Australian and New Zealand Standard Industrial Classification (ANZSIC06).

Input-Output Table

The model is based on Statistics New Zealand's latest input-output table which relates to 2012/13.

Model Industries

1	HFRG	Horticulture and fruit growing
2	SBLC	Sheep, beef, livestock and cropping
3	DAIF	Dairy and cattle farming
4	OTHF	Other farming
5	SAHF	Services to agriculture, hunting and trapping
6	FOLO	Forestry and logging
7	FISH	Fishing
8	COAL	Coal mining
9	OIGA	Oil and gas extraction, production & distribution
10	OMIN	Other Mining and quarrying
11	MEAT	Meat manufacturing
12	DAIR	Dairy manufacturing
13	OFOD	Other food manufacturing
14	BEVT	Beverage, malt and tobacco manufacturing
15	TCFL	Textiles and apparel manufacturing
16	WOOD	Wood product manufacturing
17	PAPR	Paper and paper product manufacturing
18	PRNT	Printing, publishing and recorded media
19	PETR	Petroleum refining, product manufacturing
20	CHEM	Other industrial chemical manufacturing
21	FERT	Fertiliser
22	RBPL	Rubber, plastic and other chemical product manufacturing
23	NMMP	Non-metallic mineral product manufacturing
24	BASM	Basic metal manufacturing
25	FABM	Structural, sheet and fabricated metal product manufacturing
26	MAEQ	Machinery and other equipment manufacturing
27	OMFG	Furniture and other manufacturing
28	EGEN	Electricity generation
29	EDIS	Electricity transmission and distribution
30	WATS	Water supply
31	WAST	Sewerage, drainage and waste disposal services
32	CONS	Construction
33	TRDE	Wholesale and retail trade
34	ACCR	Accommodation, restaurants and bars
35	ROAD	Road transport
36	RAIL	Rail transport
37	WATR	Water transport
38	AIRS	Air Transport
39	TRNS	Transport services
40	PUBI	Publication and broadcasting
41	COMM	Communication services
42	FIIN	Finance and insurance
43	HIRE	Hiring and rental services
44	REES	Real estate services
45	OWND	Ownership of owner-occupied dwellings
46	SPBS	Scientific research and computer services
47	OBUS	Other business services
48	GOVC	Central government administration and defence
49	GOVL	Local government administration
50	SCHL	Pre-school, primary and secondary education
51	OEDU	Other education
52	MEDC	Medical and care services
53	CULT	Cultural and recreational services
54	REPM	Repairs and maintenance
55	PERS	Personal services