

**IN THE ENVIRONMENT COURT
WELLINGTON REGISTRY**

**I TE KŌTI TAIAO O AOTEAROA
TE WHANGANUI-A-TARA ROHE**

UNDER	the Resource Management Act 1991
IN THE MATTER	of appeals under sch 1, cl 14(1) against the decision of Manawatū-Whanganui Regional Council on Plan Change 2 to the One Plan
BETWEEN	TE RUNANGA O RAUKAWA ENV-2021-WLG-20 NGĀTI TURANGA ENV-2021-WLG-21 ANDREW DAY ENV-2021-WLG-22 WELLINGTON FISH AND GAME COUNCIL ENV-2021-WLG-23 Appellants
AND	MANAWATŪ-WHANGANUI REGIONAL COUNCIL Respondent

**STATEMENT OF EVIDENCE OF PETER WILLIAM JOHN CLOUGH ON BEHALF OF
MANAWATŪ-WHANGANUI REGIONAL COUNCIL**

MACROECONOMIC IMPACTS

Dated: 17 January 2024


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STATEMENT OF EVIDENCE OF PETER CLOUGH

A. INTRODUCTION

- [1] My full name is Peter William John Clough.
- [2] My qualifications include a Bachelor of Arts in Geography and Land Economy from Cambridge University, a Master of Science in Recreational Land Management from the University of Reading, and a Post Graduate Diploma in Agricultural Economics from Massey University.
- [3] I am currently employed as a Senior Economist for the New Zealand Institute of Economic Research (**NZIER**), based in Wellington, and have held that position since 2004.
- [4] I have over 35 years' experience of consulting, mostly from working at NZIER but also from secondments to the Ministry of Economic Development, the Ministry of Transport, and at English Nature, the UK's statutory advisor on environmental policy. I have specialised in applying economics to hard-to-quantify areas of environment and public health and safety, and in comparative analysis of economic instruments and other policy measures in fields such as biosecurity, energy and transport, land use, biodiversity conservation, and natural resource management such as mining and quarrying, water quality and water use. In that time I have prepared technical reports and expert testimony for presenting in various resource management hearings and the Environment Court, on applications for plan changes and consents and also on appeals against decisions made.
- [5] I was an author, alongside my colleague Laëtitia Leroy de Morel, of the 2020 NZIER Report prepared for Manawatū-Whanganui Regional Council (**Horizons**) to inform PC2: *Economic impact assessment of Plan Change 2 of the One Plan*. In preparing evidence on the economic impact assessments of Plan Change 2 for the hearing in 2020, I also became familiar with NZIER's 2018 report on *The Macroeconomic impacts of the One Plan's intensive land use provisions* which was prepared by other colleagues no longer at NZIER at

that time. These 2018 and 2020 reports are attached to my evidence as **Appendix A** and **Appendix B**, respectively.

- [6] I also prepared evidence for the Council-level hearing of PC2, in the form of a s 42A report, which is attached to my evidence as **Appendix C**.

B. CODE OF CONDUCT

- [7] I confirm that I have read and agree to comply with the Code of Conduct for Expert Witnesses contained in the Environment Court Practice Note 2023. This evidence has been prepared in accordance with that Code. I confirm that I have not omitted to consider material facts that might alter or detract from the opinions that I express. The evidence I am giving is within my area of expertise, except where I state I am relying on the opinion or evidence of other witnesses. I understand it is my duty to assist the Court impartially on relevant matters within my areas of expertise.

C. SCOPE

- [8] I have been granted leave to file supplementary evidence with respect to the 2018 and 2020 NZIER reports and the s 42A statement I presented in 2020.
- [9] My evidence presents the work I (and my colleagues at NZIER) undertook, assessing PC2 against the key macroeconomic considerations in the Resource Management Act 1991. I provide the 2 reports prepared by NZIER on behalf of Horizons. I also attach the s 42A report which I prepared for the Council-level hearing of this matter. In doing so, I provide some brief direction to the Court on key points in the earlier reporting.

D. ECONOMIC IMPACT ASSESSMENTS

- [10] NZIER was asked by Horizons to estimate the regional macro-economic impacts of farmers and commercial vegetable growers meeting the nitrogen loss targets in Table 14.2 (Original and Recalibrated) of the One Plan in two sectors with intensive farming land uses across four local economies: vegetable growing in the Horowhenua, Manawatū and Rangitikei districts, and dairy farming in the Tararua, Manawatū and Rangitikei districts. Horizons wanted to understand how estimated on-farm costs might affect

the wider economies in the region and its constituent local authorities, and the New Zealand economy at large.

- [11] In 2018, my former colleague Laëtitia Leroy de Morel applied NZIER's Computable General Equilibrium (CGE) model to the potential compliance costs with the original Table 14.2, based on a survey by Terry Parminster of farmer options in the upper Manawatū catchment in Tararua District. This modelling covered the Tararua, Rangitikei and Horowhenua districts only (not Manawatū district). The question addressed was 'what would be the macro-economic impacts of adopting the recalibrated Table 14.2?'.¹
- [12] CGE models are used to examine the effects of a new policy or technology or other external "shocks" affecting economic activity. They are based on a model of inter-industry transactions that identifies where each productive sector in the economy obtains its inputs, and where each sector sends its outputs (e.g. for export or sold for further processing by other sectors or to direct final consumption within New Zealand). Such models are consistent with the United Nations System of National Accounts, and estimate results for changes in macro-economic aggregate measures such as GDP, total exports, total incomes and total employment. They have a similar base to the models used to produce economic multipliers which express how a direct injection of new economic activity has indirect flow on effects on other sectors that either supply inputs to or process outputs of the new activity. But CGE models have the refinement of accounting for how new activity increases demand and changes prices for input resources, and how those resources shift between sectors in an economy as a result. They are thus less likely to overstate flow on effects than multiplier models which do not account for input constraints, price changes and resource reallocations between sectors. This is explained further in **Appendix C**.¹
- [13] To assess the impacts of PC2, we constructed a hypothetical counterfactual of all farmers being forced to comply with the original Table 14.2, against which we compared the economic impacts of complying with PC2's recalibrated Table 14.2. The scenario modelled assumed intensive dairy

¹ At 26–30.

farms were driven to comply with the requirements of Table 14.2, which could be done by adopting good management practices to reduce nitrogen loss as far as possible, and then lowering herd size to deliver any further reduction of nitrogen required for compliance.

- [14] The dairy industry productivity decrease used was a weighted average of the productivity reduction by farm type/cluster obtained from Parminter (2018).² For the Horowhenua horticultural industry, we modelled a decrease in productivity required to meet the One Plan provisions, drawing on analysis by Ford (2017).³
- [15] The results of that 2018 modelling are presented in **Appendix A**. They show, in essence, that the cost of complying with the recalibrated Table 14.2 was much lower than the costs of complying with the original Table 14.2.
- [16] In 2020, the CGE database was extended and updated with new data.⁴ As such, the 2018 scenarios were remodelled on this new data, and covered the four districts of Horowhenua, Manawatū, Rangitikei and Tararua. Further, we modelled an additional scenario, examining the impacts of a 'partial compliance' pathway. The scenarios were labelled Scenario 0, the counterfactual of full compliance with the original Table 14.2; Scenario 1, the full compliance with the PC2 revised Table 14.2; Scenario 2, the partial compliance with the PC2 revised Table 14.2 (with a consenting pathway where revised Table 14.2 was not met). This resulted in our 2020 Report, attached as **Appendix B**.
- [17] This work confirmed the conclusions of the 2018 Report (that is, that the cost of complying with the recalibrated Table 14.2 was much lower than the costs of complying with the original Table 14.2), but also demonstrated that the

² Parminter, Terry (2018), Regional macroeconomic report, memo from KapAg Ltd for Horizons Regional Council.

³ Ford, Stuart. (2017). Farm scale economic impact analysis of One Plan intensive land use provisions. The Agribusiness Group. However, we only had access to a limited amount of data for the simulation, necessitating the use of a simulated/mock-up scenario in part. As such, the report noted that the impact on CVG was most likely over-estimated, and that we would refine this scenario once we had additional data.

⁴ McNally S., Jolly A.M., Mayes K. 2020. Horizons PC2 farm scale cost implications for commercial vegetable production – Provisional modelling outputs for expert caucusing.

economic impacts of compliance were further decreased where a pathway for 'partial compliance' with Table 14.2 was provided.

- [18] These results are examined in more detail in my s 42A report, attached as **Appendix C**. As explained in Appendix C, full compliance with the original table would result in GDP being \$204 million lower in 20 years' time in the four districts being studied, compared to no compliance with Table 14.2 (which would not improve water quality).⁵ This implies a significant cost on local production and community well-being, which may explain why many farmers have been slow to comply with the requirement. The cost of full compliance drops by 86% to \$28 million under the PC2 revised table, and by a further 6% to \$19 million under the partial compliance pathway. The difference in cost of complying between the original table and the PC2 calibrated table is so large the result is robust to wide variation in assumptions about the costs of complying. This suggests there is high likelihood that adopting PC2 would be beneficial compared to retaining the original Table 14.2, unless compliance costs under PC2 are exceptionally large compared to those used in our modelling.
- [19] I note that the 'partial compliance' scenario envisioned at the time of the 2020 Report was that of a discretionary consenting pathway being available, which corresponded to the regulatory settings in the notified PC2. However, over the course of the Council-level submissions and hearing process, a further 'partial compliance' scenario was proposed in the form of the specified nitrogen reduction pathways.
- [20] As I explained to the Hearing Panel at first instance, broadly speaking, these changes in regulatory options will not affect the results described in the 2020 Report. Any impact on the NZIER reporting would ultimately depend on exogenous factors that determine the effectiveness of PC2 measures in achieving changes in nitrogen applied to intensive farming. Within the confines of its own structure and assumptions about responses to changes in price and availability, the CGE model responds to a given change in nitrogen application in the economy in the same way, regardless of how that

⁵ At 55–56 and Figure 1.

change is brought about.⁶ So, if the same change in farm practice to reduce nitrogen leaching is obtained from requiring farmers to go through a discretionary consenting process or by requiring them to reduce nitrogen leaching by some other method (like the specified reduction pathway), it makes no difference to the CGE model. For there to be an appreciable difference in expected macro-economic outcomes that warrant further macro-modelling, there would need to be a significant difference in farm compliance costs between the pathways, which is not the case in comparing partial compliance scenarios given the same or similar farm practice changes are required regardless of pathway, as has been suggested by Professor Horne and Dr Jolly.

- [21] NZIER has not re-run its modelling to estimate macro-economic effects of any other changes in consenting pathway, and do not believe it necessary for reasons set out above.

17 January 2024

Peter William John Clough

⁶ Noting as I do in Appendix C (at paragraph 39) that the CGE model is not a forecasting tool, but rather an abstraction from reality that shows how a policy change like PC2 would impact on an economy as structured in the model. The model reflects the districts' and New Zealand's current economic structure as depicted in Statistics New Zealand's Input Output tables, but also allows for sectors to contract or to expand in response to changes in input prices and profitability induced by the policy change. The results are illustrative of general direction and magnitude of economic impact, not predictions of how costs fall.

E. APPENDICES

Appendix A:

NZIER *The macroeconomic impacts of the One Plan's intensive land use provisions:
Final Report to Horizons Regional Council* (July 2018).



The macroeconomic impacts of the One Plan's intensive land use provisions

NZIER final report to Horizons Regional Council

July 2018

About NZIER

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Each year NZIER devotes resources to undertake and make freely available economic research and thinking aimed at promoting a better understanding of New Zealand's important economic challenges.

NZIER was established in 1958.

Authorship

This paper was prepared at NZIER by Laëtitia Leroy de Morel

It was quality approved by John Ballingall

The assistance of Sarah Spring and Erwin Corong (NZIER) and Dr Terry Parminter is gratefully acknowledged.



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Key points

We estimate the regional economic impacts of Table 14.2 nitrogen loss limits using a Computable General Equilibrium model...

NZIER was asked by the Horizons Regional Council to estimate the regional macro-economic impacts on farmers and commercial vegetable growers of meeting the nitrogen loss targets in Table 14.2 of the One Plan in three local economies: horticulture in the Horowhenua district, and dairy farmers in the Tararua and Rangitikei¹ districts.

Horizons Regional Council wants to understand how these estimated direct on-farm/on-orchard costs might affect the wider territorial authority economies, the Horizons economy and the New Zealand economy.

We use NZIER's computable general equilibrium (CGE) model of the New Zealand economy to estimate these economic impacts.

...which explores the direct and flow-on effects of lower on-farm production as farmers adjust

As well as the direct impacts, we also examine the indirect or flow-on effects for supplying industries (e.g. agricultural services, fertiliser production, transport, etc.) and downstream industries (primary processing, retail, construction, etc.).

Our modelling considers how resources (especially labour and capital) shift between the primary sector and other industries (manufacturing, services, etc.) as the dairy and horticulture industries becomes less competitive and profitable in the face of higher costs to meet nitrogen loss targets.

Using these direct and indirect effects, we determine the flow-on effects throughout the wider Horizons economy and the national economy on GDP, employment, wages, and household spending.

Table 1 Summary of modelling scenarios

Scenario	Industry	Targeted profitability in 2038 ²	
		Original Table 14. 2	Revised Table 14.2
Tararua (Upper-Manawātū catchment)	Dairy	-24%	-8%
Rangitikei (Coastal Rangitikei Catchment)	Dairy	-17%	-8%
Horowhenua	Horticulture	-58%	N/A

Source: NZIER

¹ We didn't have all the data available to model the impacts of meeting Table 14.2 requirements for arable farmers in Rangitikei. For this reason, we only modelled impacts on dairy industry even though arable farmers will also be affected by the One Plan Table 14.2 provisions

² Shocks on productivity have been pro-rated using the share of milk production (in kg milk solid) between Upper-Manawātū catchment and Tararua district. We followed the same procedure to pro-rate the shock in Rangitikei. To estimate these ratio, we used data provided in Parminter (2018) and New Zealand Dairy Statistics (2016/2017).

Additional costs from meeting nitrogen loss targets lead to lower agricultural production...

- Dairy production falls by 28% in Tararua and by 22% in Rangitikei under the original Table 14.2 limits.
- Dairy output falls by 10% in the two regions under the revised Table 14.2.
- Commercial vegetable production in Horowhenua decreases by 64% following the implementation of the original Table 14.2.

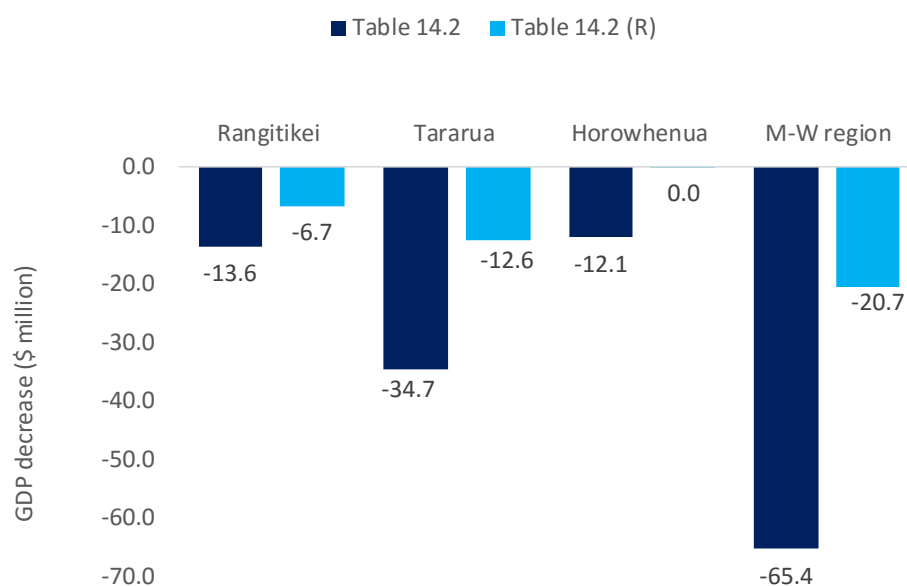
...leading to lower regional GDP and household spending

Table 2 overleaf and Figure 1 below show the negative impacts of Table 14.2 (original and revised) on regional GDP, exports and household consumption.

- GDP decreases by 4.9% or \$34.7 million in Tararua, 2.5% or \$13.6 million in Rangitikei, and 1.4% or \$12.1 million in Horowhenua.
- Regional welfare, as proxied by household spending, decreases under the original Table 14.2: consumption falls by 3.2% or \$14.6 million in Tararua, 1.0% or \$4.3 million in Rangitikei, and 1.7% or \$11.4 million in Horowhenua.
- Real wages decrease by 1.6% in Tararua, 0.5% in Rangitikei and 0.9% in Horowhenua as these economies slow and the demand for labour drops.
- GDP in the Manawatu-Wanganui region falls by \$65.4 million for the original Table 14.2 limits, and \$20.7 million for the revised limits. The region's real GDP is projected to be \$14.8 billion by 2038.

Figure 1 Impacts on GDP at the district and regional level

in \$ million



Source: NZIER, Results from CGE modelling, New Zealand Treasury Long Term Fiscal Model

Table 2 Impacts on macroeconomic variables

Indicator			GDP	Household consumption	Real wages	Exports
Original Table 14.2	Taranua	% change	-4.9%	-3.2%	-1.6 %	-2.7%
		Level (\$m)	-\$34.7	-\$14.6	NA	-\$4.5
	Rangitikei	% change	-2.5%	-1.1%	-0.5 %	-0.2%
		Level (\$m)	-\$13.6	-\$4.3	NA	-\$0.37
	Horowhenua	% change	-1.4%	-1.8%	-0.9 %	-0.8%
		Level (\$m)	-\$12.1	-\$11.4	NA	-\$2.1
	Manawatu Wanganui region ³	% change	-0.7%	-0.4%	-0.7%	-0.5%
		Level (\$m)	-\$65.4	-\$34.1	NA	-\$14.1
	New Zealand	% change	-0.05%	-0.03%	-0.04%	-0.05%
		Level (\$m)	-\$145	-\$51.6	NA	-\$34.7
Revised Table 14.2	Taranua	% change	-1.8%	-1.1%	-0.5 %	-1.0%
		Level (\$m)	-\$12.6	-\$5.1	NA	-\$1.7
	Rangitikei	% change	-1.2%	-0.5%	-0.2 %	-0.1%
		Level (\$m)	-\$6.7	-\$2.0	NA	-\$0.19
	Manawatu Wanganui region	% change	-0.2%	-0.1%	-0.2%	-0.15%
		Level (\$m)	-\$20.7	-\$8.3	NA	-\$4.74
	New Zealand	% change	-0.02%	-0.01%	-0.01%	-0.02%
		Level (\$m)	-\$45	-\$15.5	NA	-\$12.4

Source: NZIER, Results from CGE modelling

Industries closely related also suffer from the slowdown of the dairy and horticulture industries

- When dairy and horticulture farmers meet existing Table 14.2 limits, supplying industries such as transportation and utilities also experience significant declines:
 - In Taranua they are down 4.1% and 2.9%, respectively.
 - In Rangitikei they are down 1.8% and 0.3% respectively.
 - In Horowhenua they are down 1.9% and 4%, respectively.
- Dairy products and fruit, vegetable and other food products, which are downstream industries of the dairy and horticulture industries, are also negatively affected. In Taranua, dairy products are falling by 12.3% or \$39.7

³ Manawātū-Wanganui region includes Taranua, Rangitikei, Horowhenua districts as well as Rest of Manawatu-Wanganui, which includes all the other districts (Palmerston North City, Manawatu, Wanganui, Ruapehu, Stratford, Waitomo, and Taupo). Some of these other districts experience small changes in GDP as the Taranua, Rangitikei and Horowhenua economies adjust to Table 14.2 requirements.

million. In Horowhenua, fruit, vegetable and other food products falls by 3.7% or \$1.1 million.

- These flow-on output decreases are not as strong in the case of the revised Table 14.2. Dairy processing, transportation, and utilities decline by 4.5%, 1.5% and 1.0%, respectively.
- Industries where households spend their income are also affected from the contraction of the dairy and horticulture industries.
 - Real estate is down by 1.2% in Taranaki, by 0.6% in Rangitikei and by 0.7% in Horowhenua for the existing Table 14.2 limits.
 - Retail is down by 0.1% in Taranaki, by 0.2% in Rangitikei and by 2.3% in Horowhenua.
 - Overall household consumption decreases in Taranaki (3.2%), in Rangitikei (1.1%) and Horowhenua (1.8%) as seen in Table 2.

Table 3 below presents the industry impacts for the sum of the three directly affected districts, for the Manawatu-Wanganui region and New Zealand economy.

Table 3 Industry impacts

Industry	Type	District impacts (%)		Manawatu-Wanganui region impacts (%)		New Zealand impacts (%)	
		Original Table 14.2*	Revised Table 14.2**	Original Table 14.2*	Revised Table 14.2**	Original Table 14.2*	Revised Table 14.2**
Utilities	Supplying industries	-0.32%	-0.13%	-0.21%	-0.06%	-0.15%	-0.04%
Motor vehicle		-2.49%	-0.03%	-0.22%	-0.04%	-0.08%	-0.02%
Road & rail		-1.51%	-0.50%	-0.32%	-0.11%	-0.07%	-0.02%
Wholesale		-1.58%	-0.23%	-0.26%	-0.05%	-0.03%	-0.01%
Fertilisers		-1.05%	-0.21%	-0.50%	-0.10%	-0.06%	-0.01%
Ag services		-0.63%	-0.30%	-0.43%	-0.16%	-0.12%	-0.02%
Dairy product manufact.	Downstream industry	-9.55%	-3.44%	-3.42%	-1.27%	-0.38%	-0.15%
Retail	Household expenditure	-1.44%	-0.10%	-0.43%	-0.04%	-0.07%	-0.02%
Real estate		-1.07%	-0.30%	-0.36%	-0.10%	-0.06%	-0.02%
Sheep and beef	Competing industries (for dairy or horticulture)	1.26%	0.41%	0.74%	0.24%	0.16%	0.05%
Poultry		5.03%	0.25%	3.13%	0.17%	0.33%	0.03%
Forestry & logs		0.20%	0.05%	0.12%	0.03%	0.03%	0.01%
Fruit, vegetable & food products		-0.06%	0.40%	0.06%	0.21%	0.05%	0.03%
Seafood products		0.84%	0.02%	0.21%	0.03%	0.12%	0.03%
Dairy	Shocked industries	-12.89%	-5.25%	-6.98%	-2.85%	-0.37%	-0.16%
Horticulture		-46.47%	0.24%	-23.42%	0.14%	-0.43%	0.03%

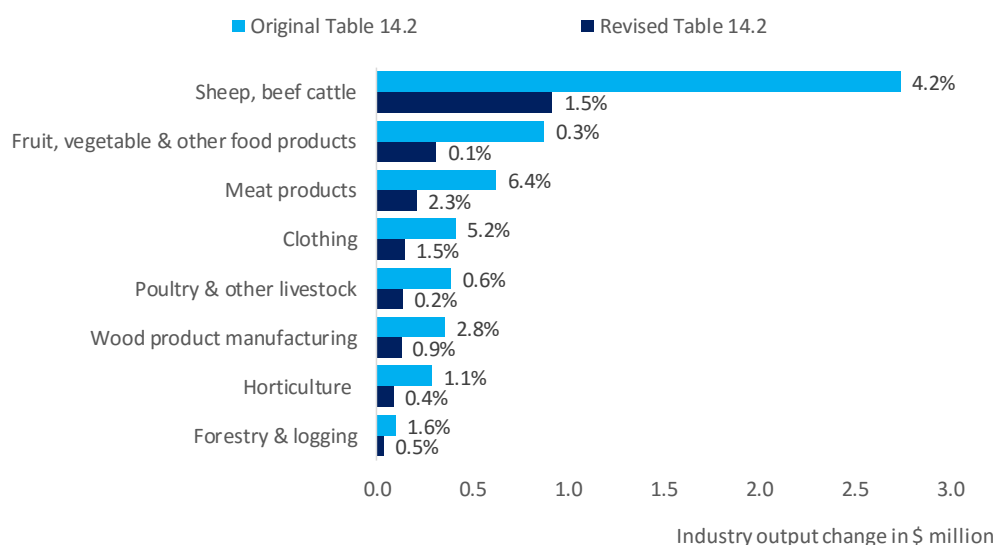
Source: NZIER, Results from CGE modelling

Competing industries gain from the decrease of the dairy and horticulture industries

With smaller dairy and horticulture industries, more resources become available for other parts of the economy, and at lower cost, allowing other industries to grow (Figure 2, Figure 3, and Figure 4).

Figure 2 Gains for selected competing industries in Taranaki

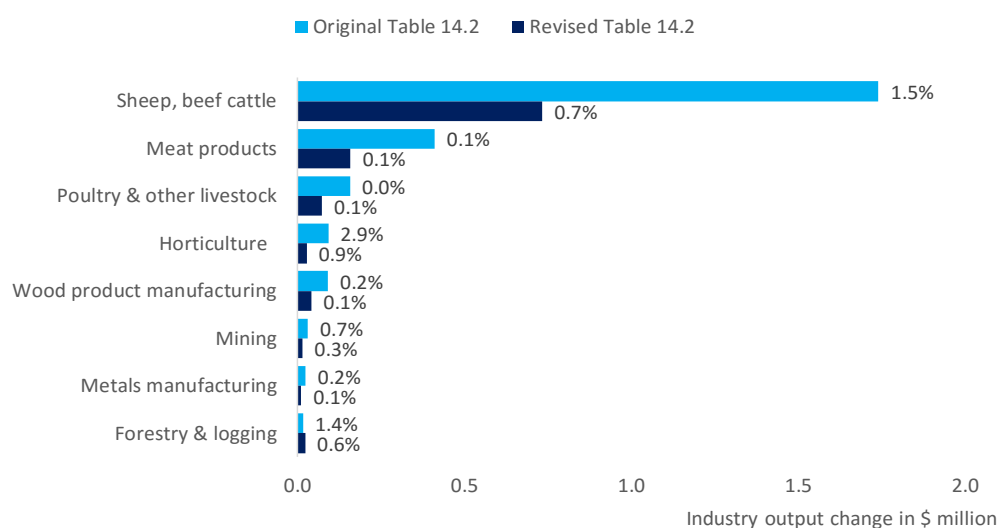
Change in industry output in \$ million and in percentage



Source: NZIER, Results from CGE modelling

Figure 3 Gains for selected competing industries in Rangitikei

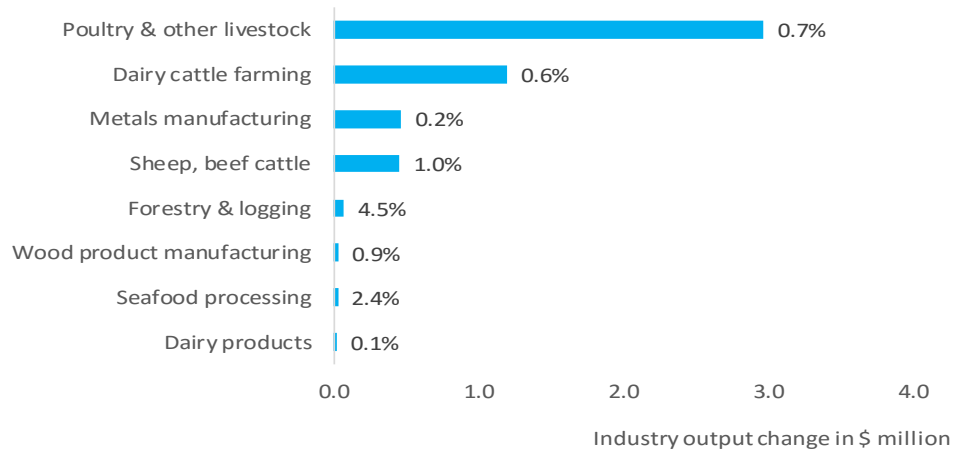
Change in industry output in \$ million and in percentage



Source: NZIER, Results from CGE modelling

Figure 4 Gains for selected competing industries in Horowhenua

Change in industry output in \$ million and in percentage, under the original Table 14.2



Source: NZIER, Results from CGE modelling

A note of caution

As we were missing some information for dairy in Rangitikei and horticulture in Horowhenua, we used the information provided by Parminter (2018) and NZ Dairy Statistics (2016/2017) to design indicative scenarios.

As more information and data becomes available on the on-farm costs associated with this measure, especially in the case of the revised Table 14.2 targets, we will be able to carry out further economic modelling as required.

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1. Background and objectives

1.1. Our task

NZIER was asked by the Horizons Regional Council to estimate the regional macro-economic impacts on farmers and commercial vegetable growers of meeting the nitrogen loss targets in Table 14.2 of the One Plan in three local economies: horticulture in the Horowhenua district, dairy farmers in the Tararua and Rangitikei⁴ districts.

Horizons Regional Council wants to understand how these estimated on-farm/on-orchard costs might affect the wider territorial authority economies, the Horizons economy and the New Zealand economy.

In this report, we examine the indirect or flow-on effects for supplying industries (e.g. agricultural services, fertiliser production, transport, etc.) and downstream industries (primary processing, retail, construction, etc.).

Our modelling also considers how resources (especially labour and capital) shift between the primary sector and other industries (manufacturing, services, etc.) as the dairy and horticulture industries becomes less competitive and profitable in the face of higher costs to meet nitrogen loss targets.

Using these direct and indirect effects, we determined the flow-on effects throughout the wider Horizons economy and the national economy on GDP, employment, wages, and household spending. This gives us the macroeconomic impacts that you are interested in for your review.

⁴ We did not have all the data available to model the impacts of meeting Table 14.2 requirements for arable farmers in Rangitikei. For this reason, we only modelled impacts on dairy even though arable farmers will also be affected by the Table 14.2 provisions.

2. Methodology and scenarios

2.1. We used our computable general equilibrium model to assess the costs of meeting the new nitrogen loss targets

We used NZIER's regional computable general equilibrium (CGE) model to assess the regional and national economic impacts of meeting nitrogen loss targets from Table 14. 2 (Original and Revised versions) of the One plan.

CGE modelling is our recommended method for conducting policy analysis or sectoral impact studies, as it delivers more conservative, but more realistic, estimates of net benefits than commonly-used (and widely criticised) alternatives such as multiplier analysis.

Our CGE model contains information on 106 industries and 201 commodities within the economy, incorporates trade and financial linkages to world markets, and estimates price responses to demand or supply shocks. It is described in more detail in Appendix B.

Table 4 below presents the values (in million \$) used as our 2017 baseline for different macro-economic indicators and industry outputs. The model is based on the latest Input-Output table and is adjusted with the most recent National Accounts table from New Zealand Statistics. These values are presented at the district, regional and national levels.

Table 4 CGE model database

2017, in \$ million

Indicator	Tararua	Rangitikei	Horowhenua	Manawatu-Wanganui	New Zealand
GDP	\$707	\$555	\$874	\$9,410	\$264,695
Household consumption	\$457	\$412	\$653	\$7,510	\$152,482
Exports	\$187	\$169	\$267	\$3,079	\$70,314
Imports	\$180	\$162	\$252	\$2,901	\$69,077
Labour	\$243	\$207	\$347	\$4,438	\$114,967
Capital	\$282	\$180	\$347	\$3,199	\$107,872
Dairy industry output	\$183	\$108	\$179	\$854	\$12,286
Horticulture industry output	\$5	\$3	\$50	\$114	\$3,467
Total output (all industries)	\$1,621	\$1,82	\$1,841	\$18,019	\$502,789
Dairy GDP	\$93	\$55	\$91	\$342	\$6,265
Horticulture GDP	\$2	\$1	\$19	\$41	\$1,322
GDP for all industries	\$640	\$495	\$779	\$7,686	\$241,719

Source: NZIER, Input-Output table 2013, National Accounts 2017 from New Zealand Statistics

2.2. We modelled the costs of meeting N-loss limits as a negative shock on profitability

Horizons Regional Council provided us with a report (Parminter, 2018) which looks at on-farm costs in Tararua, Rangitikei and Manawatū districts in response to three policy situations:

- Before undertaking management changes to achieve One Plan nitrogen loss requirements
- After undertaking management changes to achieve One Plan nitrogen loss requirements in Table 14.2
- After undertaking management changes to achieve One Plan nitrogen loss requirements in a proposed revision of Table 14.2(R).

The industries being considered in this report are:

- Dairy in the Upper Manawatū Catchment of the Tararua district
- Dairy in the Coastal Rangitikei Catchment of the Rangitikei (part) and Manawatū districts (part)
- Horticulture in the Horowhenua district.

We used the figures provided by Parminter (2018) to estimate the expected loss in profitability in the dairy industry in Tararua and Rangitikei under the original Table 14.2 targets and the revised Table 14.2 targets of the One Plan.

Table 5 below provides a summary of our modelling scenario.

- The first set of simulations consists of imposing a shock on land productivity for the dairy industry in Tararua and Rangitikei, and horticulture in Horowhenua⁵ so that it reflects the profitability losses expected from meeting the nitrogen loss targets of the original Table 14.2.
- In the second set of simulations, we impose a shock on the land productivity for the dairy industry in Tararua and Rangitikei so that it reflects the profitability losses expected from meeting the nitrogen loss targets of the revised Table 14.2.
- We do not run any simulation for horticulture in Horowhenua for the revised Table 14.2 in this situation as no additional change is expected compared with the original Table 14.2 based on Parminter (2018).
- Parminter (2018) has produced farm-level impacts for one, five, ten and twenty years. As our CGE model is static, it can only look at 'before' (i.e. current situation) and 'after'. For our scenario design, we have used results provided for year 20 (i.e. 2038).

Further explanation on our modelling approach can be found in Appendix B.5

⁵ As we did not have all the data available for the simulation, we designed an indicative scenario and shocked productivity so that it reflected a 58% decrease in profitability in the horticulture industry. This figure is most likely over-estimated, and we will refine this scenario when we get additional data.

Table 5 Summary of modelling scenarios

Scenario	Industry	Targeted profitability in 2038		
		Shock	Original Table 14. 2	Revised Table 14.2
Tararua (Upper-Manawatū catchment)	Dairy	Productivity	-24%	-8%
Rangitikei (Coastal Rangitikei Catchment)	Dairy	Productivity	-17%	-8%
Horowhenua	Horticulture	Productivity	-58%	N/A

Source: NZIER

2.3. How we analysed the modelling results

Our analysis of the modelling results is systematic as we track the impacts as they flow through the economy.

Beginning with the **direct impacts** on the dairy and horticulture industries, **at the district level**, we look at consumption, trade, labour and capital factor markets to see how these two industries respond to the introduction of new nitrogen-leaching targets.

We then analyse the **flow-on or indirect impacts** on other industries, at the district level. We split the indirect impacts into the following industry categories:

- **Supplying industries** – industries that supply intermediate inputs are likely to be negatively affected by weaker dairy and horticulture industries. These are industries such as packaging and the fertiliser industry.
- **Household expenditure industries** – industries that households spend money on are likely to be negatively affected from the decreased income that comes through lower employment and wages, and the decreased returns to capital from a deterioration of the dairy and horticulture industries.
- **Competing export industries** – industries that compete for resources (such as land and labour) with the dairy and horticulture industries gain from the implementation of the new nitrogen loss targets.

We then examined the **regional** and **national macroeconomic effects**. Here we report both value-added (GDP) and welfare (private and public consumption) measures.

3. Results

The simulation results confirm that the introduction of the Table 14.2 targets in the One Plan (original and revised) would have negative effects on the regional and national economies.

Compared to what would have happened without the implementation of the nitrogen loss targets, the regional economies are smaller.

Detailed results showing the impacts on industry output are presented in tabular form in Appendix C. These results show how resources move between competing industries in the regional economies as the dairy and horticulture industries are negatively affected by the new nitrogen loss targets in Table 14.2 of the One Plan, for both the original and revised versions of the table.

3.1. Impacts on dairy & horticulture

Agricultural production falls due to higher costs of production from meeting new nitrogen loss requirements, and from farmers spending more time on implementing new management practices to reduce their use of fertilisers.

As land productivity decreases and production costs rise, farms' capacity falls.⁶ The more reliant a farm is on fertilisers as an input, the more output is likely to drop. Dairy and horticulture exports fall, due to the overall drop in dairy and horticulture production.

Industries closely related to the dairy and horticulture industries (e.g. rural retail, fertilisers) also suffer from the primary sector slowdown.

Both effects will reduce real GDP, employment and household consumption in the region. However, the overall effect on GDP will be limited as the affected agricultural industries account for about 5% of total GDP and meeting the nitrogen loss requirements impacts only a small portion of the affected industries' overall inputs to production.

Other industries will benefit at the margin from the contraction in the dairy and horticulture industries, as more resources (labour, capital, land) become available for producing other goods and services.

3.1.1. Industry output and contribution to GDP

To meet the revised nitrogen loss requirement targets, dairy farmers in Tararua and Rangitikei, as well as commercial vegetable growers in Horowhenua will have to implement new management and agricultural practices and use less fertiliser. Farmers will therefore face lower productivity and higher production costs.

In the dairy industry, industry output decreases by 28% in Tararua under the original Table 14.2 targets and by 10% under the revised Table 14.2 targets.

⁶ Our model has a 'fixed proportions' production structure, which implies that as production costs increase, output falls as production becomes less profitable. Alternative production structures could be employed that allow producers to simply absorb higher costs and maintain production levels by dipping into savings or borrowing more, but this is not a standard approach to CGE modelling.

In Rangitikei, dairy farmers experience a 22% reduction in their outputs under the original Table 14.2 targets and a 10% output reduction under the revised Table 14.2 targets.

Results of the indicative scenario we have designed for horticulture in the Horowhenua district suggest a 64% output decrease following the implementation of the original Table 14.2 targets.

Following the implementation of the original Table 14.2 (revised Table 14.2) targets, the contribution of the dairy industry, as a share of regional GDP, falls by 4% (1.5%) in Tararua and by 2.4% (1.2%) in Rangitikei.

In Horowhenua, the regional GDP contribution of the horticulture industry decreases by 1.5% under the original Table 14.2 targets.

3.1.2. Labour demand and capital usage

Table 6 shows a significant decrease in labour demand, wages and capital usage for dairy farmers in Tararua and Rangitikei, and commercial vegetable growers in Horowhenua with the implementation of both original and revised versions of Table 14.2.

Under the original Table 14.2 targets, labour demand reduces by 23.2% in Tararua and by 18.8% in Rangitikei along with a decrease in wages of similar magnitude in the two regions. Capital usage decreases by 23.8% in Tararua and by 19.0% in Rangitikei.

Table 6 Labour demand and capital usage in dairy and horticulture

Percentage change

Indicator	Original Table 14.2			Revised Table 14.2	
	Tararua (dairy industry)	Rangitikei (dairy industry)	Horowhenua (horticulture)	Tararua (dairy industry)	Rangitikei (dairy industry)
Labour demand	-23.2 %	-18.8 %	-58.2 %	-8.1 %	-9.0 %
Capital usage	-23.8 %	-19.0 %	-58.4 %	-8.4 %	-9.1 %
Wages	-24.5 %	-19.2 %	-58.6 %	-8.6 %	-9.1 %

Source: NZIER, Results from CGE modelling

3.2. District impacts

3.2.1. District direct impacts on the dairy and horticulture industries

At the district level (Table 7), the additional costs to dairy farmers and commercial vegetable growers in meeting the nitrogen loss targets from Table 14.2 in dairy and horticulture result in:

- Real GDP decreasing by 6.1% or \$43.1 million in Tararua, 3.2% or \$17.7 million in Rangitikei, and 2.0% or \$17.5 million in Horowhenua.

- Regional welfare, as proxied by household spending, decreases with the original Table 14.2 (revised Table 14.2):
 - In Tararua, household consumption falls by 3.2% or \$14.6 million (1.1% or \$5.1 million under the revised Table 14.2)
 - In Rangitikei, household consumption falls by 1.0% or \$4.3 million (0.5% or \$2 million under the revised Table 14.2)
 - In Horowhenua, household consumption falls by 1.7% or \$11.4 million under the original 14.2 Table.
- Real wages decreasing by 1.6% in Tararua, by 0.5% in Rangitikei and by 0.8% in Horowhenua.

Macroeconomic effects from the targets in the revised Table 14.2 are also negative for the different indicators; but are only a third of the magnitude of the costs of meeting the original Table 14.2 targets.

Table 7 Impacts on macroeconomic indicators at the regional level

Indicator	Original Table 14.2			Revised Table 14.2	
	Tararua (%change)	Rangitikei (% change)	Horowhenua (% change)	Tararua (% change)	Rangitikei (% change)
Real GDP	-6.1 %	-3.2 %	-2.0 %	-2.2%	-1.6 %
Household consumption	-3.2%	-1.1 %	-1.7 %	-1.1 %	-0.5 %
Exports	-2.7%	-0.2 %	-0.8 %	-1.0 %	-0.1 %
Imports	-1.5 %	-0.6 %	-0.5 %	-0.5 %	-0.3 %
Real wage	-1.6 %	-0.5 %	-0.9 %	-0.5 %	-0.2 %

Indicator	Original Table 14.2			Revised Table 14.2	
	Tararua (\$m change)	Rangitikei (\$m change)	Horowhenua (\$m change)	Tararua (\$m change)	Rangitikei (\$m change)
Real GDP	-\$43.1	-\$17.7	-\$17.5	-\$15.5	-\$8.8
Household consumption	-\$14.6	-\$4.3	-\$11.4	-\$5.1	-\$2.0
Exports	-\$4.0	-\$0.37	-\$2.1	-\$1.7	-\$0.19
Imports	-\$2.7	-\$0.9	-\$1.3	-\$0.9	-\$0.5
Real wage	NA	NA	NA	NA	NA

Source: NZIER, Results from CGE modelling

3.2.2. District indirect impacts on other industries

The economic effects from the contraction of the dairy and horticulture industries are not just contained within these industries; they are more widely felt throughout the economy.

The indirect impacts of the nitrogen loss targets from Table 14.2 in dairy in Taranaki are widespread across other industries within the economy (see Table 8):

- **Supplying industries** – Other transport, utilities and motor vehicles supply the dairy industry with intermediate goods and services. These industries are negatively affected with significant declines, down 4.1%, 2.9% and 2.6%, respectively.
- The output decrease is not as strong in the case of the revised Table 14.2 targets. Other transportation, utilities and motor vehicle decline by 1.5%, 1.0% and 0.9% respectively.
- **Downstream industries** – Dairy processing output falls by 12.3% under Table 14.2 and by 4.5% with the revised Table 14.2 limits.
- **Household expenditure industries** – Industries where households spend their income are also affected from the contraction of the dairy and horticulture industries.
 - Real estate is down by 1.2% under Table 14.2 and by 0.4% under the revised Table 14.2.
 - Retail industry output is down by 0.1% with the original Table 14.2 limits and by 0.01% under the revised version.
 - Overall household consumption decreases in Taranaki by 3.2% with the original Table 14.2 limits; and by 1.1% with the revised Table 14.2.
- **Competing industries** – These industries gain from the decrease in the dairy industry in Taranaki.
 - In the primary sector, sheep and beef⁷, the second biggest industry in Taranaki after dairy, grows by 1.1%.
 - Two other important competing industries in the primary sector, poultry⁸ and forestry⁹, increase by 2.7% and 0.3%, respectively.
 - In services, finance and insurance grows by 1.6%.
- Output growth of the competing industries is about a third under the revised Table 14.2 targets compared to the original Table 14.2 limits.

The effects of the revised Table 14.2 are lower in magnitude as the nitrogen loss targets are less ambitious than the original Table 14.2 hence, less costly to implement by farmers.

Additional results for the dairy industry in Rangitikei and horticulture in Horowhenua can be found in Table 12 and Table 13 in Appendix C.

⁷ The output of the sheep and beef industry in Taranaki is worth \$247 million in 2017.

⁸ The output of the poultry industry in Taranaki is worth \$13.9 million in 2017.

⁹ The output produced in the forestry industry in Taranaki is worth \$26.5 million in 2017.

Table 8 Indirect impacts on selected industries in the Tararua district

Percentage change in industry output due to the contraction of the dairy and horticulture industries

Industry	Type	Impacts (%)	
		Original Table 14.2	Revised Table 14.2
Other transport	Supplying industries	-4.1%	-1.5%
Utilities		-2.9%	-1.0%
Motor vehicle		-2.6%	-0.9%
Road, rail transport		-2.3%	-0.9%
Wholesale		-0.9%	-0.3%
Fertilisers		-0.8%	-0.2%
Agriculture services		-0.7%	-0.1%
Dairy product manufacturing	Downstream industry	-12.3%	-4.5%
Retail	Household expenditure	-0.1%	-0.01%
Real estate		-1.2%	-0.4%
Sheep and beef	Competing industries	1.1%	0.4%
Poultry		2.8%	0.9%
Forestry and logging		0.4%	0.1%
Fruit, vegetable and food products		6.4%	2.3%
Horticulture		5.2%	1.5%
Seafood products		4.2%	1.4%

Source: NZIER, Results from CGE modelling

3.2.3. District trade

As shown in Figure 5, meeting the nitrogen loss targets in the original and revised Table 14.2 of the One Plan also affects trade. As seen previously, the dairy and the horticulture industries face lower productivity and lower production because of higher costs of production. This translates into a reduced export supply in the industry.

Figure 5 shows the trade effects of meeting the original Table 14.2 targets in Tararua. Exports of milk and other dairy products are substantially affected with a decrease of 18.9% and 11.0%, respectively. Exports of products coming from supplying industries are also negatively affected. Exports of food products decrease by 4.5% and grain products by 3.5%.

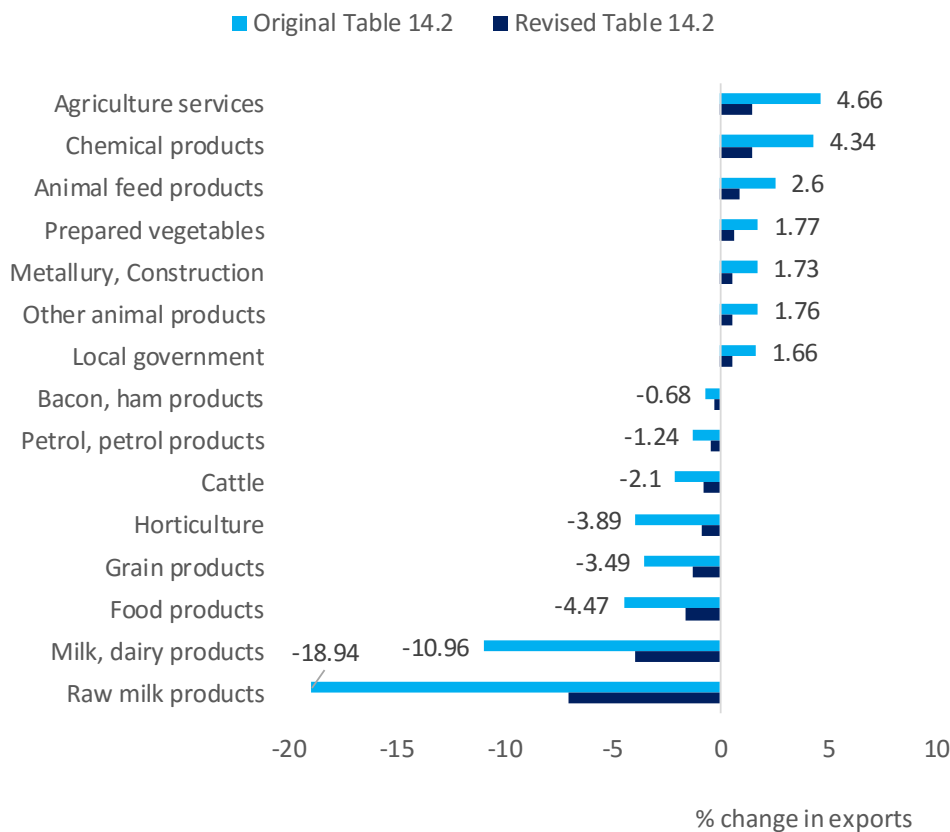
Trade effects for the revised Table 14.2 targets are about a third of the original targets.

Results for the Rangitikei and Horowhenua districts are presented in Figure 13 and Figure 14 in Appendix C.

The decline in agricultural exports is partly offset by small increases in exports across many manufacturing and services industries due to the shift of resources away from the dairy and horticulture industries into other industries of the economy.

Figure 5 Trade effects on selected products in the Tararua district

Percentage change in exports



Source: NZIER, Results from CGE modelling

3.3. Regional impacts

At regional level (see Table 9 and Figure 6), the additional costs for dairy and horticulture in meeting the nitrogen loss targets from the Table 14.2 (revised Table 14.2) result in:

- Manawatu-Wanganui's 2017 nominal GDP decreasing by \$65 million (\$21 million), relative to what it would have been had the dairy and horticulture industries stayed at their 2017 levels.
- Manawatu-Wanganui's welfare, as proxied by private and public consumption, being \$34 million (\$8 million) lower than it would have been otherwise.
- Regional real wages decreasing by 0.74% (-0.20%).
- GDP in the Manawatu-Wanganui region falls by \$65.4 million for the original Table 14.2 limits, and \$20.7 million for the revised limits. The region's real GDP is projected to be \$14.8 billion by 2038.

Table 9 Impacts on Manawatu-Wanganui macroeconomic indicators

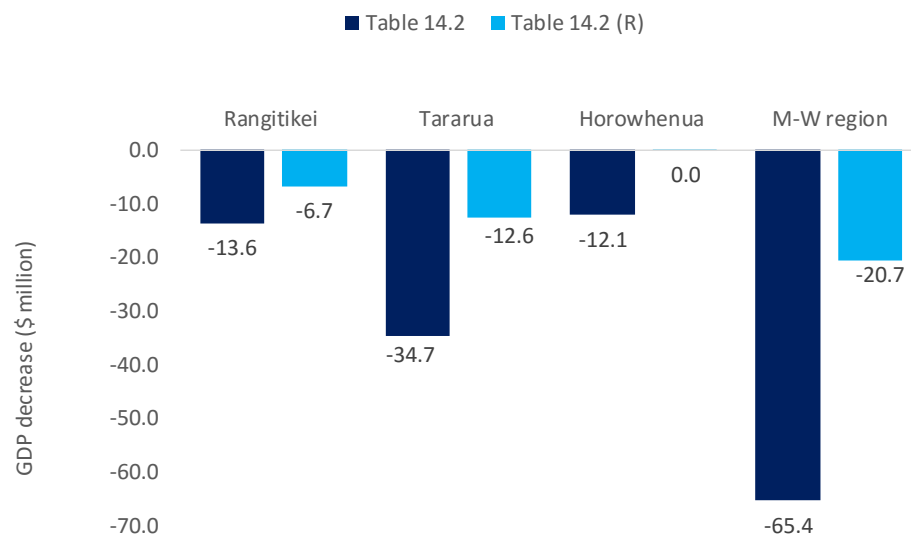
Percentage deviation due to the contraction of the dairy and horticulture industries

Indicator	Original Table 14. 2		Revised Table 14.2	
	% change	Levels change, \$m	% change	Levels change, \$m
Real GDP	-0.86%	N/A	-0.26%	N/A
Nominal GDP	-0.69%	-\$65	-0.22%	-\$21
Private consumption	-0.45%	-\$34	-0.11%	-\$8
Exports	-0.45%	-\$14	-0.15%	-\$5
Imports	-0.37%	-\$10	-0.11%	-\$3
Real wage	-0.74%	N/A	-0.20%	N/A
Capital	-0.71%	-\$23	-0.21%	-\$7

Source: NZIER, Results from CGE modelling

Figure 6 Impacts on GDP at the district and regional level

in \$ million



Source: NZIER, Results from CGE modelling

3.4. National impacts

At the national level (see Table 10) the additional costs for dairy and horticulture in meeting the nitrogen loss targets from the Table 14.2 (revised Table 14.2) result in:

- New Zealand's 2017 nominal GDP decreasing by \$361 million (\$120 million), relative to what it would have been had the dairy and horticulture industries stayed at their 2017 levels.
- New Zealand's welfare, as proxied by private and public consumption, being \$84 million (\$28 million) lower than it would have been otherwise.
- Economy wide real wages decreasing by 0.04% (-0.01%).
- Significantly, the economic effects from the contraction of the dairy and horticulture industries, including wage decreases, are not just felt within the industry itself, but more widely throughout the economy.

Table 10 Impacts on New Zealand macroeconomic indicators

Percentage deviation due to the contraction of the dairy and horticulture industries

Indicator	Original Table 14. 2		Revised Table 14.2	
	% change	Levels change, \$m	% change	Levels change, \$m
Real GDP	-0.03%	N/A	-0.01%	N/A
Nominal GDP	-0.06%	-\$361	-0.02%	-\$120
Private consumption	- 0.03%	-\$84	-0.01%	-\$28
Exports	-0.05%	-\$150	-0.02%	-\$60
Imports	-0.03%	-\$140	-0.01%	-\$47
Real wage	-0.04%	N/A	-0.01%	N/A
Capital	-0.03%	-\$34	-0.01%	-\$11

Source: NZIER, Results from CGE modelling

Appendix A References

Ford, Stuart. (2017). Farm scale economic impact analysis of One Plan intensive land use provisions. The Agribusiness Group.

Parminster, Terry (2018), Regional macroeconomic report, memo from KapAg Ltd for Horizons Regional Council.

New Zealand dairy statistics 2016/2017,
<https://www.dairynz.co.nz/media/5788533/nz-dairy-statistics-2016-17-web.pdf>

Appendix B CGE models

B.1 What are CGE models?

To measure how changes in one part of a regional or national economy flow through the rest of the economy, we use CGE models.

CGE models are data-driven and used to capture the effects of a new policy or technology or other external shocks affecting economic activity. They capture the economy-wide effects of changes ('shocks' in modelling jargon) directly on the affected industry, as well as indirectly on supplying industries, competing industries, and factor markets (labour and capital).

CGE models also estimate the effect of a shock on macroeconomic variables such as GDP, employment, wages and trade.

CGE models are a powerful tool, allowing economists to explore empirically many issues on which econometrics or multiplier analysis would be unusable. For these reasons, CGE models have become widely used internationally (e.g. by OECD, IMF, World Bank) for economic impact analysis.

B.2 Why do we prefer CGE over multipliers?

Multiplier studies¹⁰ are popular for economic impact analysis as they are relatively cheap and produce appealing big figures. However, they are based on several assumptions which requires them to be interpreted and considered with considerably care.

Key caveats include that multiplier studies:

- Do not consider any adjustment path between the status quo and the future state of the economy
- Do not consider the impacts of policy changes on the price of goods, services, intermediate inputs, labour (wages) and capital.
- Assume that land, labour and capital are available in unlimited quantities, and at no additional cost to firms
- Cannot consider the opportunity cost of using additional resources in one industry on the rest of the economy – there are almost never any losers (i.e. contracting industries) in multiplier studies.

Because of these assumptions, multipliers overestimate the impacts of a change in a particular industry on the rest of the economy. Both the Ministry of Business, Innovation and Employment (MBIE) and Treasury have highlighted the inherent flaws in using multiplier studies for serious economic analysis.¹¹ NZIER no longer offers

¹⁰ Also known as 'input-output studies'.

¹¹ For an overview of these weaknesses, see the [New Zealand Treasury](#) and [MBIE](#). Both documents, and Gretton (2013), clearly state that multipliers over-state economic impacts and thus lack credibility for economic analysis. Or in Treasury's words: "Unless there is significant unemployment of people with the requisite skills, it is therefore likely that multiplier effects do not exist".

multiplier-based analysis to our clients as they no longer align with our independence and reputation for delivering high quality, data-driven analysis.

For all these reasons, we prefer to use CGE models.

A CGE model provides an estimation of opportunity costs (between action and inaction), winners and losers. Resources are limited. It also considers price impacts of shocks and can capture regional linkages between industries as well as spill-over effects.

The results from CGE modelling are therefore more likely to stand up to scrutiny from decision makers. This is crucial when you are looking to secure funding or to influence policy decisions.

NZIER's CGE models are highly regarded amongst government agencies with whom we have worked for to conduct policy analysis or sectoral impact studies. This includes MBIE, Treasury, the Ministry of Foreign Affairs and Trade, the Ministry for Primary Industries and the Ministry for the Environment.

We also regularly work with private sector firms to provide them with economic evaluations of their activities. Some recent examples of our CGE work include:

- An economic impact analysis of expanding the Wellington International Airport of for Air New Zealand
- Analysis of growth in NZ wine sector for New Zealand Winegrowers
- Analysis of Sky City Auckland's National Convention Centre and the Queenstown Convention Centre
- Value of irrigation in New Zealand: an economy-wide assessment
- Assessing the impact of the Canterbury rebuild at the regional and national level
- Estimating the impact of the Marlborough aquaculture industry on the regional and national economy.

B.3 How do CGE models work?

A CGE model consists of equations which describe model variables. It also uses detailed data on the structure of the economy that is consistent with these model equations.

This data provides a snapshot of the economy in a particular year, which is used as a starting point for a baseline (or business as usual (BAU)) against which to compare policy simulations or economic changes.

The model data is linked together through a set of equations which capture how the economy evolves over time in response to a shock. These equations, which are based on the economic theory of general equilibrium, ensure supply and demand for goods, services and factors of production in the economy are balanced, and determine how firms and households react in response to changes in incentives.

Most CGE models are written and solved in a specific software system, usually GAMS¹² or GEMPACK.¹³

¹² General Algebraic Modelling System: <https://www.gams.com/>

¹³ General Equilibrium Modelling PACKage: <https://www.copsmodels.com/gempack.htm>

In any CGE model, we must choose as to what is to be determined within the model (the endogenous variables) and what is to be considered external to the model (the exogenous variables). A CGE model is just a way of explaining the endogenous variables in terms of the exogenous variables.

Where we draw the line between endogenous and exogenous variables, and which ones can vary or have to remain fixed, depends on a number of factors, including the purpose for which the model simulations are to be used. The choice that we make is called the model closure.

Determining the closure is a key part of any modelling exercise and it is very important that the modeller be transparent about what is a result of the modelling and what has been imposed by assumption via the closure.

The difference between the initial and the new equilibrium can then be analysed to determine the effect of the shock on a range of economic indicators, such as GDP, employment, wages and living standards.

B.4 Our regional CGE model TERM-NZ

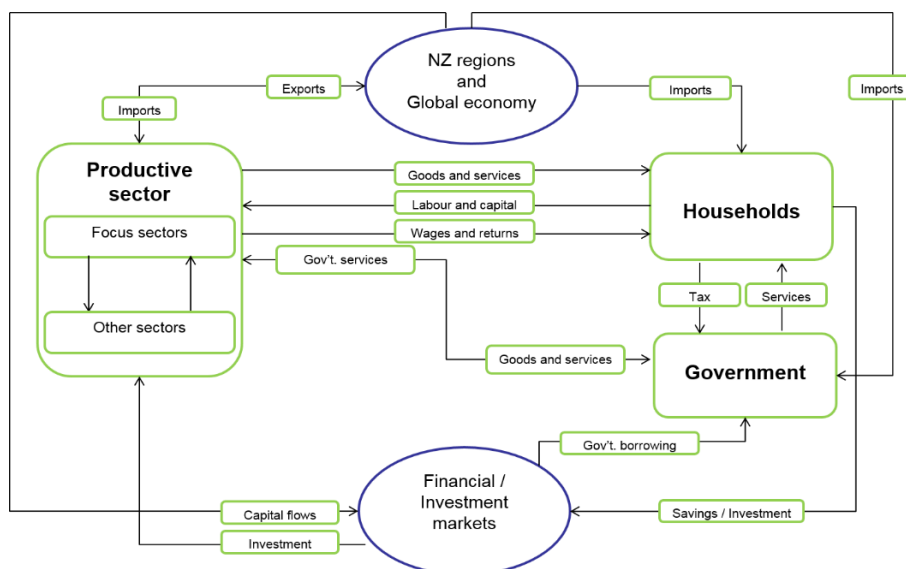
NZIER's TERM-NZ¹⁴ model is the only bottom-up regional CGE model of the New Zealand economy. TERM-NZ is based on a Statistics New Zealand's Input-Output table that identifies the structure of the industries involved. It contains information on 106 industries, 201 commodities and 15 regions, including the Manawatū-Whanganui regional economy.

TERM-NZ model is a bottom-up regional model, in which each of fifteen regions is modelled as its own economy, but all the regions are connected through inter-regional trade and flows of capital and labour. National results are the summation of the regional results.

Figure 7 shows how the model captures the complex and multidirectional flows between the various actors of each regional economy and how they interact with the rest of New Zealand and the rest of the world.

¹⁴ TERM-NZ stands for "The Enormous Regional Model" of the New Zealand economy. It was developed at NZIER by Dr Erwin Corong based on the original Australian TERM model created by Professor Mark Horridge of the Centre of Policy Studies, Victoria University-Melbourne, Australia. <http://www.copsmodels.com/term.htm>. NZIER maintains close connections with the Centre, ensuring that our modelling techniques reflect international best-practice.

Figure 7 Our CGE model represents the circular flows between all the agents and activities in the economy



Source: NZIER

B.5 Our modelling approach

B.5.1 Business as usual 2017

We want to identify the economic impacts of the current and proposed One Plan nutrient management policies and rules on the local, regional and national economies.

We first need to develop a baseline or BAU picture of the economy with the current One Plan measures. To do so, we calibrate our model of the Horizons economy and its territorial authorities to the latest available data from Statistics New Zealand.

As part of our calibration process, we split the Horizons regional economy into separate economies for Horowhenua, Tararua, Rangitikei and the rest of Manawatū-Whanganui region. To disaggregate the Horizons regional economy into these four sub-regions, we use detailed local employment data from Statistics New Zealand.¹⁵

Since up-to-date industry GDP numbers are not available at the district level, we assume that industries within Tararua, Horowhenua, Rangitikei and the rest of Manawatū-Whanganui region grow at the same rate as the industries at the Manawatū-Whanganui (regional) level. We use this assumption to estimate the share of industry, exports, inventory, government and consumption, within these four sub-regions, based on the local employment data.

This allows us to ensure we correctly benchmark the size of the various agricultural industries and gives us a BAU snapshot of the local, regional and national economies under the current One Plan measures.

While TERM-NZ is computationally efficient, running and solving the model for the full 106-industry, 201-commodity and 15-region database would be slow. We therefore

¹⁵ Latest data (February 2017) can be found at this link: [Business demography statistics](#)

aggregate the industries and commodities to only focus on those relevant to this report and to speed up the computational process.

B.5.2 Scenario design

We want to see how the impact of meeting existing One Plan provisions scenarios in 2038 (year 20) differs from the BAU situation. To identify those scenarios and evaluate the additional on-farm/orchard costs, we use information from reports you have commissioned.

We weight these costs up from the farm level to the industry level. This is because in our CGE model, our dairy farming industry is not split by land type. We have just one aggregate dairy farming industry. We use the data you provided us on the milk production of the various dairy farm types by territorial authority.

B.5.3 Economic impact modelling of additional costs to farmers and commercial vegetable growers

We impose the additional costs to dairy farmers for the dairy industry in Tararua and Rangitikei, and horticulture industry in Horowhenua. The resulting decrease in output and margins, for each industry, gives us the direct costs to farmers of the consenting regime (for those without consent).

For the Tararua and Rangitikei dairy farms, we model a dairy industry productivity decrease which is a weighted average of the productivity reduction by farm type/cluster obtained from Parminter (2018). The report focused on dairy farms in the Upper-Manawātū catchment, which represents about 41% of the milk production in Tararua. We use this share to pro rata our shock as the Tararua district is not disaggregated in our model.

Regarding dairy farms in the Coastal Rangitikei Catchment of the Rangitikei (part) and Manawātū districts (part), some data were not available. We used the figures in the report to design our scenario, but it will need to be refined when we get more information.

For the Horowhenua horticultural industry, we model a decrease in productivity required to meet the One Plan provisions, drawing on the analysis by Ford (2017). As we didn't have all the data available for the simulation, we mocked up a scenario and shocked land productivity so that it reflected a 58% decrease in profitability in the horticulture industry. This figure is most likely over-estimated, and we will refine this scenario when we get additional data.

To estimate the effects of the original Table 14. 2 targets and the revised Table 14.2 targets of the One Plan, we run two sets of separate simulations:

- In the first set of simulations we imposed a shock on productivity for the dairy industry in Tararua and Rangitikei, and horticulture in Horowhenua so that it reflected the profitability losses expected from meeting the nitrogen loss targets of the original Table 14.2.
- In the second set of simulations, we imposed a shock on the land productivity for the dairy industry in Tararua and Rangitikei so that it reflected the profitability losses expected from meeting the nitrogen loss targets of the revised Table 14.2. We have not run a simulation for horticulture in

Horowhenua for the revised Table 14.2 targets as no additional change is expected compared with the original Table 14.2.

B.6 Closure

As noted previously, in any CGE model, it is important to understand which factors have been allowed to vary and which remain fixed by assumption (also known as exogenous variables). The particular combination of fixed factors is known as the closure.

In Table 11, we list the main variables included in the closure in the modelling underlying this report.

- National employment is fixed but labour is completely mobile between industries and regions, and real wages adjusts. This is consistent with the idea that, both the labour force and the rate of employment are, in the long run, determined by mechanisms outside the model.
- Household and government expenditures move together to accommodate a fixed balance of trade as a share of GDP.
- Rates of return are exogenous and capital is mobile between industries and regions. This mobility can occur either in the form of machinery etc. being physically moved, or capital in one industry/region being allowed to depreciate without replacement while investment builds up the stock of another industry/region.
- Foreign currency prices of imports are naturally exogenous.
- Real government consumption is also exogenous.
- Other exogenous variables include rates of production tax, technological coefficients, national population, and national labour supply.

Table 11 Fixed elements of the CGE model

Exogenous variables
Taxes on production
Technological change
Government demand
Gross growth rate of capital
Gross rate of return on capital
Number of households
National population
National labour supply
Import prices, foreign currency
Foreign demand for New Zealand exports
Land use

Source: NZIER

Appendix C Additional results

Table 12 Indirect impacts on selected industries in the Rangitikei district

Percentage change

Industry	Type	Impacts (%)	
		Original Table 14.2	Revised Table 14.2
Other transports	Supplying industries	-1.82%	-0.83%
Utilities		-0.31%	-0.13%
Motor vehicle		-0.88%	-0.40%
Road, rail transport		-0.68%	-0.30%
Wholesale		-0.77%	-0.35%
Agriculture services		-0.74%	-0.25%
Dairy product manufacturing	Downstream industry	-39.42%	-20.25%
Retail	Household expenditure	-0.22%	-0.01%
Real estate		-0.60%	-0.27%
Sheep and beef	Competing industries	0.59%	0.25%
Meat product manufacturing		0.19%	0.08%
Mining		0.20%	0.09%
Forestry		0.12%	0.05%
Poultry and other livestock		1.37%	0.64%
Fruit, vegetable and other food products		0.05%	0.07%
Horticulture		2.94%	0.03%
Seafood products		2.53%	0.04%

Source: NZIER, Results from CGE modelling

Table 13 Indirect impacts on selected industries in the Horowhenua district

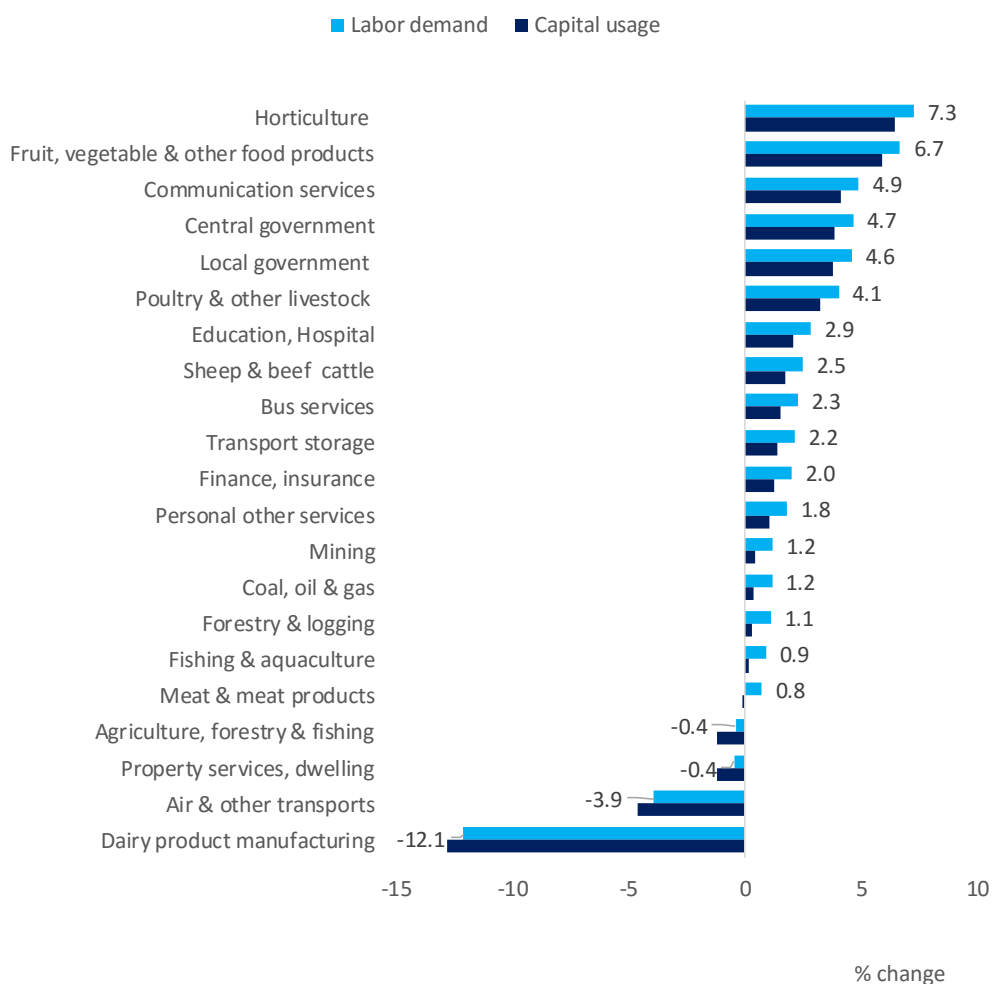
Percentage change

Industry	Type	Impacts (%) with the Original Table 14.2
Other transports	Supplying industries	-1.90%
Utilities		4.00%
Motor vehicle		-2.20%
Road, rail transport		-0.53%
Wholesale		-1.74%
Fertilisers		-1.12%
Agriculture services		3.02%
Fruit, vegetable and other food products	downstream industries	-3.70%
Retail	Household expenditure	-2.32%
Real estate		-0.71%
Electricity generation	Competing industries	0.33%
Sheep and beef		2.37%
Dairy cattle		0.67%
Dairy product manufacturing		0.57%
Poultry		4.52%
Forestry		0.18%
Paper product manufacturing		0.45%
Clothing		2.77%

Source: NZIER, Results from CGE modelling

Figure 8 Impacts of the original Table 14.2 targets on primary factors for selected industries in the Tararua district

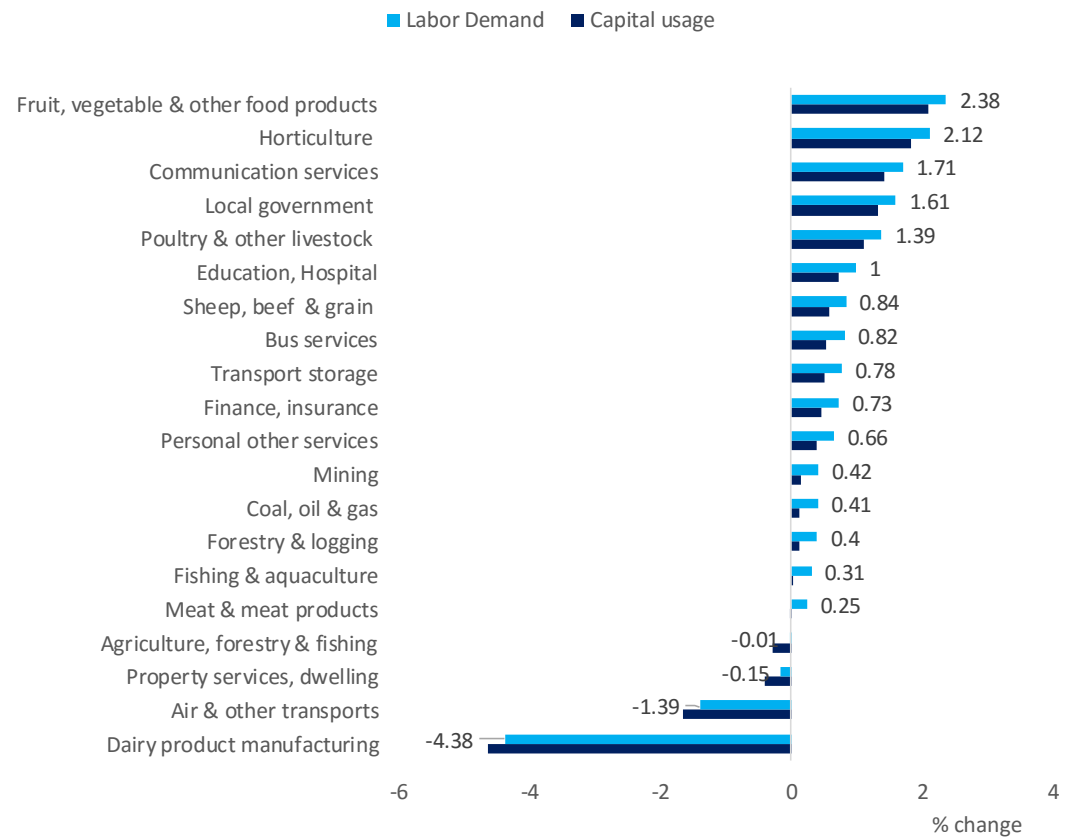
Percentage change of primary factor demands



Source: NZIER, Results from CGE modelling

Figure 9 Impacts of the revised Table 14.2 targets on primary factors for selected industries in the Tararua district

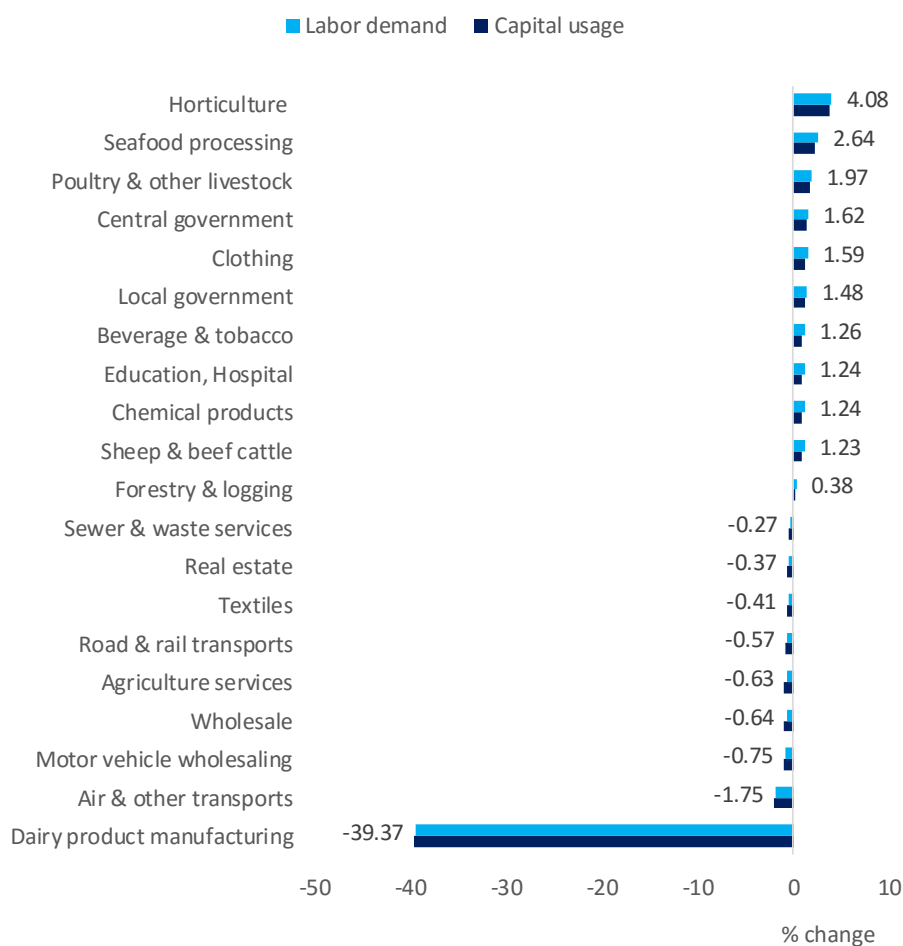
Percentage change of primary factor demands



Source: NZIER, Results from CGE modelling

Figure 10 Impacts of the original Table 14.2 targets on primary factors for selected industries in Rangitikei

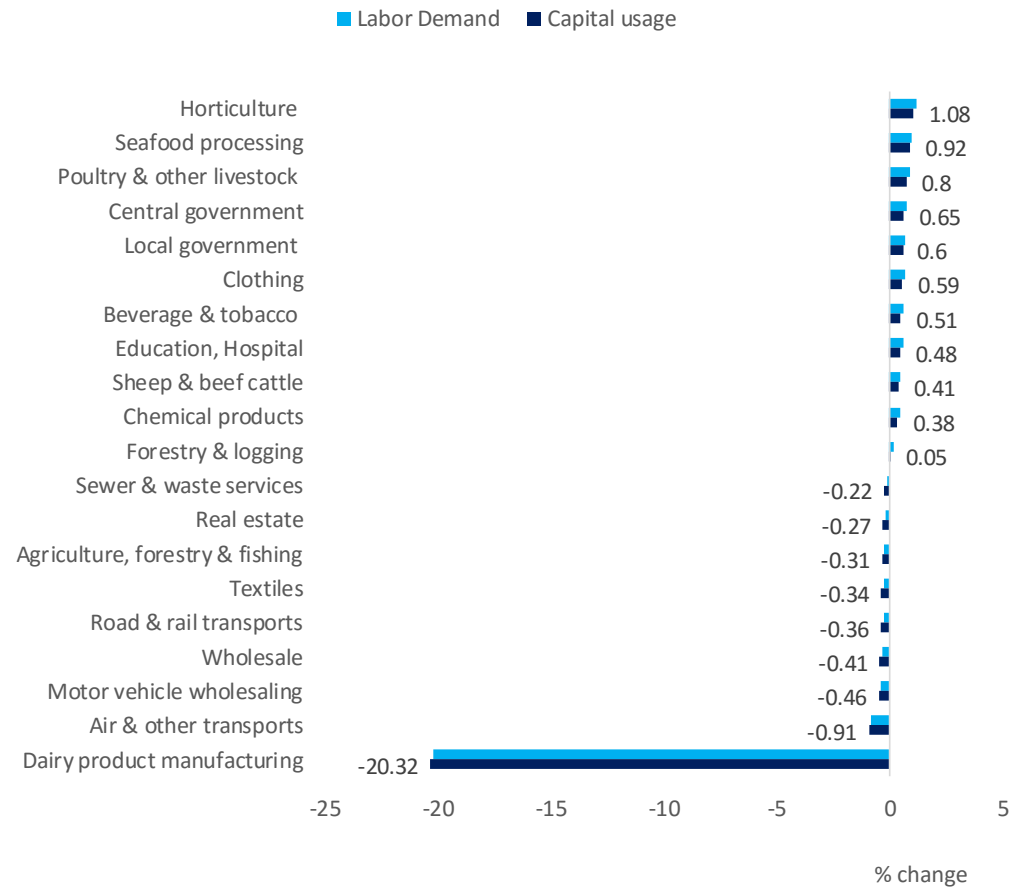
Percentage change of primary factor demands



Source: NZIER, Results from CGE modelling

Figure 11 Impacts of the revised Table 14.2 targets on primary factors for selected industries in Rangitikei

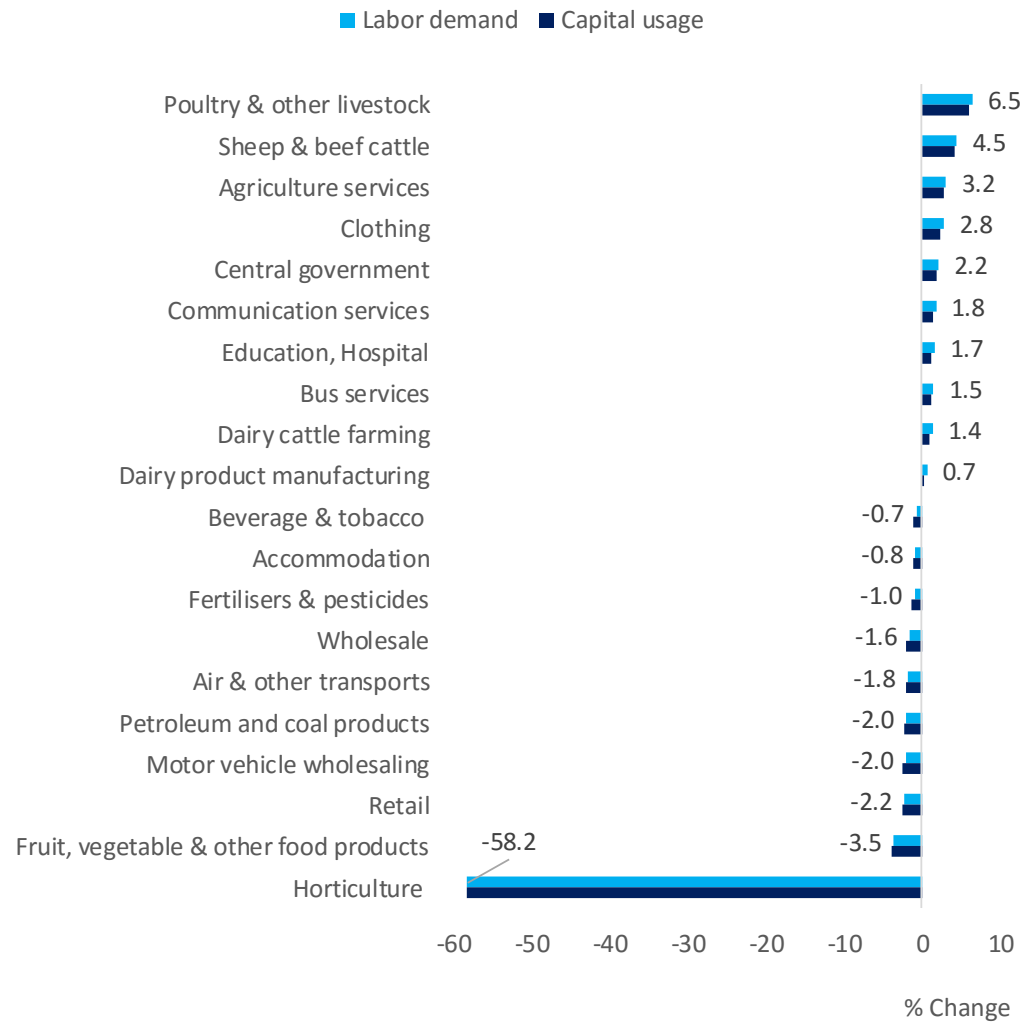
Percentage change of primary factor demands



Source: NZIER, Results from CGE modelling

Figure 12 Impacts of the original Table 14.2 targets on primary factors for selected industries in Horowhenua

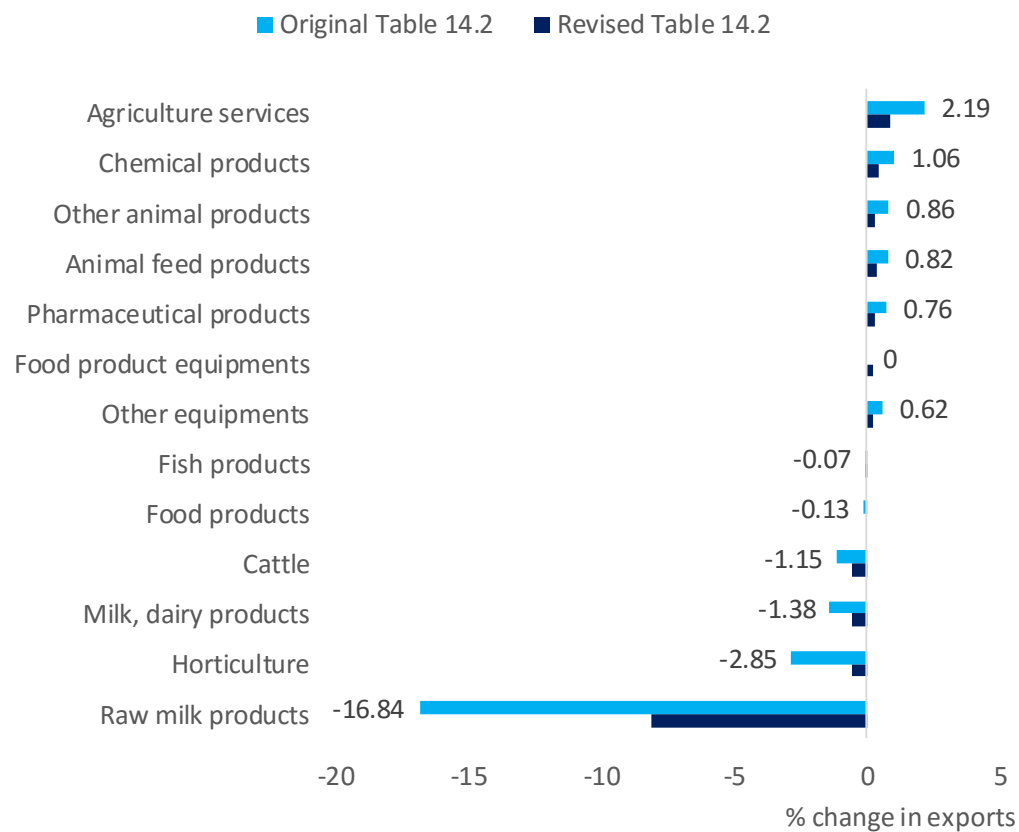
Percentage change of primary factor demands



Source: NZIER, Results from CGE modelling

Figure 13 Trade effects on selected products in Rangitikei

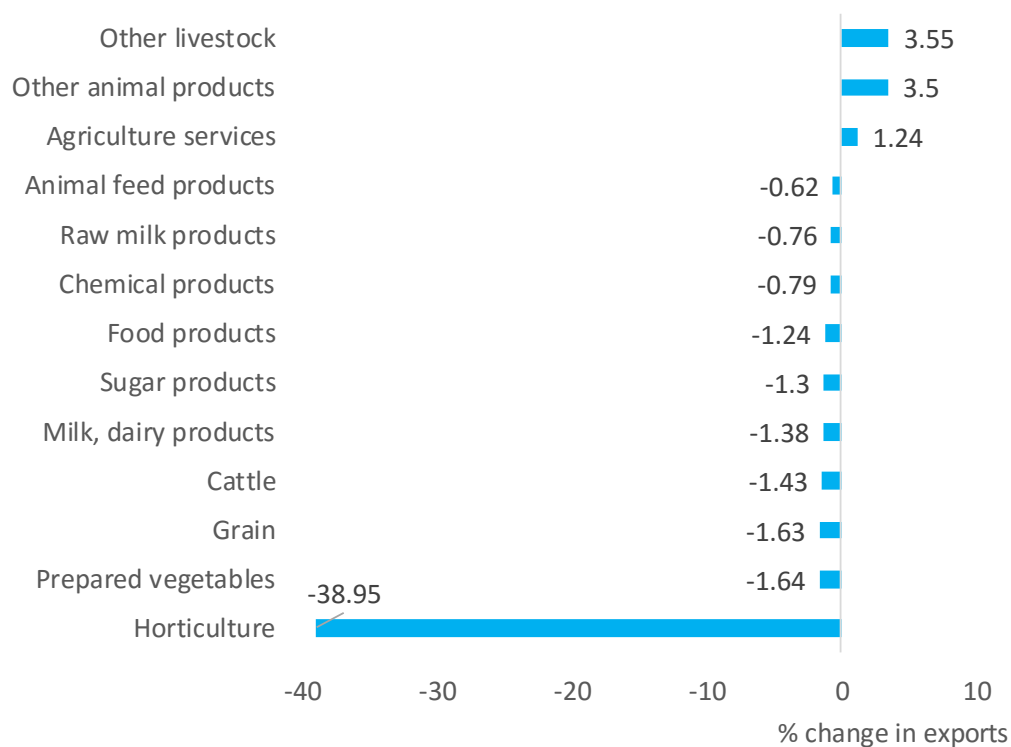
Percentage change in export demands



Source: NZIER, Results from CGE modelling

Figure 14 Trade effects on selected products in Horowhenua with the original Table 14.2 targets

Percentage change in export demands



Source: NZIER, Results from CGE modelling

Appendix B:

NZIER *Economic impact assessment of Plan Change 2 of the One Plan: A CGE modelling analysis* (September 2020).



Economic impact assessment of Plan Change 2 of the One Plan

A CGE modelling analysis

NZIER report to Horizons Regional Council

September 2020

About NZIER

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Key points

We estimate the local economic impacts of Table 14.2 nitrogen loss limits using a computable general equilibrium model...

NZIER was asked by the Horizons Regional Council to build on a previous NZIER report (2018) and estimate the local and regional macroeconomic impacts of different degrees of compliance by farmers and commercial vegetable growers with the recalibrated Table 14.2 as part of Plan Change 2 of the One Plan (PC2). We also remodel and update the economic impacts of the original Table 14.2 to set up a base against which to compare effects of the recalibrated Table 14.2.

For this work, we use NZIER's regional bottom-up computable general equilibrium (CGE) model and we focus on four local economies: Horowhenua, Rangitikei, Tararua and Manawatū districts.

...which explores the direct and flow-on effects of lower on-farm production as farmers adjust

We have designed three modelling scenarios to evaluate the additional on-farm costs of meeting existing and proposed measures of nitrogen controls in 20 years from now, under the current One Plan provisions and those under proposed Plan Change 2:

Scenario 0 – Original Table 14.2

In this scenario, we assume that all vegetable growers and dairy arable farmers are forced to comply with the original Table 14.2 of the One Plan (controlled pathway).

Scenario 1 – No consent pathway for exceedance

In this scenario, we assume that all vegetable growers and dairy arable farmers comply with the recalibrated Table 14.2 of the One Plan (controlled pathway). In doing so, we estimate the effects of meeting the recalibrated Table 14.2 of the One Plan in the absence of any discretionary activity consent pathway for exceedances of the recalibrated Table 14.2.

Scenario 2 – Consent pathway for exceedance and only partial compliance by Year 20

In this scenario, we consider there is a discretionary activity consent pathway for exceedances of the recalibrated Table 14.2 with only partial compliance by Year 20. As such, 'most' farms comply in Year 20. Those who do not comply by Year 20 are on an improving trend and have been reducing their nitrogen loss using good and best management practices (GMP and BMP)

We examine the direct and indirect or flow-on effects on GDP, employment, wages, and household spending throughout the four districts, the wider Horizons regional economy and the national economy.

In this report, we present results from the modelling in two ways:

- Results are provided for all scenarios and compared with our CGE baseline which represents the state of the New Zealand economy as of 2019.
- Results from scenarios 1 and 2 (recalibrated Table 14.2) are compared with Scenario 0 (Original Table 14.2).

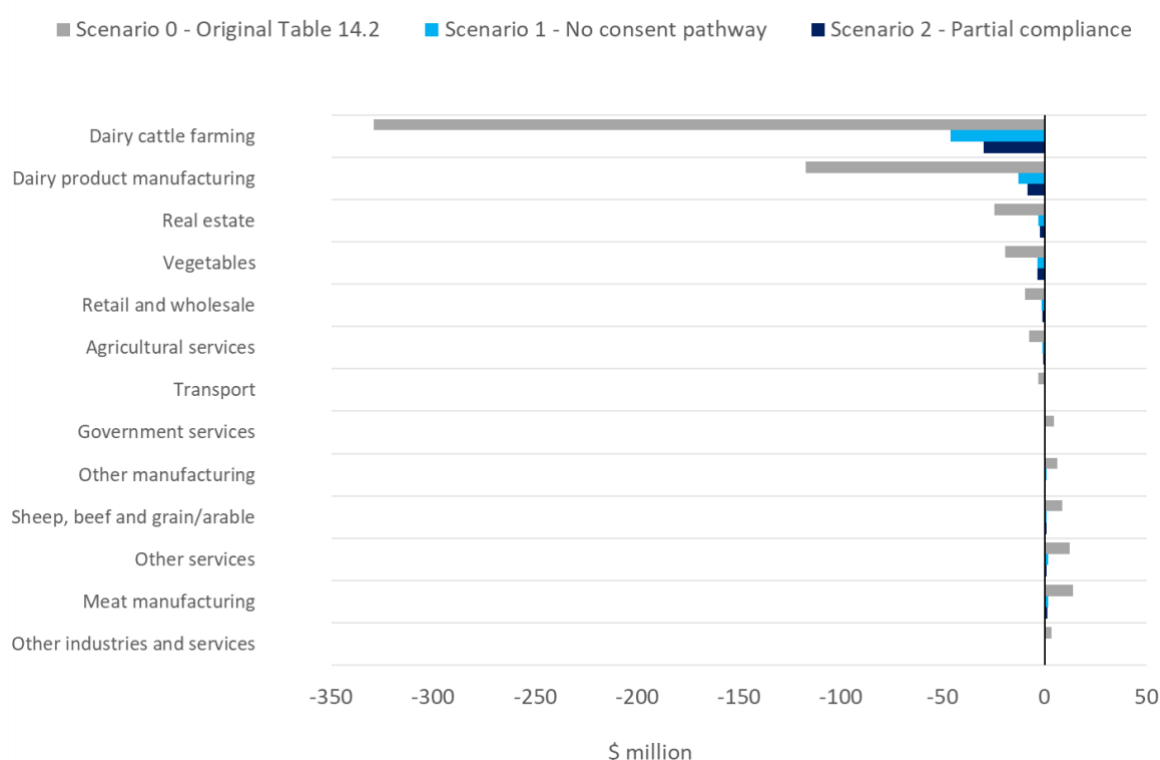
Losses in industry outputs from meeting existing and proposed nitrogen loss targets from the recalibrated Table 14.2. are smaller...

Figure 1 compares changes in industry outputs¹ for scenarios 1 and 2 with Scenario 0 (original Table 14.2) from the direct and flow-on effects resulting from meeting the different nitrogen targets.

As expected, losses in industry output are significantly smaller for scenarios 1 and 2 than scenario 0. For example, the output loss in dairy cattle farming industry is between \$280 million and \$287 million higher in scenario 0 when compared with Scenario 1 and Scenario 2, respectively.

Figure 1 Total direct and flow-on effects on closely-related industries for all four districts

Annual changes in output compared with 2019 baseline in Year 20, in \$ million (real terms)



Source: NZIER

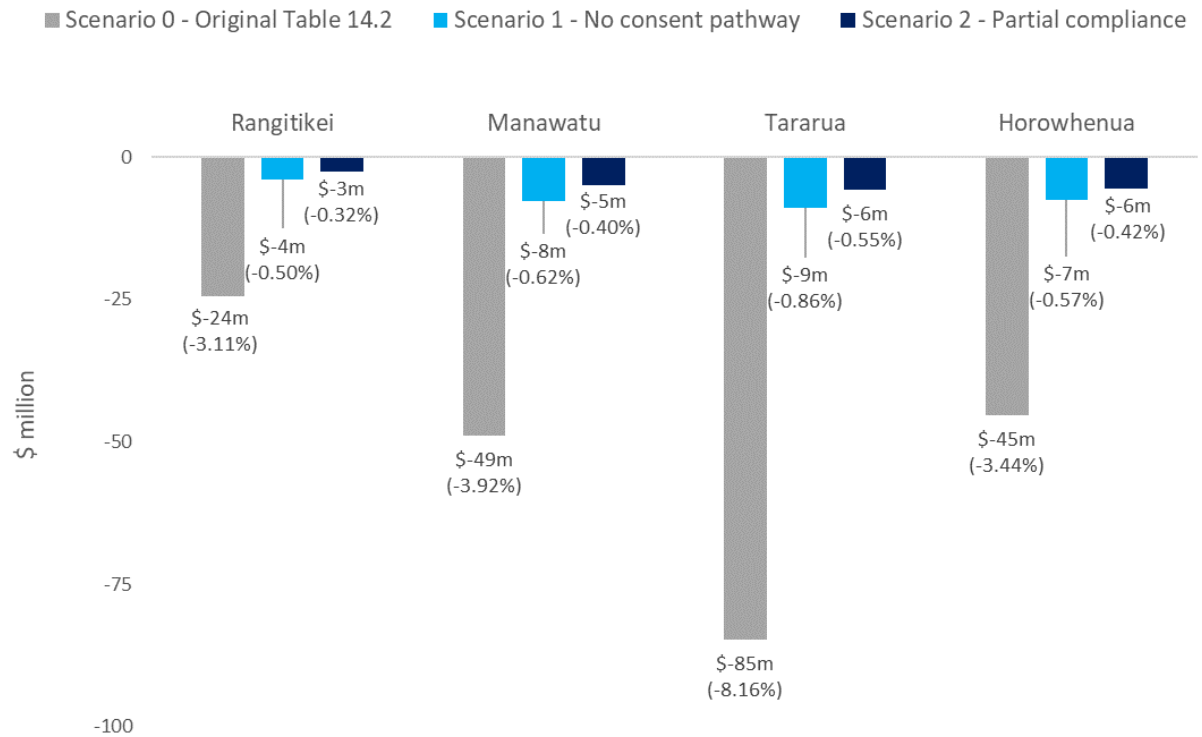
...leading to lesser impacts on GDP and household spending

Figure 2 and Figure 3 below show the impacts of meeting existing and proposed measures of Plan Change 2 of the One Plan provisions in Year 20 for each of the four districts considered. Economic impacts of meeting the original Table 14.2 (Scenario 0) are significantly higher than the economic impacts of meeting proposed measures of the recalibrated Table 14.2 (Scenario 1 and Scenario 2, respectively).

¹ Industry gross output is the sum of the intermediate consumption and the value-added.

Figure 2 Real GDP impacts within each district

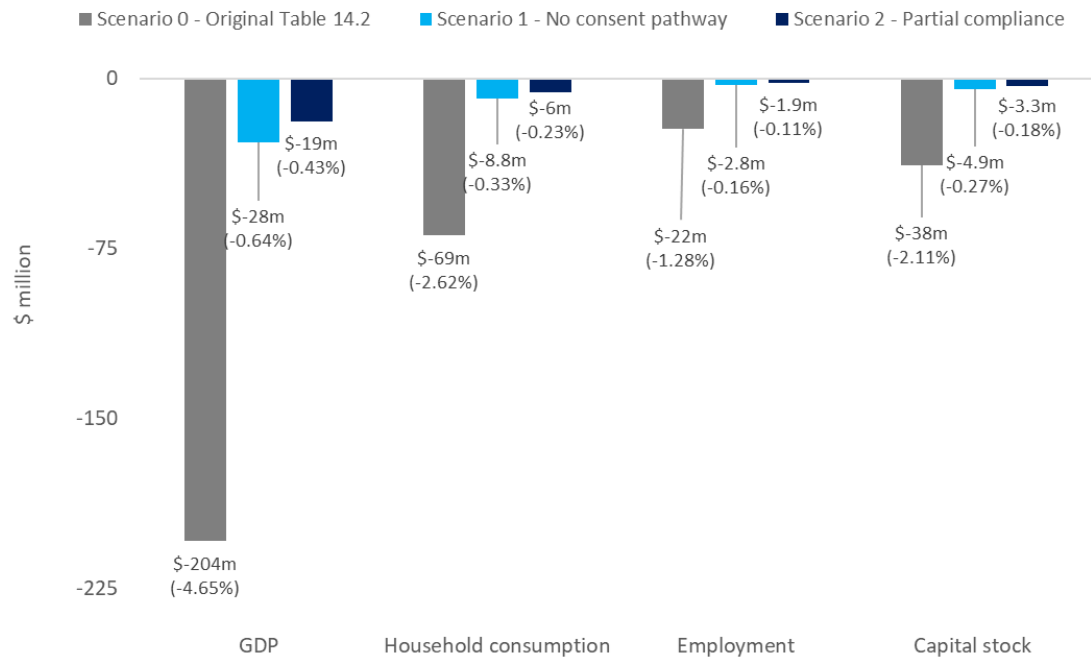
Annual changes from 2019 baseline in Year 20, in \$ million (in real terms) and in percent



Source: NZIER

Figure 3 Macroeconomic impacts for all four districts combined

Annual changes compared with 2019 baseline in Year 20, in percent and in \$ million (real terms)



Note: Figures presented in this graph combine changes for Rangitikei, Manawātū, Tararua and Horowhenua districts.

Source: NZIER

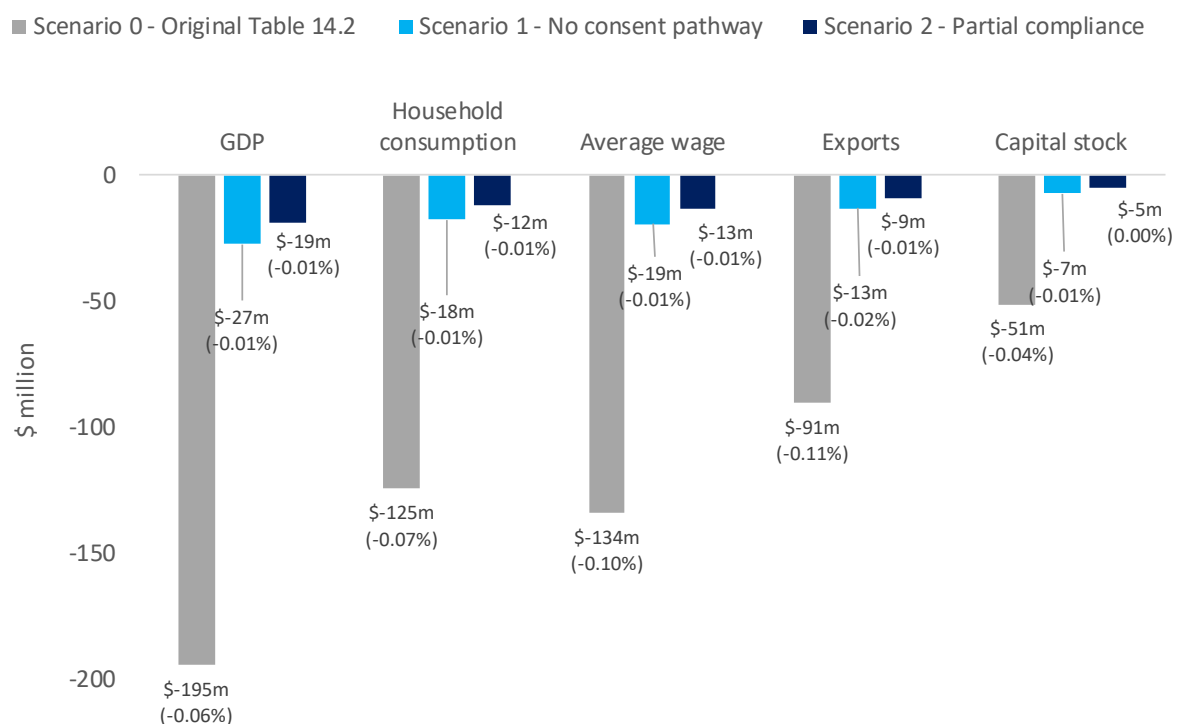
Providing a consent pathway with partial compliance leads to a lesser economic impact than a pathway without consent for exceedance

This is because allowing for partial compliance with the recalibrated Table 14.2 (Scenario 2) allows farmers to implement on-farm management practices over time and spread the associated costs. However, the difference between Scenario 2 and Scenario 1 is rather more marginal.

Overall, our results confirm that the costs of introduction of the recalibrated Table 14.2 targets in the One Plan are substantially lower than complying with the original Table 14.2 targets (Figure 3 and Figure 4).

Figure 4 Headline economic impacts for all New Zealand

Annual changes compared with 2019 baseline in Year 20, in percent and in \$ million (real terms)



Note: Percentages in the graph differ at the 3rd decimal place.

Source: NZIER

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1 Background and objectives

NZIER was asked by the Horizons Regional Council to build on a previous NZIER report (2018) and estimate the local and regional macroeconomic impacts of different degrees of compliance by farmers and commercial vegetable growers to the recalibrated Table 14.2 as part of Plan Change 2 of the One Plan. We also remodel and update the economic impacts of the original Table 14.2 to set up a base against which to compare effects of the recalibrated Table 14.2.

For this work, we use NZIER's regional bottom-up computable general equilibrium (CGE) model and we focus on four local economies: the Horowhenua, Rangitikei, Tararua and Manawātū districts.

We examine the indirect or flow-on effects for supplying industries (e.g. agricultural services, fertiliser production, transport, etc.) and downstream industries (primary processing, retail, construction, etc.). Our modelling also considers how resources (especially labour and capital) shift between the primary sector and other industries (manufacturing, services, etc.) as the dairy and vegetable industries becomes less competitive and profitable in the face of higher costs to meet nitrogen loss targets and different degrees of compliance to the recalibrated Table 14.2 as part of Plan Change 2 of the One Plan.

Using these direct and indirect flow-on effects, we determine the combined effects on GDP, employment, wages, and household spending for the selected districts, the wider Horizons economy and the national economy.

2 Methodology and scenarios

2.1 What are CGE models?

CGE models measure how changes in one part of a regional or national economy flow through the rest of the economy.

They are data-driven and used to capture the effects of a new policy or technology or other external shocks affecting economic activity. They capture the economy-wide effects of changes ('shocks' in modelling jargon) directly on the affected industry, as well as indirectly on supplying industries, competing industries, and factor markets (labour and capital). CGE models also estimate the effect of a shock on macroeconomic variables such as GDP, employment, wages and trade.

Our model follows standard neoclassical assumptions, which can be described as follows:

- Consumers maximise their utility subject to their budget constraints. They purchase goods and services from firms, and provide firms with their labour inputs.
- Producers maximise their profits by buying intermediate goods and inputs (labour and capital) and selling outputs to other domestic and international firms, households and government.

- There is a market for each commodity (goods and intermediates) and in equilibrium market prices are such that demand equals supply in all input and output markets.
- Under the standard assumption of constant returns to scale, firms earn zero pure economic profit (i.e. enough to remain in business but not enough to induce new firms to enter the market). The assumption here is that if any firm is able to make profits, then new firms will enter the market and compete. The increase in supply that follows leads to a reduction in prices. A lower price will then reduce profits for both the old and the new firms. This process continues until the excess profits equal zero.

CGE modelling is our recommended method for conducting policy analysis or sectoral impact studies, as it delivers more conservative, but more realistic, estimates of net benefits than commonly-used (and widely criticised) alternatives such as Input-Output (I-O) multiplier analysis. I-O multiplier methodologies, like CGE analysis, are looking at interconnection between an industry and the rest of the economy. There are not farm-level methods. However, unlike CGE models, I-O multiplier analysis typically over-state economic impact estimates because they assume that economic resources such as land, labour and capital are infinitely available, are never idle or can be reallocated without adjustment costs. They also assume that all prices remain constant, even if demand increases. In contrast, CGE models are not only driven by prices that respond to changes in supply and demand, but they also account for resource constraints and flow-on effects. That is, in a CGE model, there are no 'free lunches'.

2.2 How do CGE models work?

A CGE model consists of equations which describe model variables. It also uses detailed data on the structure of the economy that is consistent with these model equations.

This data provides a snapshot of the economy in a particular year, which is used as a starting point for a baseline (or business as usual (BAU)) against which to compare policy simulations or economic changes.

The model data is linked together through a set of equations which capture how the economy evolves over time in response to a shock. These equations, which are based on the economic theory of general equilibrium, ensure supply and demand for goods, services and factors of production in the economy are balanced, and determine how firms and households react in response to changes in incentives.

Most CGE models are written and solved in a specific software system, usually GAMS² or GEMPACK.³

In any CGE model, we must decide what is within the model (the endogenous variables) and what is to be considered external to the model (the exogenous variables). Where we draw the line between endogenous and exogenous variables, and which ones can vary or have to remain fixed, depends on a number of factors, including the purpose for which the model simulations are to be used. The decision that we make is called the model closure.

Determining the closure is a key part of any modelling exercise, for transparency about what is a result of the modelling and what has been imposed by assumption via the closure.

² General Algebraic Modelling System: <https://www.gams.com/>

³ General Equilibrium Modelling PACKage: <https://www.copsmodels.com/gempack.htm>

The difference between the initial and the new equilibrium can then be analysed to determine the effect of the shock on a range of economic indicators, such as GDP, employment, wages and living standards.

2.3 Our regional CGE model TERM-NZ

We used our CGE model, TERM-NZ,⁴ which is the only bottom-up regional CGE model of the New Zealand economy. TERM-NZ is based on a Stats NZ's Input-Output tables that identify the structure of the industries involved. The model database is benchmarked to 2019 using Stats NZ's latest available National Accounts data (November 2019). Our CGE database contains information on 149 industries, 149 commodities and 88 districts,⁵ including the Manawātū-Whanganui regional economy comprising six districts, four of which are used in our district-level modelling. The six districts are:

- Ruapehu District
- Whanganui District
- Rangitikei District
- Manawātū District
- Palmerston North City
- Tararua District
- Horowhenua District.

We usually run TERM-NZ with an aggregated version of the database to focus on districts and industries of interest, speed-up the model computation and because it is not technically possible to run the model with such a large database in its full dimensions. For this study, we aggregated the model's database to six geographical areas⁶ and 49 industries.

TERM-NZ treats New Zealand's regions as separate economies. This means that we are able to account for region-specific inter-linkages between industries, as well as their links to households (via the labour market), local and central government, capital markets, the rest of New Zealand (via inter-regional trade) and the global economy (via imports and exports).

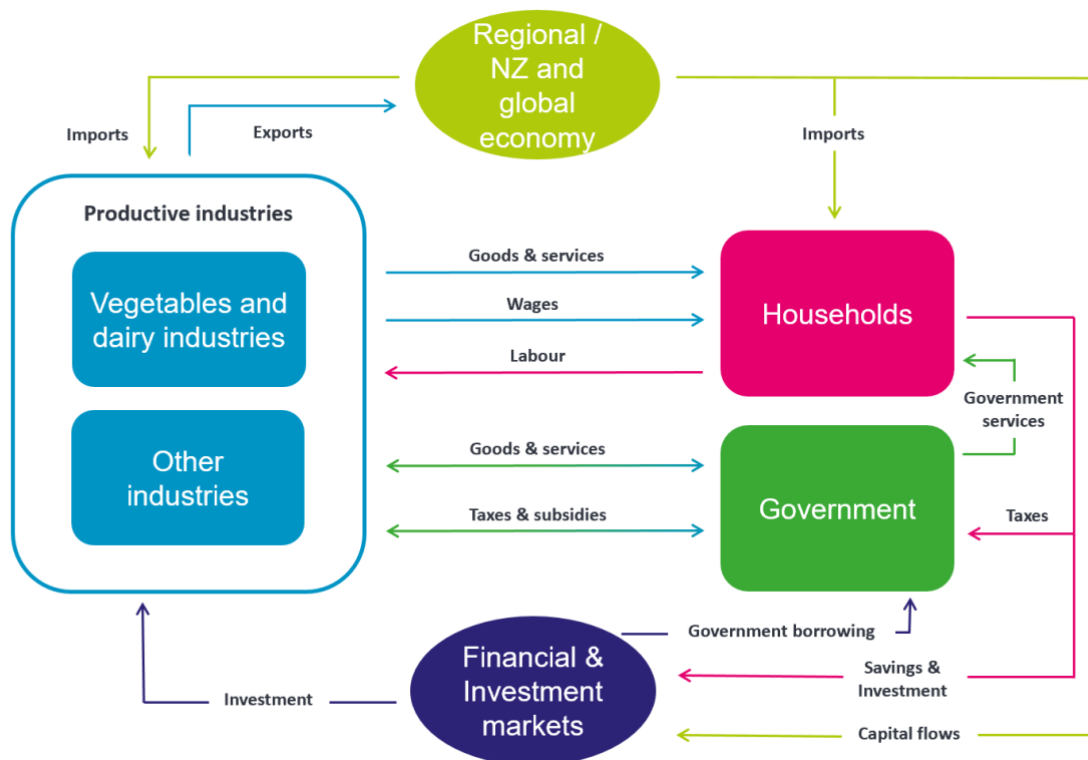
Figure 5 shows how the model captures the complex and multidirectional flows between the various actors of each regional economy and how they interact with the rest of New Zealand and the rest of the world. A list of the model's key features can be found in Appendix B.

⁴ TERM-NZ stands for "The Enormous Regional Model" of the New Zealand economy. It was developed at NZIER by Dr Erwin Corong based on the original Australian TERM model created by Professor Mark Horridge of the Centre of Policy Studies, Victoria University-Melbourne, Australia. <http://www.copsmodels.com/term.htm>. NZIER maintains close connections with the Centre, ensuring that our modelling techniques reflect international best-practice.

⁵ These 88 districts comprise the 68 local territorial and unitary authorities (including the Chatham Islands) and 20 local boards within Auckland Council. These can be combined into regional or other sub-national groupings.

⁶ These six geographical areas include Rangitikei, Manawātū, Tararua, Horowhenua, rest of Manawātū-Whanganui and rest of New Zealand.

Figure 5 Our CGE model represents the circular flows between all the agents and activities in the economy



Source: NZIER

2.4 Our modelling approach

2.4.1 Focus industries and districts

The industries being considered in this report are:

- Dairy in the Tararua, Rangitikei and Manawatū districts.
- Vegetable growing in the Horowhenua, Rangitikei and Manawatū districts.

2.4.2 Setting up the baseline

We first need to develop a baseline picture of the economy with the current One Plan measures. To do so, we calibrate our model of the Horizons economy and its territorial authorities to the latest available data from Stats NZ's National Accounts (2019).

This allows us to ensure we correctly benchmark the size of the various agricultural industries and it gives us a business as usual (BAU) snapshot of the local, regional and national economies under the current One Plan measures.

Our baseline assumes that the farmers and growers of consented intensive farming land uses (IFLUs) have already made their investments required to secure consent and their operating costs to maintain their authorised nitrogen loss are already part of their BAU. Most consents were granted before 2017 (and definitely before 2019 when Plan Change 2 was publicly notified). Our baseline also assumes that farmers and growers with unconsented IFLUs all comply with the operative Table 14.2 by Year 5 and in Year 20.

There is ambiguity within the One Plan policy framework about whether activities involving exceedances of Table 14.2 could be granted consent after year 5. Over time, the policy framework (which requires compliance with Table 14.2), coupled with updates to the Overseer model resulting in the nitrogen leaching maximums becoming out of date, has meant implementation of the One Plan rules for IFLUs as written has become very challenging. The practical reality is that no farmers or growers are currently pursuing consent applications to exceed Table 14.2 under the operative One Plan. For the purposes of the baseline (i.e. without PC2), we assume this situation will continue. The One Plan is intended to regulate all existing IFLUs. Therefore, our baseline assumes that no IFLUs (whether consented or unconsented) are unregulated or operating with unauthorised exceedances of Table 14.2. The baseline is not attempting to represent actual nitrogen loss in Year 5 and Year 20. It is attempting to represent what might have been expected if IFLUs implemented the measures necessary to comply with Table 14.2

As our CGE model is static, it can only look at 'before' (i.e. current situation) and 'after' (No consent exceedance pathways under the original and recalibrated Table 14.2 and consent exceedance pathway under the recalibrated Table 14.2). We therefore do not explicitly model the timing of farmers and commercial vegetable growers moving toward compliance by Year 20. We simply compare the local, regional and national economies with the recalibrated Table 14.2 against the situation with the original Table 14.2. As such, and for our scenario design, we use annualised data provided for Year 20 from Terry Parminter and WSP (Stephen McNally) to estimate our shocks.

While our CGE model doesn't capture any adjustment path, its static feature makes it easier to interpret the flow-on effects of complying with the original and recalibrated Table 14.2. Results are not cluttered with interim variations that would be driven by assumptions.

2.4.3 Scenario design

Based on discussions with Horizons Regional Council officials and industry experts, we have designed three modelling scenarios to evaluate the additional on-farm costs of meeting existing and proposed measures of Plan Change 2 of the One Plan provisions in Year 20:

Scenario 0 – Original Table 14.2

In this scenario, we assume that all vegetable growers and dairy farmers are forced to comply with the original Table 14.2 of the One Plan (controlled pathway).

Scenario 1 – No consent pathway for exceedance

In this scenario, we assume that all vegetable growers as well as dairy farmers comply with the recalibrated Table 14.2 of the One Plan (controlled pathway). Therefore, we estimate the effects of meeting the recalibrated Table 14.2 of the One Plan in the absence of any discretionary activity consent pathway for exceedances of the recalibrated Table 14.2.

Scenario 2 – Consent pathway for exceedance and only partial compliance by Year 20

In this scenario, we consider there is a discretionary activity consent pathway for exceedances of the recalibrated Table 14.2 with only partial compliance by Year 20. This is the version of PC2 as notified. As such, 'most' farms comply in Year 20. Those who do not comply by Year 20 are on an improving trend and have been reducing their nitrogen loss using good and best management practices (GMP and BMP).

We model our three scenarios against a counterfactual. Normally this would be a situation with no regulation but it is unlikely there would ever be no regulation of dispersed nitrogen discharges from land use. The counterfactual is the current situation in which minimal

landholders comply with the original Table 14.2, so the baseline becomes the cost of forcing all remaining landholders to comply, for comparison against the PC2 alternatives of all landholders complying with the recalibrated table. Our baseline reflects the state of the New Zealand economy as of 2019 and implicitly captures measures implemented with the original Table 14.2. Therefore, it captures a number of consented farmers. As such, our estimates are likely to (slightly) overestimate the cost of compliance for farmers and commercial vegetable growers.

In this report, we present results from the modelling in two ways:

- Results are provided for all scenarios and compared with our 2019 baseline
- Results from scenarios 1 and 2 (recalibrated Table 14.2) are compared with Scenario 0 (Original Table 14.2).

2.4.4 Data requirement and methodology to estimate our shocks

Economic impact modelling of additional costs to dairy farmers

Similar to our previous report (NZIER, 2018), we used the figures (in kg MS) provided by Terry Parminter to estimate the expected loss in productivity in the dairy industry in Tararua and Rangitikei for both Scenario 0 (Original Table 14.2) and Scenario 1 (Recalibrated Table 14.2 – No consent pathway). To this extent, we were able to use most of the data provided by Terry Parminter (Parminter 2018) for these two districts.

In Parminter's report (2018), there was no data available for dairy in Manawatū and Horowhenua. After discussions with Horizons and WSP, we took the average approach from the dairy cluster farms in Tararua (acknowledging the assumptions around soil and climate types) and applied it to the other districts, namely Manawatū and Horowhenua.

Our model is capable of being updated with further and better information and data in relation to on-farm costs associated with meeting the recalibrated Table 14.2, as such information or data becomes available.

For Scenario 2 (Recalibrated Table 14.2 – Partial compliance), we used changes in milk production (Kg MS/district) estimates provided by WSP for dairy in Tararua, Manawatū, Rangitikei and Horowhenua.

Economic impact modelling of additional costs to commercial vegetable growers

We rely on information provided by WSP in respect of changes to vegetable yield (tonnage/district) for the Horowhenua district for both scenarios 1 and 2. WSP provided changes in gross margin (in \$ per hectare per year) for each IFLU type and district from which yield figures are derived and which we use to derive our shocks on vegetable growing outputs.

No data provided to us was sufficiently detailed to derive our productivity shock on the vegetable industry for Scenario 0 (Original Table 14.2). Accordingly, we designed an indicative scenario by averaging the changes in milk production (Kg MS) across all four districts and assuming this average productivity change also applies to the vegetable industry.

The WSP data allows us to model the economic impacts of complying with the recalibrated Table 14.2 with no consent pathway (Scenario 2). We were unable to do this in our modelling for our 2018 report (NZIER 2018) because of data unavailability.

Figure 6 presents a summary of our scenarios as well as the estimated values used to shock productivity in our CGE model. These values are derived from Parminter's (2018) report and WSP (2020) data. As would be expected, Scenario 2's partial compliance has less impact on farm operations than Scenario 1. Scenario 0's full compliance under the original Table 14.2 has significantly higher impacts on farm operations than both Scenarios 1 and 2.

Figure 6 Summary of our scenarios

Change in milk and vegetable production, in percentage

Scenario	Scenario description	Focus districts	Focus sectors	Source	Yield	% change
Baseline	Snapshot of the NZ economy (and districts) as of 2019 - CGE Database					
Scenario 0	Original Table 14.2 - No consent pathway for exceedance	Tararua	Dairy	Parminter (2018)	Kg ms/district	-41.5%
		Rangitikei		Parminter (2018)		-27.8%
		Manawatu		No data. Indicative scenario designed using average approach		-27.8%
		Howrowhenua	Dairy	Use average approach	Tonnage/district	-27.8%
			Commercial vegetables	No data. Indicative scenario designed using average approach		-31.3%
Scenario 1	Recalibrated Table 14.2 - No consent pathway for exceedance	Tararua	Dairy	WSP (2020)	Kg ms/district	-4.7%
		Rangitikei		WSP (2020)		-4.6%
		Manawatu		No data. Indicative scenario designed using average approach		-4.6%
		Howrowhenua	Dairy	Use average approach	Tonnage/district	-4.6%
			Commercial vegetables	No data. Indicative scenario designed using average approach		-6.4%
Scenario 2	Recalibrated Table 14.2 - Consent pathway for exceedances with partial compliance by Year 20	Tararua	Dairy	WSP (2020)	Kg ms/district	-3.0%
		Rangitikei		WSP (2020)		-3.0%
		Manawatu		WSP (2020) - average approach		-3.0%
		Howrowhenua	Dairy	WSP (2020) - average approach	Tonnage/district	-3.0%
			Commercial vegetables	WSP (2020) - average approach		-6.3%

Source: NZIER, derived from data provided by WSP (2020) and Terry Parminter (2018)

2.4.5 Closure

In any CGE model, it is important to understand which factors have been allowed to vary and which remain fixed by assumption (also known as exogenous variables). The particular combination of fixed factors is known as the closure. Given the twenty-year timeframe, we adopt a long-term closure for the simulations.

In Table 1, we list the main variables included in the long-term closure in the modelling underlying this report.

- National employment is fixed but labour is completely mobile between industries and regions, and real wages adjust. This is consistent with the idea that, both the labour force and the rate of employment are, in the long run, determined by mechanisms outside the model.
- Household and government expenditures move together to accommodate a fixed balance of trade as a share of GDP.

- Rates of return are exogenous and capital is mobile between industries and regions. This mobility can occur either in the form of machinery etc. being physically moved, or capital in one industry/region being allowed to depreciate without replacement while investment builds up the stock of another industry/region.
- Foreign currency prices of imports are naturally exogenous.
- Real government consumption is also exogenous.
- Other exogenous variables include rates of production tax, technological coefficients, national population, and national labour supply.

Table 1 Fixed elements of the CGE model

Exogenous variables	
Taxes on production	National population
Technological change	National labour supply
Government demand	Import prices, foreign currency
Gross growth rate of capital	Foreign demand for New Zealand exports
Gross rate of return on capital	Land use
Number of households	

Source: NZIER

3 Results from the modelling

3.1 Key modelling outputs: a focus on the macroeconomy

The CGE technique calculates impacts as changes relative to the baseline level. Results are then reported as percentage changes from the baseline. The CGE model captures the effects across a range of sectors in the economy as described in section 2.3.

The national results flow logically from the local and regional direct and indirect impacts. We will focus on key macroeconomic variables such as GDP, exports, and household spending, which we use as a proxy for wellbeing.

3.2 What would we expect to see?

Figure 7 summarises the chain of economic effects from different degrees of compliance with the One Plan in the dairy and vegetables industries in the Horizons region.

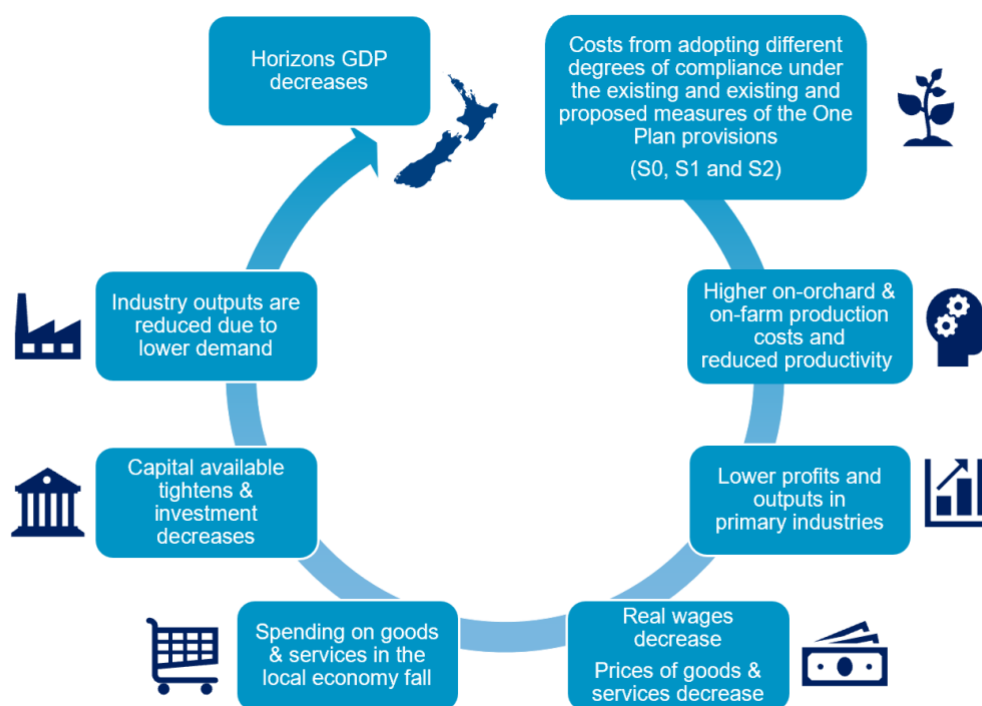
The introduction of the current and recalibrated Table 14.2 targets in the One Plan affect the local, regional and national economies. However, costs are significantly greater under Scenario 0 than under Scenarios 1 and 2. Under Scenario 2, providing a consent pathway, reduces the cost of compliance (compared to a situation with no consent for exceedance) for farmers and commercial vegetable growers in all four districts, with less economic impacts, and improvements relative to Scenario 0

There are multiple moving parts at play within the model. It is to be expected that agricultural profits and production would fall with higher costs of production and reduced productivity from farmers and vegetable growers because of more resources being put towards implementing measures to meet nitrogen loss requirements.

Generally, as costs rise, the farm's capacity will fall.⁷ Sectors closely related to the agricultural sector (e.g. agricultural services, rural retail) would be affected by a primary sector slowdown, as well as household spending industries (accommodation, food and beverages, retail, real estate) due to lower employment and real wages. Competing industries will benefit at the margin from the contraction in the primary sector, as more resources (labour, capital, land) become available for producing other products. All these effects lead to a decrease in real GDP, employment and household consumption within the Horizons region. The economic slowdown of the Horizons region drives a decrease in national real GDP, household expenditure, exports, output and investment.

Therefore, we would expect that the options that require the greatest resource to achieve compliance would have the largest adverse economic effect on the agricultural sector and GDP. Our results are consistent with expectations.

Figure 7 Main economic effects from complying with Plan Change 2 of the One Plan



Source: NZIER

3.3 Direct and flow-on effects at the district level

To meet the revised nitrogen loss requirement targets, dairy farmers in Tararua, Rangitikei, Manawatū and Horowhenua, as well as commercial vegetable growers in Horowhenua, will have to implement new management and agricultural practices and use less fertiliser. Farmers and vegetable growers will therefore face lower productivity and higher production costs.

⁷ Our model has a 'fixed proportions' production structure, which implies that as production costs increase, output falls as production becomes less profitable. Alternative production structures could be employed that allow producers to simply absorb higher costs and maintain production levels by dipping into savings or borrowing more, but this is not a standard approach to CGE modelling.

Table 2 shows the annual direct and indirect impacts of meeting targets from the original Table 14.2 (Scenario 0) and different degrees of compliance in Year 20 to the recalibrated Table 14.2 (Scenario 1 and Scenario 2) as part of Plan Change 2 of the One Plan across industries⁸ within the local, regional and New Zealand economies.

Partly offsetting the losses from the dairy and vegetable growing industries,⁹ as well as their supporting industries (e.g. dairy product manufacturing, retail and wholesale, agricultural services, transport), is the expansion of competing industries (e.g. other services and other manufacturing). These industries gain from the decrease in the dairy and vegetable growing industries' outputs as they compete for resources (labour and capital), which become less expensive.

Table 2 District impacts on industry outputs for all 4 districts – aggregated industries

Annual changes from Scenario 0 in Year 20, in \$ million (in real terms)

Industry	Scenario 0	Scenario 1	Scenario 2
Dairy cattle farming	-329.1	-46.3	-30.1
Dairy product manufacturing	-117.4	-13.0	-8.3
Real estate	-24.6	-3.3	-2.3
Vegetables	-19.4	-3.7	-3.7
Retail and wholesale	-9.6	-1.5	-1.2
Agricultural services	-7.7	-1.3	-0.9
Transport	-3.1	-0.5	-0.3
Government services	4.6	0.6	0.4
Other manufacturing	6.1	0.7	0.6
Sheep, beef and grain/arable	8.6	1.1	0.7
Other services	12.4	1.6	1.0
Meat manufacturing	13.8	1.9	1.2
Other industries and services	3.3	0.4	0.2
National output	-462.1	-63.2	-42.5

Note: * Figures provided for all 4 districts impacted by the One Plan combine results for Rangitikei, Manawātū, Tararua and Horowhenua.

Source: NZIER

Further detail on output changes for selected industries in each district can be found in Figure 12 in Appendix A.

Macroeconomic impacts at the district and regional level

Figure 8, Figure 9 and Figure 10 below show the district impacts on real GDP and other macroeconomic variables of meeting the original Table 14.2 (Scenario 0) and recalibrated Table 14.2 with different degrees of compliance (Scenario 1 and Scenario 2).

⁸ These are industries classified under the ANZSIC classification system: <http://archive.stats.govt.nz/methods/classifications-and-standards/classification-related-stats-standards/industrial-classification.aspx>

⁹ Results for the vegetable growing industry under Scenario 0 are based on an indicative scenario we designed due to lack of data available. See section 2.4.3 for further detail.

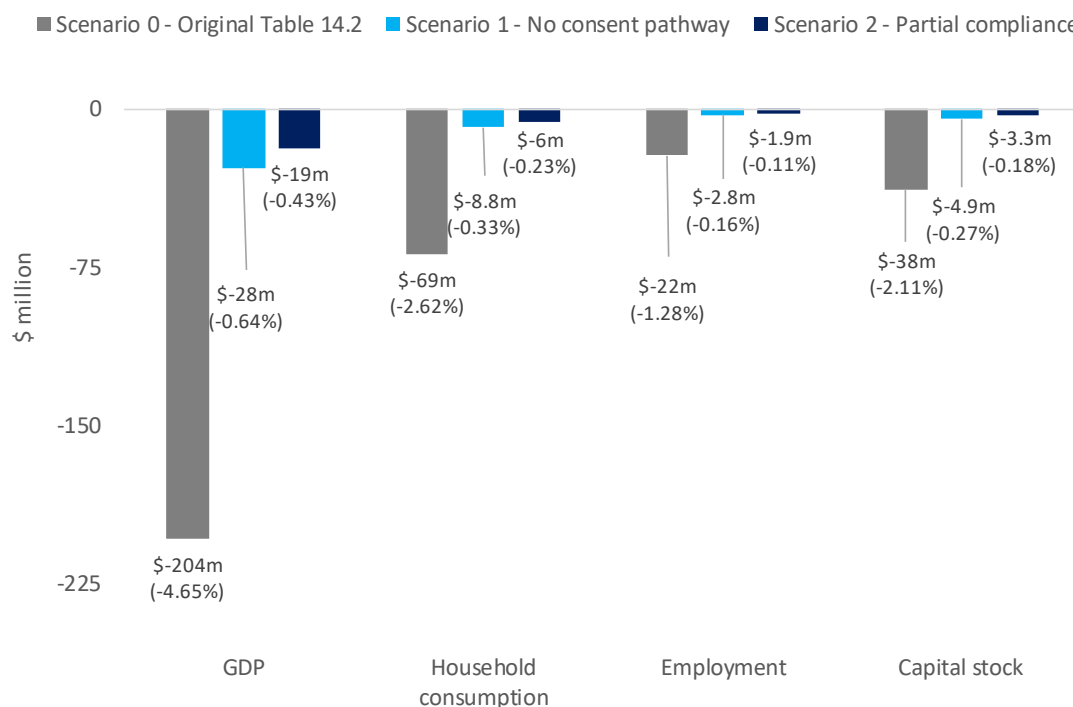
The impacts of meeting the original Table 14.2 (Scenario 0) are much more significant than meeting requirements of the recalibrated Table 14.2 (Scenario 1 and Scenario 2). This is because the recalibrated Table 14.2 allows for more achievable targets in terms of nitrogen leaching maximums.

Macroeconomic effects from the costs of meeting the recalibrated Table 14.2 targets with only partial compliance by Year 20 (Scenario 2) are of lesser magnitude than the costs of meeting the recalibrated Table 14.2 targets without any consent pathway for exceedance (Scenario 1). This is because allowing for partial compliance to the recalibrated Table 14.2 allows farmers to implement good and best management practices over time, spreading the associated costs, and does not force them to apply higher cost measures to meet the Table 14.2 targets immediately or over the short term.

Economic impacts in Tararua are stronger than in the other districts for all three scenarios (Figure 9 and Figure 10). While dairy cattle farming is the most significantly affected, impacts of meeting the original and recalibrated Table 14.2 are also affecting the dairy product manufacturing industry quite significantly in Tararua. This is because the district, which hosts a Fonterra milk powder plant in Pahiatua, is impacted from the loss in dairy across all districts and is processing less milk.

Figure 8 Aggregated economic effects at the district level

Changes compared with 2019 baseline in Year 20, in percent and in \$ million (real terms)

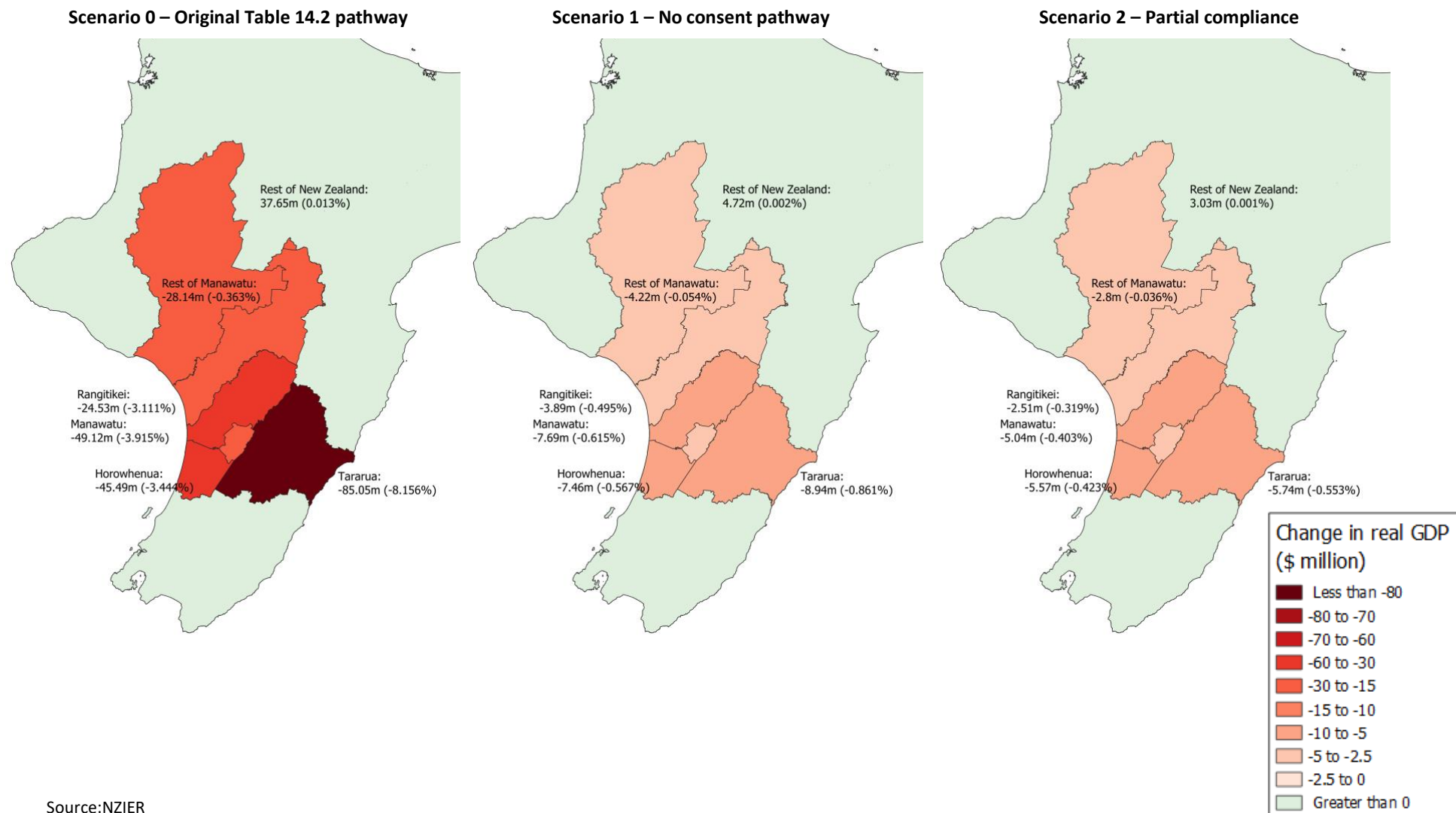


Note: Figures presented in this graph combine changes for Rangitikei, Manawatū, Tararua and Horowhenua districts.

Source: NZIER

Figure 9 Real GDP impacts at the district, regional and national levels

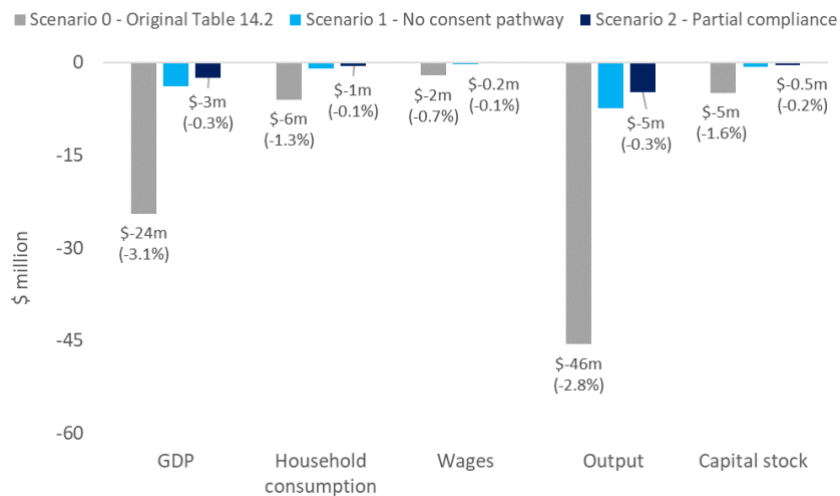
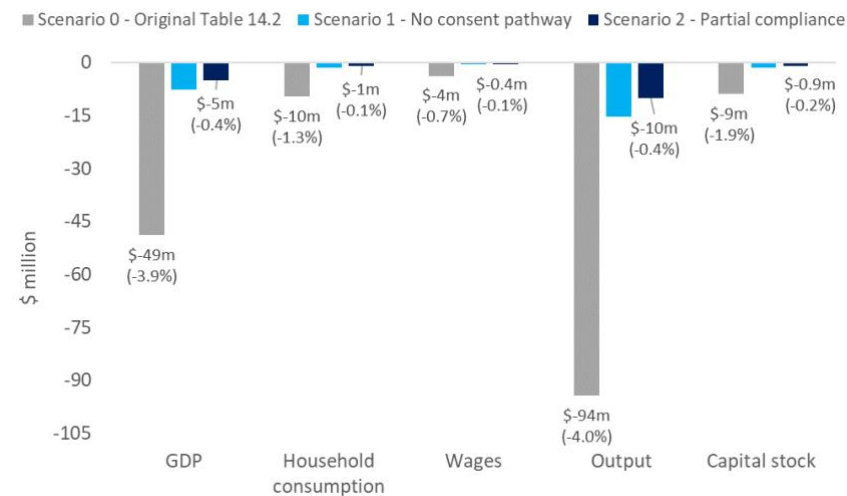
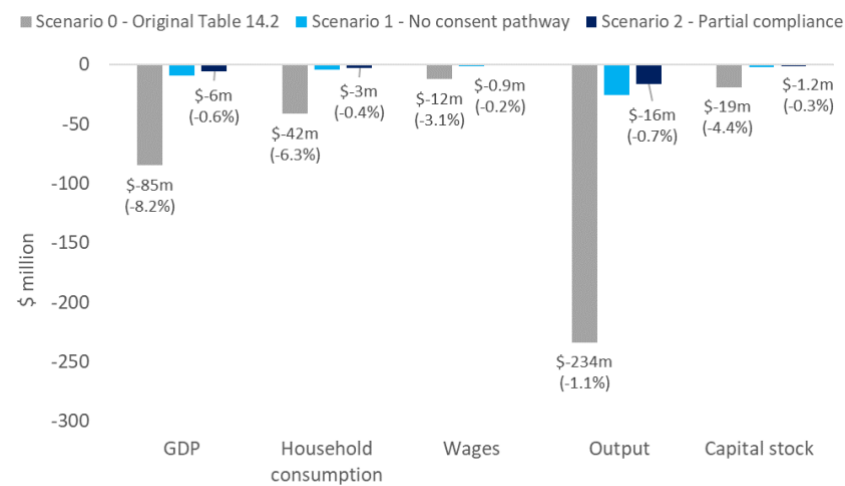
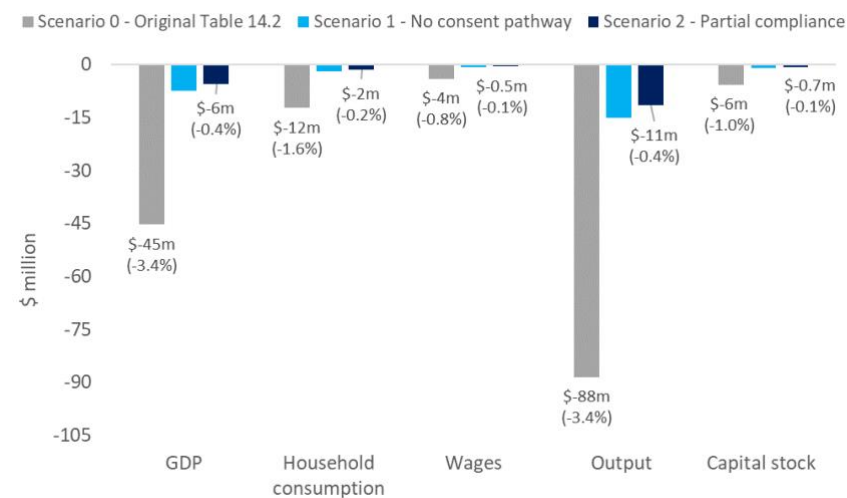
Annual changes compared with 2019 baseline in Year 20, in percent and in \$ million (real terms).



Source: NZIER

Figure 10 Difference in macroeconomic impacts between scenarios for each district

Annual changes compared with 2019 baseline in Year 20, in \$ million (real terms) and in percent

Rangitikei**Manawatu****Tararua****Horowhenua**

Source: NZIER

Table 3 and Table 4 show the regional impacts on real household spending and employment, respectively, under the three scenarios.

The costs associated with meeting nitrogen limits release some labour from the dairy and vegetable growing industries as well as from their supporting industries (e.g. dairy product manufacturing) which moves toward competing industries such as services and manufacturing. However, increasing employment in these competing industries only partly offsets the employment and income decrease within Rangitikei, Manawatū, Tararua and Horowhenua districts. This leads to a decrease in household spending.

As expected, the wellbeing impacts¹⁰ of the recalibrated Table 14.2 (Scenario 1 and Scenario 2) are lower in magnitude than under the original Table 14.2 (Scenario 0). Under the recalibrated Table 14.2, impact on household spending is even smaller when farmers and vegetable growers are provided with a partial compliance pathway, compared with a no consent pathway.

Table 3 Real household spending impacts at the district level

Annual changes compared with 2019 baseline in Year 20, in percent and in \$ million (real terms)

Region	Scenario 0 – Original Table 14.2		Scenario 1 – No consent pathway		Scenario 2 – Partial compliance	
	in %	in \$ million	in %	in \$ million	in %	in \$ million
Rangitikei	-1.29%	-6.0	-0.20%	-0.9	-0.13%	-0.6
Manawatū	-1.31%	-9.6	-0.20%	-1.5	-0.13%	-1.0
Tararua	-6.33%	-41.3	-0.68%	-4.5	-0.44%	-2.9
Horowhenua	-1.56%	-12.3	-0.25%	-1.9	-0.19%	-1.5
Total districts	-2.62%	-69.2	-0.33%	-8.8	-0.23%	-6.0
Rest of Horizons region	-0.56%	-26.1	-0.08%	-3.9	-0.06%	-2.6
Rest of New Zealand	-0.02%	-29.3	0.00%	-5.0	0.00%	-3.5
National	-0.07%	-124.5	-0.01%	-17.7	-0.01%	-12.07

Source: NZIER

¹⁰ Household spending is our proxy for wellbeing

Table 4 Change in the number of jobs at the district level

Annual changes in jobs compared with 2019 baseline in Year 20, in percent and number

Region	Scenario 0 – Original Table 14.2		Scenario 1 – No consent pathway		Scenario 2 – Partial compliance	
	in %	Jobs	in %	Jobs	in %	Jobs
Rangitikei	-0.64%	-37	-0.10%	-6	-0.1%	-4
Manawatū	-0.65%	-62	-0.10%	-10	-0.1%	-6
Tararua	-3.34%	-200	-0.35%	-21	-0.2%	-14
Horowhenua	-0.79%	-73	-0.12%	-12	-0.1%	-9
All 4 districts	-1.22%	-373	-0.16%	-48	-0.11%	-33
Rest of Horizons region	-0.26%	-191	-0.04%	-29	0.0%	-19

Source: NZIER

3.4 Headline macroeconomic impacts

New Zealand-wide results flow from the direct and indirect impacts at the district and regional levels as a result of different degrees of compliance to the recalibrated Table 14.2 as part of Plan Change 2 of the One Plan.

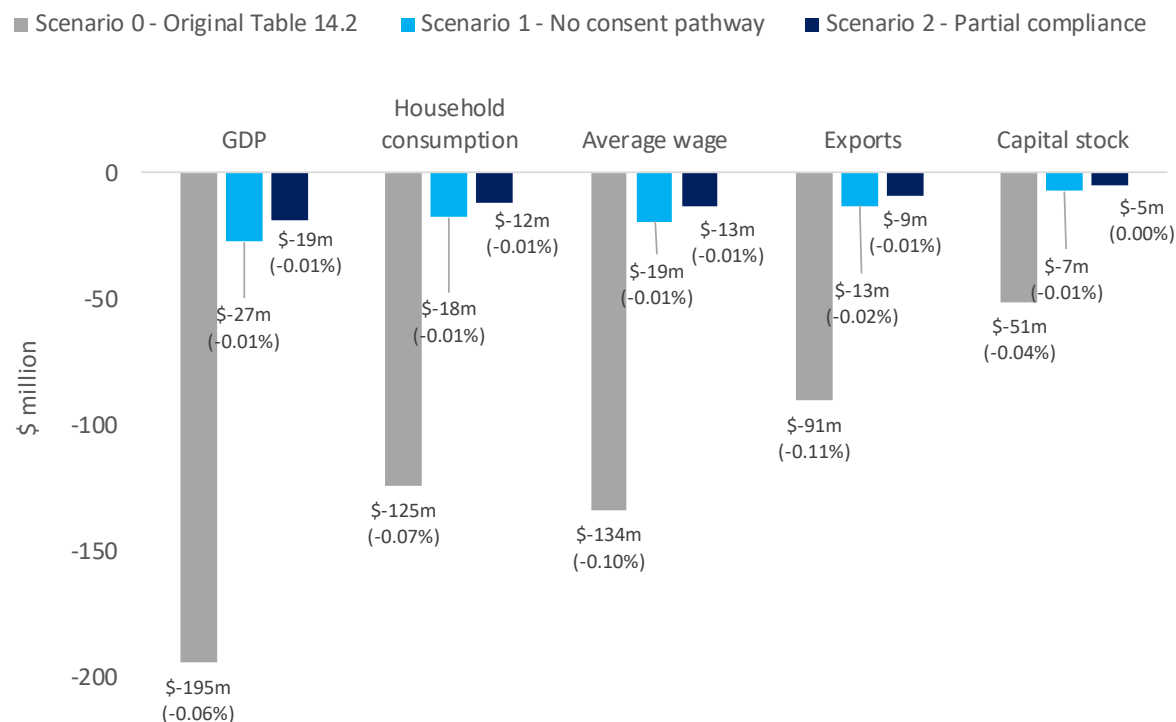
At the national level (Figure 11) the additional costs for dairy and vegetable growing industries from meeting the nitrogen loss targets from the recalibrated Table 14.2 with different degrees of compliance result in:

- New Zealand's real GDP decreasing by \$195 million (0.06%), \$27 million (0.01%) and \$19 million (0.01%), under Scenario 0, Scenario 1 and Scenario 2, respectively. New Zealand's real GDP loss is driven by the fall in national output.
- New Zealand's welfare, as proxied by household spending, is \$18 million (0.01%) and \$12 million (0.001%) lower than it would have been otherwise, under Scenario 1 and Scenario 2, respectively. The impact on household spending is much more significant under Scenario 0 with \$125 million (0.07%) decrease.
- The economy-wide average real wage decreases by \$134 million (-0.1%), \$19 million (-0.01%) and by \$13 million (-0.01%) under Scenario 0, Scenario 1 and Scenario 2, respectively. The decrease in the average real wage is consistent with an overall slowing of the economy.
- Total real exports across the entire economy fall by a smaller amount: by \$91 million (Scenario 0), \$7 million (Scenario 1) and \$5 million (Scenario 2). This is because the decline in agricultural exports is partly offset by increases in exports across many manufacturing and services sectors due to the greater availability of resources (labour, capital, intermediate inputs), hence in outputs, in those sectors.

As expected, economic loss at the national level is significantly smaller for both Scenarios 1 and 2 than Scenario 0.

Figure 11 Main macroeconomic impacts for all New Zealand

Annual changes compared with 2019 baseline in Year 20, in percent and in \$ million (real terms)



Note: Percentages in the graph differ at the 3rd decimal place.

Source: NZIER

4 Assumptions, caveats and information gaps

- Our model of the New Zealand and regional economies is not a farm-level model. CGE models' strengths lie in their robust theoretical frameworks and detailed databases of how industries respond to changes in an economy. However, the model itself cannot determine (say) how much time dairy farmers and vegetable growers will need to spend on implementing good or best management practices and how costly these practices will be. These parameters need to be determined outside of the model, and then translated into CGE modelling scenarios that proxy their effects.
- Our model focuses on flows of income rather than wealth and quality effects. We are not able to examine how meeting the nitrogen targets from the original and recalibrated Table 14.2 might affect the value and quality of farmland. However, we would expect that a reduction in profitability in land uses would lower land value below what it would otherwise be, offset in part, where land and adjoining waterways show less sign of excessive nitrogen by an increase in quality and hence, in value, relative to similar contaminated land. Estimating these potential wealth and quality impacts is beyond the scope of this project.

- As our CGE model is static, it can only look at ‘before’ (i.e. current situation) and ‘after’. For our scenario design, we use annualised results provided for Year 20, similarly to what we did in our previous report (NZIER 2018).
- We discussed modelling a scenario 3 “Consent pathway for exceedances and full compliance by Year 20” in which we considered a discretionary activity consent pathway for exceedances of the recalibrated Table 14.2. This scenario involves ‘most’ farmers and vegetable growers complying with the recalibrated Table 14.2 by Year 5, with the remainder rapidly moving towards compliance before Year 20 so that in Year 20, all farmers and growers comply with the recalibrated Table 14.2.

After discussions with Horizons, WSP and Terry Parminter, we agreed not to model Scenario 3 as it has the same end point as Scenario 1 in our static CGE model using annualised data to the status in Year 20. Macro-level economic modelling is less susceptible to transitional differences, between the initial year and Year 20, than the primary sector level farm financial analysis, and a static model cannot show those differences. The effect of this is that the CGE modelling results for Scenarios 1 and 3 would be essentially the same.

- In both Scenario 0 (Original Table 14.2) and Scenario 1 (No consent pathway), there was no data available for dairy in the Manawatū and Horowhenua in Parminter’s report (2018). After discussions with Horizons and WSP, we assumed all farms across the districts faced similar production conditions and took an average from the dairy cluster farms in Tararua and applied it to the other districts, namely Manawatū and Horowhenua. This method was agreed to be an acceptable way to represent the change even if it doesn’t capture effects of the different soil types and climate zones.

If more information and data become available on the on-farm costs associated with meeting the recalibrated Table 14.2 of Plan Change 2 of the One Plan, we will be able to carry out further economic modelling as required.

- We have not modelled sheep & beef and arable/grain. There are only 5 known unconsented sheep, beef and arable farms in the Horizons region which cover a small percentage of the land area and contribute less to nutrient run-off per hectare than dairy and vegetable growing. As such, the impacts of Plan Change 2 from our modelling are likely to be marginal for the sheep & beef and arable/grain industry.
- Data from WSP provide estimates on the cost of compliance to the existing and proposed sets of measures from Plan Change 2 of the One Plan. They compare this set of measures with a baseline which looks at 2014, pre-Table 14.2 of the One Plan. Our baseline reflects the state of the New Zealand economy as of 2019 and implicitly captures a higher number of consented farmers (albeit not many). As such, our estimates are likely to (slightly) overestimate the cost of compliance for farmers and commercial vegetable growers.
- We assume no direct changes in the use of nitrogen fertiliser as we didn’t have the data to incorporate in our model for all 3 scenarios and sectors. However, the model captures a (marginal) decrease in the output of the fertiliser industry, which reflects a reduced use of fertiliser from the flow-on effects.

5 References

McNally S., Jolly A.M., Mayes K. 2020. Horizons PC2 farm scale cost implications for commercial vegetable production – Provisional modelling outputs for expert caucusing.

NZIER. 2018. The macroeconomic impacts of the One Plan's intensive land use provisions. NZIER report to Horizons Regional Council.

Parminster, T. 2018. Regional macroeconomic report, memo from KapAg Ltd for Horizons Regional Council.

Appendix A Additional results

Table 5 Real GDP impacts at the district level

Annual changes compared with 2019 baseline in Year 20, in percent and in \$ million (real terms)

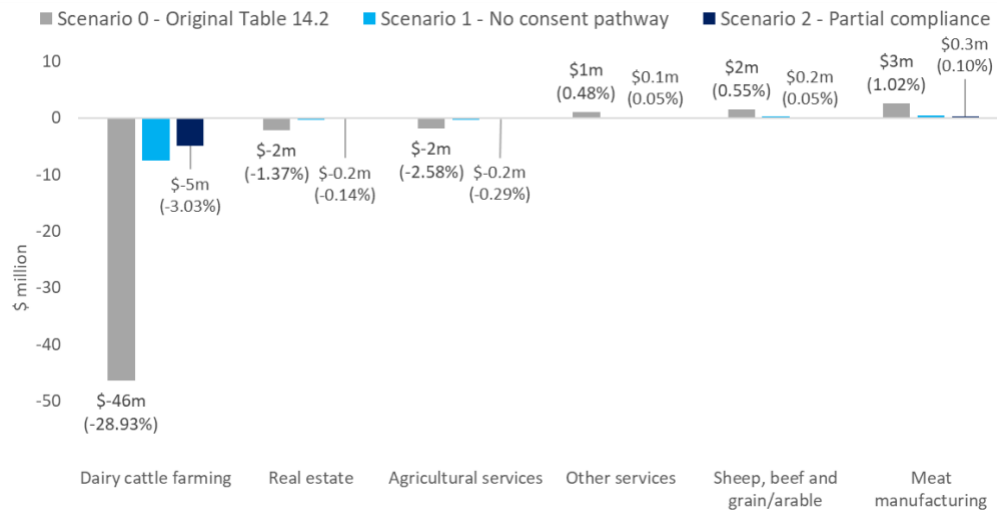
Region	Scenario 0 – Original Table 14.2		Scenario 1 – No consent pathway		Scenario 2 – Partial compliance	
	in %	in \$ million	in %	in \$ million	in %	in \$ million
Rangitikei	-3.11%	-24.5	-0.50%	-3.9	-0.32%	-2.5
Manawatū	-3.92%	-49.1	-0.62%	-7.7	-0.40%	-5.0
Tararua	-8.16%	-85.1	-0.86%	-8.9	-0.55%	-5.7
Horowhenua	-3.44%	-45.5	-0.57%	-7.5	-0.42%	-5.6
Total districts	-4.65%	-204.2	-0.64%	-28.0	-0.43%	-18.9
Rest of Horizons region	-0.36%	-28.1	-0.05%	-4.2	-0.04%	-2.8
Rest of New Zealand	0.01%	37.6	0.00%	4.7	0.00%	3.0
National	-0.06%	-194.7	-0.01%	-27.5	-0.01%	-18.6

Source: NZIER

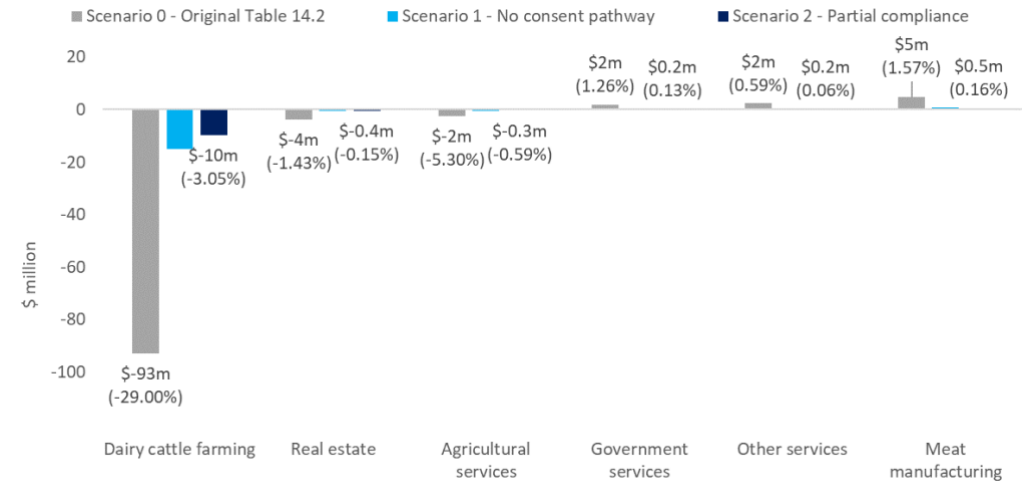
Figure 12 Difference in industry output impacts between scenarios for each district – selected top and bottom industries

Annual changes compared with Scenario 0 in Year 20, in \$ million (real terms)

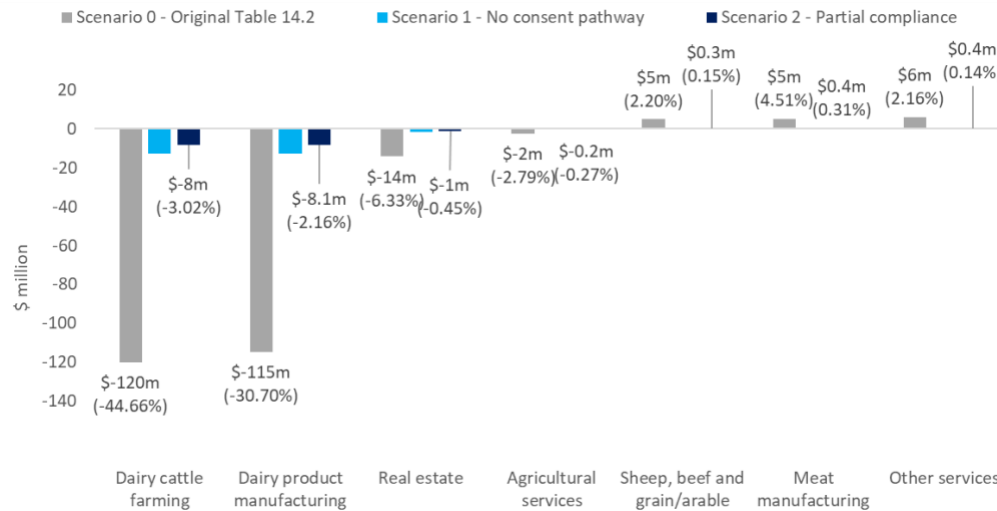
Rangitikei



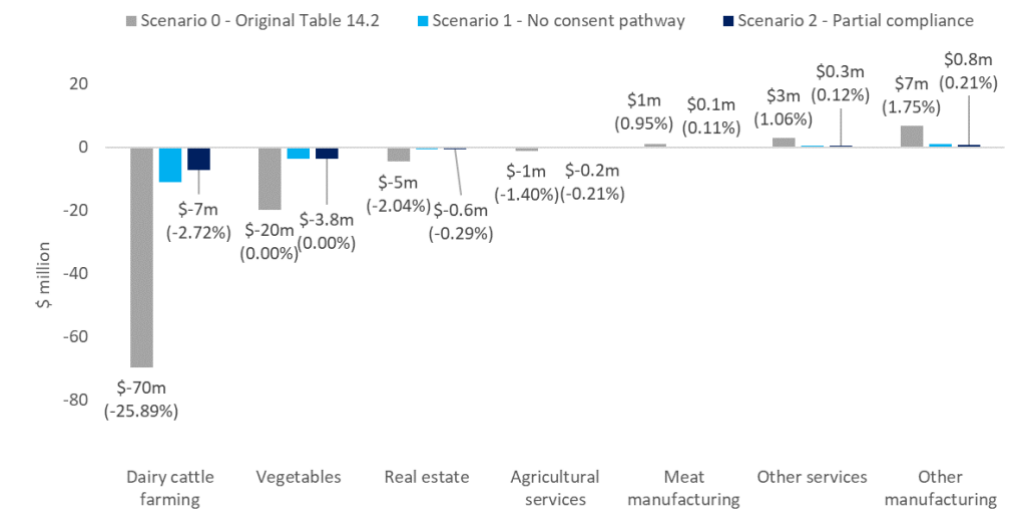
Manawatū



Taranaki



Horowhenua



Source: NZIER

Table 6 Impacts on industry outputs for all four districts

Annual changes compared with 2019 baseline in Year 20, in \$ million (real terms)

Industry	Scenario 0 – Original Table 14.2	Scenario 1 – No consent pathway	Scenario 2 – Partial compliance
Dairy cattle farming	-329.06	-46.27	-30.06
Dairy product manufacturing	-117.37	-12.96	-8.33
Property services and dwelling	-24.57	-3.28	-2.26
Vegetables	-19.40	-3.74	-3.72
Construction	-11.61	-1.56	-1.06
Retail	-8.15	-1.24	-0.97
Agricultural services	-7.73	-1.26	-0.87
Road and rail transport and freight	-3.11	-0.49	-0.33
Accommodation, food and beverages	-2.65	-0.33	-0.23
Wholesale	-1.41	-0.28	-0.24
Fertilisers manufacturing	-1.22	-0.19	-0.14
Personal and other services	-0.78	-0.13	-0.09
Gas, water, sewerage and waste	-0.54	-0.07	-0.04
Pharmaceutical manufacturing	-0.37	-0.06	-0.04
Machinery manufacturing	-0.20	-0.04	-0.02
Rubber manufacturing	-0.02	0.00	0.00
Coal, oil and gas	0.00	0.00	0.00
Petrol manufacturing	0.00	0.00	0.00
Other transport	0.00	0.00	0.00
Air transport and freight	0.00	0.00	0.00
Basic chemicals manufacturing	0.00	0.00	0.00
Fishing	0.00	0.00	0.00
Local government	0.01	0.00	0.00
Electrical equipment manufacturing	0.04	0.01	0.00
Other manufacturing	0.07	0.01	0.01
Seafood processing	0.09	0.01	0.01
Horticulture	0.13	0.02	0.01
Transport and storage	0.14	0.02	0.01
Beverages manufacturing	0.14	0.02	0.01
Mining and exploration	0.32	0.04	0.03
Media and telecommunication	0.48	0.06	0.05
Printing	0.48	0.07	0.05
Transport equipment manufacturing	0.70	0.09	0.06

Industry	Scenario 0 – Original Table 14.2	Scenario 1 – No consent pathway	Scenario 2 – Partial compliance
Fruit processing	0.86	0.10	0.05
Sport and recreation services	0.90	0.12	0.08
Textiles	1.31	0.16	0.11
Forestry	1.48	0.19	0.12
Wood manufacturing	1.50	0.18	0.11
Clothing	1.66	0.20	0.14
Pulp and paper manufacturing	1.67	0.26	0.18
Minerals and metals manufacturing	1.78	0.21	0.14
Finance and insurance services	1.88	0.22	0.15
Tourism services	3.03	0.43	0.29
Business services	3.44	0.41	0.27
Education and health services	3.44	0.44	0.30
Central government	4.57	0.62	0.41
Sheep & beef and grain/arable	8.60	1.08	0.71
Electricity generation and transmission	13.55	1.81	1.31
Meat manufacturing products	13.82	1.88	1.24
National output	-462.08	-63.23	-42.54

Source: NZIER

Appendix B Key feature of our CGE model

Key features of the model:

- Each industry can produce a number of different commodities.
- Production inputs are intermediate commodities (domestic and imported) and primary factors (labour, land and capital).
- The demand for primary factors and the choice between imported and domestic commodities are determined by Constant Elasticity of Substitution (CES) production nests. This means an increase in price of one input shifts sourcing towards another input.
- Intermediate goods, primary factors and other costs are combined using a Leontief production function. This means the proportion of production inputs is held constant for all levels of output.
- The production mix of each industry is dependent on the relative prices of each commodity. The proportion of output exported or consumed domestically is also dependent on relative prices.

Policy impacts are often unevenly spread across industries and regions/districts. To capture these heterogeneous effects, the model uses a 'bottom-up' approach in which the national impacts are the sum of the regional/districts impacts.

Appendix C CGE 2019 baseline

Table 7 below presents the values (in \$ million) used as our 2019 baseline for different macro-economic indicators and industry outputs. The model is based on the latest Input-Output tables and is adjusted with the most recent National Accounts table from Statistics NZ. These values are presented at the district, regional and national levels.

Table 7 CGE model database

2019, in \$ million and employee counts

Indicator	Rangitikei district	Manawatū district	Tararua district	Horowhenua district	All 4 districts	Manawatū-Whanganui region	New Zealand
GDP	\$786	\$1,249	\$1,039	\$1,315	\$4,389	\$12,154	\$300,994
Household consumption	\$464	\$735	\$656	\$790	\$2,645	\$7,336	\$173,408
Exports	\$31	\$46	\$32	\$54	\$162	\$653	\$83,428
Imports	\$30	\$71	\$30	\$57	\$188	\$822	\$82,554
Labour (employee counts)	5,800	9,500	6,000	9,300	30,600	104,900	2,284,000
Capital	\$301	\$479	\$431	\$599	\$1,811	\$4,818	\$127,565
Dairy industry output	\$160	\$320	\$269	\$240	\$990	\$1,167	\$14,668
Vegetable growing industry output	\$8	\$5	\$0	\$59	\$72	\$105	\$1,099
Total output (all industries)	\$1,617	\$2,384	\$2,239	\$2,641	\$8,882	\$23,327	\$567,352

Source: NZIER, derived from Stats NZ' 2013 Input-Output tables, Stats NZ' 2019 National Accounts and from Business demographics (for employee counts, 2019)

Appendix D CGE database – Additional details

Table 8 Industry concordance between IO tables and CGE database

Industries from Stats NZ's IO tables	Industries in CGE database
Horticulture and fruit growing	Living plant
	Vegetables
	Kiwifruit
	Pome fruit
	Grape
	Berry fruits
	Stone fruits
	Citrus fruits
	Other fruits & nuts
Dairy cattle farming	Dairy, cattle
	Milk (raw)

Source: NZIER

Table 9 Regional breakdown in our CGE database

Region	CGE districts
Manawatū-Whanganui	Ruapehu District
	Whanganui District
	Rangitikei District
	Manawatū District
	Palmerston North City
	Tararua District
	Horowhenua District

Source: NZIER

Appendix E Definitions

For the purposes of Plan Change 2, Horizons Regional Council defines the 'intensive farming land uses' (IFLUs) as follows:

Dairy farming

Dairy farming is defined as any area of land greater than 4 hectares (ha) used for the farming of dairy cattle for milk production. This includes land used as dairy cattle grazing runoff but excludes any dairy grazing arrangement. A dairy grazing arrangement is defined as a third-party commercial arrangement between the owner of dairy cattle and another landowner for the purpose of temporary grazing.

Commercial vegetable growing

Commercial vegetable growing is defined as an area of land greater than 4 ha used for producing vegetable crops for human consumption. It includes the whole rotational cycle, being the period of time that is required for the full sequence of crops, including any pasture phase in the rotation. Fruit crops, vegetables that are perennial, dry field peas or beans are not included.

Cropping

Cropping refers to the use of an area of land in excess of 20 ha to grow crops, such as cereal, coarse grains, oilseed, peanuts, lupins, dry field peas or dry field beans. This definition does not include crops fed to animals or grazed on by animals on the same property.

Intensive sheep and beef

Intensive sheep and beef farming refers to properties greater than 4 ha engaged in the farming of sheep and cattle, where any of the land grazed is irrigated.

Appendix C:

Section 42A Technical Report of Peter Clough – Macroeconomic Impacts (4 September 2020).⁷

⁷ This report originally attached the 2020 NZIER report as an Appendix. To avoid duplication, the Appendix has been removed from this copy, as it is already attached as Appendix B above.

BEFORE THE HEARINGS PANEL

IN THE MATTER of the Resource Management Act 1991

AND

IN THE MATTER of proposed Plan Change 2 to the One Plan

AND

IN THE MATTER of the submissions and further submissions
set out in the s 42A Officer Report

SECTION 42A TECHNICAL REPORT OF PETER WILLIAM JOHN CLOUGH

ON BEHALF OF MANAWATŪ-WHANGANUI REGIONAL COUNCIL

TECHNICAL – MACRO ECONOMIC IMPACTS

4 SEPTEMBER 2020

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A. EXECUTIVE SUMMARY

1. My evidence examines the macro-economic effects of meeting the nitrogen loss targets in Table 14.2 of the One Plan and recalibrated Table 14.2 in the proposed Plan Change 2 (“PC2”). The economic assessment uses a computable general equilibrium (“CGE”) model.
2. We (NZIER) have modelled the effects on two intensive farm enterprises – dairy cattle farming and vegetable growing – through three scenarios applied to four districts – Tararua, Manawatū, Rangitikei and Horowhenua.
3. We modelled a hypothetical baseline of the costs of all dairy cattle and vegetable farming, driven to complying with the original Table 14.2, to compare against the cost of two options for full or partial compliance with PC2’s recalibrated Table 14.2, assuming a viable alternative in respect of the partial compliance scenario.
4. The computable general equilibrium model is an abstraction of reality, not a prediction, and it focuses on industry-wide effects rather than the impact on individual farmers. But its industry database does account for changes in annual capital investments as well as more routine input costs, and it covers the diversion of inputs across a wide range of sectors to where their return is highest. As such it is the most comprehensive way of modelling macro-economic impacts net of the offsetting effects that occur when resources freed from one activity get picked up by other activities
5. Our modelling shows that while all regulation scenarios come at a macro-economic cost for the region and New Zealand, the costs of complying with PC2’s recalibrated Table 14.2 are significantly lower than the baseline scenario of compliance with the current table. This means there would be economic benefit accruing from implementing the plan change scenarios we modelled under PC2’s Scenario 1 or 2 achievement of respectively full or near full compliance, compared to continuing to use the original Table 14.2.
6. The model suggests that driving or forcing compliance with the original Table 14.2 would negatively affect gross domestic product (“GDP”) by over \$200m a year across the four districts, while Scenario 1’s full compliance with the recalibrated Table 14.2 compares relatively favourably, affecting GDP across the four districts by \$28 million

per year. Partial compliance with Table 14.2 under Scenario 2 would affect GDP by even less, at \$20 million per year. These results show that recalibrating Table 14.2 under PC2 would lead to reductions in the macro-economic cost of compliance by 86% and the discretionary pathway would reduce it by a further 4% compared to the situation under the current Table 14.2.

7. Compliance with the original table would reduce GDP contributions across the four districts of dairy farming, real estate and agricultural services, vegetable growing (in Horowhenua) and dairy product manufacture (in Tararua), and result in rather smaller offsetting gains for sheep and beef farming, meat manufacture and other services, as resources are diverted from dairy farming and vegetable growing towards other industries. Compliance with the recalibrated table produces the same pattern of offsets, but at a much lower scale.
8. The modelling suggests that with PC2 full compliance with nitrogen restraint limits could be reached for a loss of GDP of \$28m and loss of \$8.8 million in household consumption. These are upper bound estimates of the economic price of water quality improvement, as the alternative is not the absence of any regulation or associated compliance cost.

B. INTRODUCTION

9. My full name is Peter William John Clough.
10. My qualifications include a Bachelor of Arts in Geography and Land Economy from Cambridge University, a Master of Science in Recreational Land Management from the University of Reading, and a Post Graduate Diploma in Agricultural Economics from Massey University in Palmerston North. I have served on the Executive Committees of the New Zealand Agricultural and Resource Economics Society and the New Zealand Branch of the Australian Agricultural Economics Society.
11. I am currently employed as a Senior Economist for the New Zealand Institute of Economic Research (“NZIER”), based in Wellington, and have held that position since 2004. Prior to that, my title was Manager, Resource Economics Division within NZIER from 1999 until all divisional management positions were abolished in restructuring in 2004.

12. I have over 30 years' experience of consulting, mostly from working at NZIER but also from secondments to the Ministry of Economic Development, the Ministry of Transport, and at English Nature, the UK's statutory advisor on environmental policy. I have specialised in applying economics to hard-to-quantify areas of environment and public health and safety, and in comparative analysis of economic instruments and other policy measures in fields such as biosecurity, energy and transport, land use, biodiversity conservation, and natural resource management such as mining and quarrying, water quality and water use.
13. In that time I have prepared technical reports and expert testimony for presenting in various resource management hearings and the Environment Court, on applications for plan changes and consents and also on appeals against decisions made. This has covered such matters such as:
- (a) The efficiency and affordability of combined land and water disposal schemes in re-consenting wastewater treatment plants at Feilding (2013), Shannon (2014) and Foxton (2017).
 - (b) The economic value of using natural resources for electricity generation for weighing against effects on the environment, for instance in the re-consenting of the Lake Kaniere, McKay's and Patea hydro-electric power schemes and, more particularly, the amendment of the Rakaia Water Conservation Order and associated re-consenting of the Lake Coleridge Hydro-electric Scheme (2012) to enable greater value to be obtained from diverted water by timing its use to benefit both electricity generation and irrigation needs.
 - (c) The efficient use of water by different users of an aquifer in the Opiki Basin.
 - (d) Application for consents on several new wind generation farms (at Mahinerangi, Kaiwera Downs, Waverley/Waipipi, Tiritea).
 - (e) Evidence on the economic consequences of environmental policy proposals under the Resource Management Act ("**RMA**"), such as appropriate offsets for

new activities creating greenhouse gas emissions,¹ restricting land clearance for biodiversity conservation, and the use of biodiversity offsets.

14. My evidence relates to the approach taken by Manawatū-Whanganui Regional Council (“**Horizons**”) on the following specific matters:
 - (a) Estimation of the regional and national economic impacts of meeting One Plan’s nitrogen loss limits in Table 14.2 and those in the recalibrated Table 14.2 PC2 using a computable general equilibrium model;
 - (b) Estimation of the flow-on effects of the production impacts of meeting the nitrogen loss limits for the wider regional economy, taking into account the upstream and downstream linkages to other sectors and households; and
 - (c) Preparation of a technical report based on our modelling results.
15. I am familiar with the One Plan and the content of PC2, in particular the original Table 14.2 and the recalibrated Table 14.2 to which these proceedings relate. I was an author, alongside my colleagues, of the 2018 NZIER Report prepared in support of PC2, “The Macroeconomic impacts of the One Plan’s intensive land use provisions”.
16. I have been engaged by Horizons to prepare this statement of evidence.

C. CODE OF CONDUCT

17. I confirm that I have read and agree to comply with the Code of Conduct for Expert Witnesses contained in the Environment Court Practice Note 2014. I confirm that I have considered all the material facts that I am aware of that might alter or detract from the opinions that I express, and that this s 42A report is within my area of expertise.

D. SCOPE

18. This s 42A report examines the economic consequences of PC2 against the key economic considerations in the Resource Management Act 1991 (“**RMA**”). Specifically, my s 42A report addresses:

¹ See *Environmental Defence Society v Taranaki Regional Council* A184/2002 ENC.

- (a) The direct impacts on dairy cattle farming and vegetable growing industries of meeting the nitrogen loss targets in Table 14.2 and recalibrated Table 14.2 of the One Plan in the Horowhenua, Tararua and Rangitikei districts;
 - (b) The macro-economic impacts and flow-on effects within each of four districts in the Horizons region that have intensive farm land uses (“IFLU”); and
 - (c) The regional and national macro-economic impacts.
19. In addition to my own observations I rely on the technical reports of Parminter (2018) and Stephen McNally of WSP (2020) and the assistance of my colleague, Laëtitia Leroy de Morel, who maintains and runs the NZIER’s CGE model.
20. I attended expert witness conferencing held on 19 August 2020 in relation to Macro Economics, and am a party to the outcome of that conferences as recorded in the joint witness statement of that same date.
21. I have also reviewed the submissions and further submissions on PC2. Beyond some submissions stating the contribution an industry or business makes to local economic activity and employment and the potential consequences of job losses, I have not seen any submissions specifically questioning the macro-economic impacts of the proposed PC2. There was, however, an expert witness conference on macro-economics which concluded with some areas of disagreement, which are briefly addressed in this evidence at paragraphs 62-68.
22. My evidence is limited to technical matters and I do not provide recommendations on matters of policy.

E. BACKGROUND

23. NZIER was asked by Horizons to estimate the regional macro-economic impacts on farmers and commercial vegetable growers of meeting the nitrogen loss targets in Table 14.2 (Original and Recalibrated) of the One Plan in four local economies and two sectors with intensive farming land uses: vegetable growing in the Horowhenua, Manawatū and Rangitikei districts, and dairy farming in the Tararua, Manawatū and Rangitikei districts. The Council wanted to understand how estimated on-farm costs

might affect the wider economies in the region and its constituent local authorities, and the New Zealand economy at large.

24. When considering the economic worth of a proposal, there are two types of analysis commonly employed. One is cost benefit analysis (“**CBA**”), also known as partial equilibrium analysis), which compares the benefits obtained from a project against the costs arising from it for all parties in the affected economy. It is built around discounted cash flow analysis similar to that used in business investment appraisal, but extended to include benefits and costs for all parties affected by a proposal, and also potential effects not subject to market transactions, including those on the natural environment and public safety.² The resulting net present value and benefit cost ratios derived from CBA can give direct measures of the efficiency of resource uses for comparison with alternative uses, and in principle CBA can also be informative about community well-being to the extent that it accounts for effects on the surrounding environment, if these can be valued. In practice most such analyses are limited to items that can be readily quantified and valued, leaving the remaining “intangibles”, including a wide range of environmental effects, outside the quantified analysis to be considered in other ways. CBA focuses on the direct effect of a proposal and has no direct means of assessing flow-on effects to other sectors in the economy, so it relies on other models to infer macro-economic impacts.
25. The alternative approach, known as economic impact analysis (“**EIA**”), measures effects on the total economic activity in a country or region, and results in changes in GDP. A project injects expenditure into an economy, which in turn stimulates more business and job creation in the other industries in the economy. Such analyses usually distinguish between the direct impacts of expenditure and employment in the project or industries directly affected; indirect impacts from businesses either supplying inputs to, or using produce from, those directly affected sectors; and induced impacts of household expenditure from an increase in household incomes in the local economy. Thus, EIA focuses on the changes in economic activity and employment of the sort referred to in the amended section 32, however is not on its own informative of the full societal return on investment in a project or in implementing regulatory changes.

² For instance, the New Zealand Transport Agency’s Economic Evaluation Manual describes a CBA in which benefits include reductions in vehicle operating costs, travel times, the number and severity of accident casualties, greenhouse gas emissions and road dust nuisance.

26. The combined direct, indirect and induced effects are commonly presented in the form of economic multipliers, which are ratios of the total impact of a proposal to its direct impact, after flow on effects of indirect and induced business stimulation are accounted for. While direct effects can usually be estimated with some accuracy from the size of a proposed project or the scale of regulatory changes across the economy, indirect and induced effects need to be inferred from the expected responses of the economy to the changes caused by a proposed action. A common means of doing this is to draw on input-output models of inter-industry transactions across an economy, which shows where each industry obtains its inputs from, and where each industry's outputs are used as exports, final consumption in export or domestic markets or as intermediate inputs into other sectors' outputs. The input output framework is relatively easy to understand, draws on official statistics that form the basis of preparing national accounts measures such as GDP, and it gives a comforting sense of precision to its results.
27. However, the most commonly encountered economic multipliers drawn from input-output models tend to overstate the net gains in economic activity stimulated by a new project because they do not account for the way in which constraints on input resources change prices that reverberate through the economy. Such multipliers assume that economic resources such as land, labour and capital are infinitely available, are never idle or that they can be reallocated between sectors without incurring adjustment costs. They are also based on the assumption that all prices remain constant, even if demand for inputs increases. This is not realistic when modelling a scenario with significant direct impact, such as changes to major infrastructure or significant regulatory changes. New demands change resource prices and shift resources to those sectors where they are most valuable, so all sectors that use those inputs face some tightening of input supply and increase in costs, which reduces their profits and ability to invest in sustaining further activity. New projects that significantly increase input demands will cause some offsetting adjustments in other sectors, so their net impact on the economy will always be less than that implied by the input-output based multipliers. The same applies (in reverse) to the impacts of regulatory changes that increase costs and reduce profitability and production of directly affected industries: if those industries reduce their demand for inputs, it opens opportunities for other industries to draw resources away to other valuable uses.

28. The economic model we use at NZIER is a CGE model, a type which is widely regarded as providing more credible economic impact assessments of change than input-output models from which more commonly encountered “economic multipliers” are derived.³ The CGE model is built on data from Statistics New Zealand’s Input Output tables and has the same inter-industry transactions, but it differs from multiplier analysis in allowing for constrained resources and resulting price changes in response to changing demands. If a project increases demand for constrained inputs their prices rise, and they are reallocated to higher yielding uses. Some sectors gain resource inputs, some sectors lose them, and some sectors retain them but have their profits reduced by higher input prices. The effect of this modelling is that every major new project or expenditure in an industry has offsetting effects in other industries because rising demands make some of their inputs costlier. By allowing for such offsetting impacts of projects, CGE analysis gives more conservative estimates of economic impacts than multiplier analysis, with implicit multipliers in CGE more often in the range of 1-2 than the 2-3 or even higher sometimes claimed for conventional multipliers.
29. Despite its well-documented limitations, conventional multiplier analysis is still used and input-output analysis is a widely-applied method for estimating regional impacts of environmental policy, because of its apparent clarity in describing economic structures and inter-linkages between sectors. But while multipliers have their uses in static comparison of industry sectors and their reach across the economy, they exaggerate the scale of flow on effects of changes in policies by not accounting for resource constraints and pricing effects.
30. At NZIER we believe the CGE model is the best available means of assessing the flow on effects through the district, regional and New Zealand economies and considering macro-economic impacts. We present results of NZIER’s CGE model of the New Zealand economy to show the economic impact of the One Plan land use provision changes on intensive vegetable growing and dairy farming, including the flow-on effects on business in other sectors that either supply vegetable growing and dairy or face

³ See Gretton, P. (2013) *On Input-output Tables: uses and abuses*. Australian Productivity Commission Staff Research Note for a discussion of what multipliers are, how they are constructed and their short-comings as tools for assessing economic impacts.

Note also that the Australian Bureau of Statistics has ceased to provide multiplier estimates from its input output tables.

<https://www.abs.gov.au/ausstats/abs@.nsf/Previousproducts/5209.0.55.001Main%20Features4Final%20release%202006-07%20tables>.

decreased demand for their services from those whose incomes lose from the One Plan change.

F. ECONOMIC IMPACT ASSESSMENT METHODOLOGY AND ASSUMPTIONS

31. I understand PC2 is intended to improve provisions in the One Plan for regulating dispersed nitrogen losses to the environment from existing intensive farming land uses, principally by recalibrating Table 14.2 on Cumulative Nitrogen Leaching Maximums (“**CNLMs**”) in line with recent versions of Overseer®. The current provisions for existing IFLU have had unintended negative consequences for the uptake of the provisions, which recalibration of Table 14.2 is expected to alleviate. The question we were asked to answer was what would be the macro-economic impacts of adopting the recalibrated Table 14.2 under PC2.
32. In 2018 my colleague Laëtitia Leroy de Morel applied NZIER’s CGE model to an earlier set of data on potential compliance costs with the original Table 14.2, based on a survey by Terry Parminter of farmer options in the upper Manawatū catchment in Tararua District. The scenario modelled assumed intensive dairy farms were driven to comply with the requirements of Table 14.2, which could be done by adopting good management practices to reduce nitrogen loss as far as possible, and then culling of cow numbers for any further reduction of nitrogen required for compliance. That modelling showed that the cost of complying with the recalibrated Table 14.2 was much lower than the costs of complying with the original Table 14.2. The CGE database has been extended and updated with new data since then, so for this evidence we have remodelled the 2018 scenario on the new data, and extended it to include vegetable growing as well as dairying, and also to cover Horowhenua, Manawatū and Rangitikei districts as well as Tararua.
33. CGE models are data driven and used to capture the effects of a new policy or technology or other external “shocks” affecting economic activity. They capture the direct effects of changes on affected industries, then trace their economy-wide flow on effects on supplying industries, competing industries, markets for labour and capital and the aggregate measures such as economic output and GDP. The models are consistent with United Nations System of National Accounts from which GDP, (otherwise known as Economic Value Added) is estimated as:

- (a) The difference between an economy's gross output value and the value of inputs used in creating that output, over a given period; or
 - (b) The sum of incomes accruing to New Zealand factors of production as employee compensation (salaries and wages), fixed capital consumption (the sums required to maintain or renew capacity of fixed capital assets against physical wear and tear), operating surplus (profits to business owners) and net indirect taxes after subsidies are removed; or
 - (c) The sum of expenditures on final consumption and investment.
34. The CGE database shows a snapshot of an economy and its inter-industry linkages in a particular year, which can be used to prepare a business as usual baseline against which to compare the effects of a new project or policy change. The model data is linked through a set of equations to show how the economy responds to the "shock" of a new project, policy or other major change in economic conditions. The equations are based on the economic theory of general equilibrium which states that after any disruption, the economy responds through price changes and resource reallocation to reach to new equilibrium. This theory also states that in the long run there is zero economic profit (which is different from accounting profit). The model determines how firms and households react in response to changes in incentives, and it ensures supply and demand for goods and services and factors of production shift and regain balance in a new equilibrium.
35. NZIER's model is based on Statistics New Zealand's Input-Output tables of the New Zealand economy, and contains information on 149 industries, 149 commodities and 88 districts (68 local authorities and 20 Auckland board areas) which can be combined into regional and national territories. Each district is modelled as its own economy, but all districts are connected through trade and flows of capital and labour. Further details of the model's key features can be found in this statement's Appendix and in NZIER's 2020 report of the Economic Impact Assessment of PC2.
36. In CGE modelling (and indeed also in CBA) it is usual to compare a change in condition against a baseline or counterfactual without such changes. In this instance the counterfactual is not absence of nitrogen regulation, as it is unlikely that the question of freshwater quality is going to disappear from public policy discussion in New Zealand.

As the focus of our enquiry was about the effects of PC2, and following the lead of the 2018 NZIER modelling and report, we construct a hypothetical counterfactual of all farmers being forced to comply with the original Table 14.2, against which to compare the economic impacts of complying with PC2's recalibrated Table 14.2.

37. In short, we modelled:

- (a) Two industries, Dairy cattle farming in the Tararua, Rangitikei, Manawatū and Horowhenua districts and Vegetable growing in the Horowhenua district; sheep and beef and arable farms were excluded as intensive farms needing consent are few and unlikely to be major discharge sources;
- (b) Three scenarios, namely:
 - (i) Scenario 0: In this scenario, we assumed that all vegetable growers and dairy farmers are forced or driven to fully comply with the original Table 14.2 of the One Plan (controlled pathway).
 - (ii) Scenario 1: In this scenario, we assumed that all vegetable growers as well as dairy farmers comply with the recalibrated Table 14.2 of the One Plan (controlled pathway). That is, we estimated the effects of meeting the recalibrated Table 14.2 of the One Plan in the absence of any discretionary consent pathway for exceedances of the recalibrated Table 14.2.
 - (iii) Scenario 2: In this scenario, we assumed there is a discretionary activity consent pathway for exceedances of the recalibrated Table 14.2 with only partial compliance by Year 20: 'most' farms comply in Year 20, and those that do not are on an improving trend and have been reducing their nitrogen loss using good and best management practices (GMP and BMP). This is the version of PC2 as notified.
- (c) Four districts in the region: Tararua, Rangitikei, Manawatū and Horowhenua – although we also model flow on effects on the rest of Horizons Region and on New Zealand at large.

38. The main assumptions behind the modelling are:

- (a) The CGE is a static model, comparing the situation before and after a given change or shock to the economy. The model examines how different scenarios change the result 20 years from now, however does not model the transition path in getting there. That is because the transition path would require modelling a lot of other potential changes between now and then, requiring a lot more data and assumptions about what is going to happen and introducing “noise” into the results that obscure what’s attributable to the plan changes. There are dynamic CGE models that could provide some transition estimates, but these would be computationally challenging and there are no such models at the district level in New Zealand.
 - (b) As a consequence of the static model a third scenario 3 of a consent pathway for exceedances and full compliance by Year 20 has not been modelled, as it has the same end point as Scenario 1.
 - (c) We had no data for dairy impacts in Manawatū and Horowhenua under Scenario 1, so have assumed the likely impacts in these districts based on averages from dairy farms in Tararua.
 - (d) Sheep and beef farms and arable/grain farms are not modelled, as there are only a very small number of unconsented intensive farms and they do not form a significant share of nitrogen loss in the districts.
39. The CGE model is not a forecasting tool in the sense of providing a picture of some future state of the world. Like all models, it is an abstraction from reality. What it does show is how a policy change like the One Plan would impact on an economy as structured in the model (which is representative of the district’s and New Zealand’s current economic structure as depicted in Statistics New Zealand’s Input Output tables), including flow-on effects between the sectors linked in the model and allowing for some sectors’ contraction or expansion in face of input price changes caused by the policy changes. Changes in the nitrogen limits affect the results, but these are exogenous factors that are implicitly input into the model through the results of the farm level impact assessments, and can be changed to test the sensitivity of results to changes in these assumptions.

40. This has implications for the interpretation of results. First, there is no simple means of validating the model. I can verify that the model works as theory would expect it to, and it has been used by a number of government departments and agencies to examine the impacts of particular policy questions. But there is no real-world situation against which to compare its results, even looking retrospectively from some future date, because the comparison is between an abstracted model and a more complicated world. Such criticism applies to all economic models, as they all simplify the complexity of influences on the real world in order to examine and illustrate the workings of part of it. The model should be viewed as giving broad magnitudes and directions of impacts, not precise forecasts. In my opinion this is still better than having no idea of the scale and proportionality of impact in the economy.
41. While similar in structure to the commonly encountered economic multiplier studies based on input-output models, CGE models have crucial differences as I describe in paragraphs 27-29 above. For projects that are large enough to face input constraints that can change prices and result in significant change in macro-economic aggregates like output, exports or imports, it is my opinion that CGE modelling is the best available method for examining the inter-industry impacts on the economy.

G. MODELLING SCENARIO DESIGN

42. With NZIER's CGE model, we can see how the impact of meeting existing One Plan provision scenarios in Year 20 differs from the result of meeting requirements of the recalibrated Table 14.2 under PC2. To identify those scenarios and evaluate the additional on-farm costs, we used information from Parminter (2018) and from Stephen McNally of WSP (2020). We weight these costs up from the farm level to the industry level. This is because in our CGE model, our dairy farming industry is not split by land type. There is only one aggregate dairy farming industry. We also used the data provided in Terry Parminter's report on the milk production of the various dairy farm types by territorial authority.
43. Similar to our previous report (NZIER, 2018), we used the figures (in kg MS) provided by Terry Parminter to estimate the expected loss in productivity in the dairy industry in Tararua and Rangitikei for both Scenario 0 (Original Table 14.2) and Scenario 1 (Recalibrated Table 14.2 – No consent pathway). To this extent, we were able to use most of the data provided by Terry Parminter (Parminter 2018) for these two districts.

44. In Terry Parminter's report (2018), there was no data available for dairy in Manawātū and Horowhenua. After discussions with Horizons and WSP, we took the average approach from the dairy cluster farms in Tararua (acknowledging the assumptions around soil and climate types) and applied it to the other districts, namely Manawātū and Horowhenua. Our model is capable of being updated with further and better information and data in relation to on-farm costs associated with meeting the recalibrated Table 14.2, as such information or data becomes available.
45. For Scenario 2 (Recalibrated Table 14.2 – Partial compliance), we used changes in milk production (Kg MS/district) estimates provided by WSP for dairy in Tararua, Manawātū, Rangitikei and Horowhenua. We relied on information provided by WSP in respect of changes to vegetable yield (tonnage/district) for the Horowhenua district for both Scenarios 1 and 2. WSP provided changes in gross margin (in \$ per hectare per year) for each IFLU type and district from which yield figures are derived and which we use to derive our shocks on vegetable growing outputs.
46. No data provided to us was sufficiently detailed to derive our productivity shock on the vegetable industry for Scenario 0 (Original Table 14.2). Accordingly, we designed an indicative scenario by averaging the changes in milk production (Kg MS) across all four districts and assuming this average productivity change also applies to the vegetable industry.
47. The WSP data allows us to model the economic impacts of complying with the recalibrated Table 14.2 with no consent pathway (Scenario 2). We were unable to do this in our modelling for our 2018 report (NZIER 2018) because of data unavailability.
48. Parminter's report (2018) and WSP (2020) provided us with estimates on additional costs, gross margins and output changes to dairy farmers for the dairy cattle farming industry in Tararua, Rangitikei, Manawātū and Horowhenua, and for the vegetable growing industry in Horowhenua. With this data, we derived an effective reduction in productivity for the different farm types that we used to shock the model.
49. For the Tararua and Rangitikei dairy farms, we model a dairy industry productivity decrease as a weighted average of the productivity reduction by farm type/cluster obtained from Parminter (2018).

50. Regarding dairy farms in the Coastal Rangitikei Catchment of the Rangitikei (part) and Manawatū districts (part), some data was not available. We used the figures from Parminter in the 2018 report and from WSP (2020) to design our scenarios' impacts on these districts.
51. For the Horowhenua vegetable growing industry, we model a decrease in productivity required to meet the One Plan provisions, drawing on the analysis by Stephen McNally of WSP (2020).
52. To estimate the effects of the original Table 14.2 targets of the One Plan and the recalibrated Table 14.2 targets of PC2, we run three scenarios in which we impose productivity shocks for the dairy cattle farming and vegetable growing industries in each district so that it reflects the profitability losses expected from meeting the nitrogen loss targets of the original and recalibrated Table 14.2

H. RESULTS

Impacts on dairy and vegetable growing

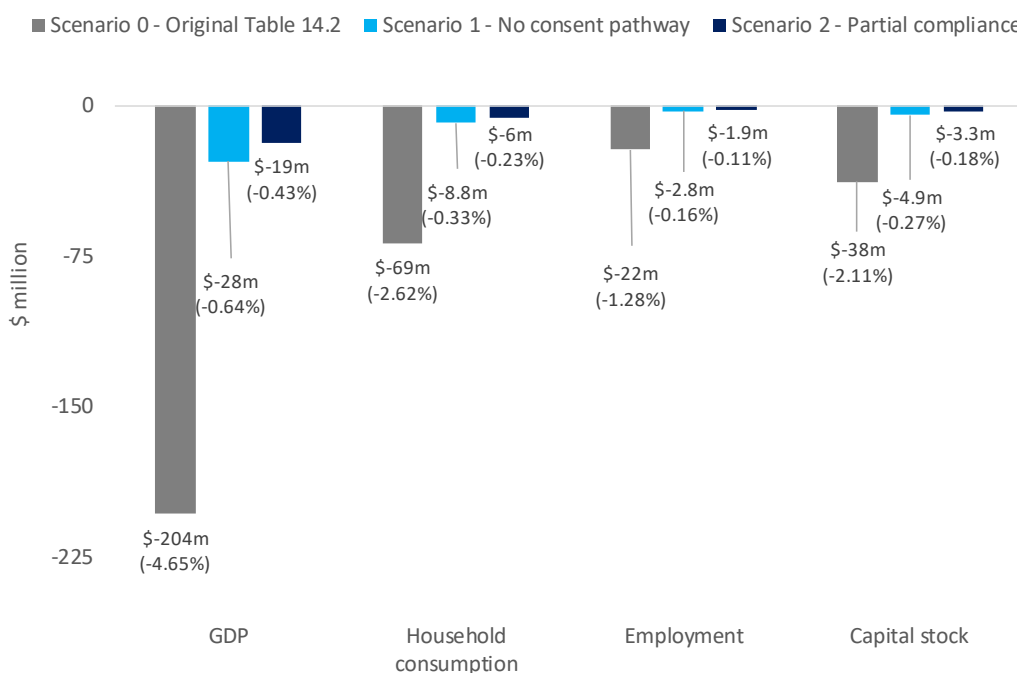
53. The CGE simulation results confirm that the introduction of the Table 14.2 targets in the One Plan (original and recalibrated) would both have negative effects on the regional and national economies, but those costs are substantially lower in complying with the recalibrated Table 14.2 targets under PC2. In other words, compared to a current business as usual in which the original Table 14.2 targets remain operative but largely not met, so that compliance requires significant enforcement activity and additional costs for farmers and growers, either of the options under PC2 with the recalibrated table are significantly more beneficial, in achieving higher rates of compliance and reduction of nitrogen loss at lower cost for the farmers and growers and for the wider economy.
54. At this point it may be useful to remember that people do not live by GDP alone, but also draw benefit from the state of the natural environment around them. This is recognised by the Government with its focus on well-being, and also by the Treasury in its Living Standards Framework which attempts to monitor changes in multiple distinct "capitals" – physical, natural, human and social capitals as well as financial capital stocks – alongside the flow measures of changes in GDP. In short, if GDP goes down with

application of One Plan, this must be viewed in context with improvement in the quality of water and its potential uses and value as natural capital. The GDP loss is a cost of achieving natural capital improvement, and an indicator of how big societal value of natural capital improvement needs to be in economic terms for the benefit to be “worth” the costs incurred and enhance societal well-being.

55. The differences between complying with the original and recalibrated Table 14.2 are illustrated in the following graphs, at the regional and the national levels. Figure 1 shows relatively substantial costs of full compliance with the old Table 14.2, but substantial reduction in cost in full compliance with recalibrated Table 14.2, and a smaller incremental reduction in cost in adopting the discretionary pathway to allow less than full compliance. Note that Scenario 0, for which full compliance would incur a cost equivalent to 4.65% of the GDP of the four combined districts, is a significant cost on local production and community well-being, so it is hardly surprising that farmers appear to be slow to comply with the requirement. The \$204 million cost is also substantially higher than the \$65 million estimated in the 2018 NZIER report; the threefold difference being due to the current estimate’s expanded coverage over four districts rather than two, more detailed coverage of vegetable growing, and the general update of the database in the NZIER model.

Figure 1 Aggregated economic effects at the district level

Changes compared with 2019 baseline in Year 20, in percent and in \$ million (real terms)



Note: Figures presented in this graph combine changes for Rangitikei, Manawatū, Tararua and Horowhenua districts.

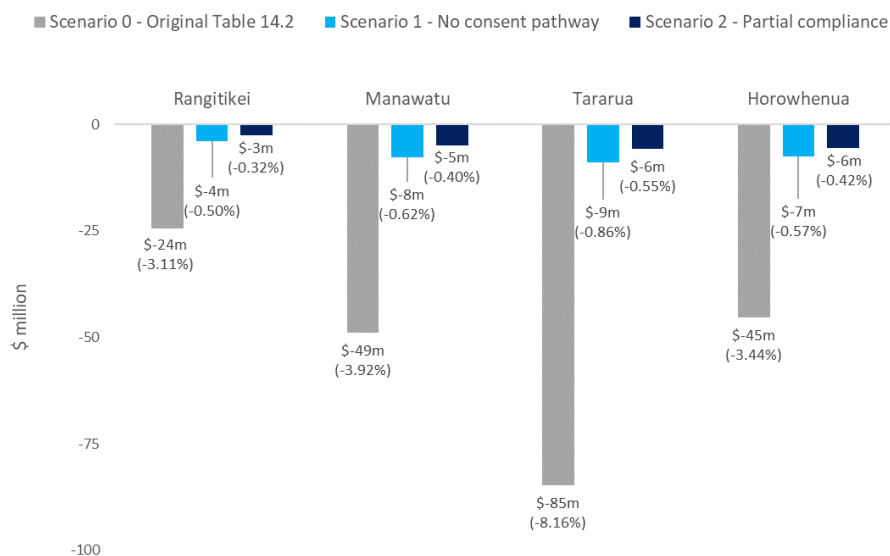
Source: NZIER

56. The explanation for these results is that agricultural production falls due to higher costs of production from meeting new nitrogen loss requirements, and from farmers spending more time on implementing new management practices to reduce their use of fertilisers.⁴ Land productivity decreases and production costs rise, so farms' capacity falls. The more reliant a farm is on fertilisers as an input, the more output is likely to drop. Dairy and vegetable exports fall, due to the overall drop in dairy and vegetable growing production. Industries closely related to the dairy and vegetable growing industries (e.g. dairy processing, rural retail, fertilisers) also suffer from the primary sector slowdown. Both effects will reduce real GDP, employment, and household consumption in the region. However, the overall effect on GDP will be limited as the affected agricultural industries account for about 5% of total GDP and meeting the nitrogen loss requirements impacts only a small portion of the affected industries' overall inputs to production. These effects apply to all modelled scenarios but are smaller in the PC2 scenarios with the recalibrated Table 14.2.
57. Figure 2 shows the real GDP impacts within each district. The largest impacts are felt in the Tararua District, where complying with the original Table 14.2 would result in both contraction in output of dairy farming and also dairy production manufacturing at the Pahiatua milk powder plant. In all cases the cost of compliance with the PC2 options are substantially reduced: again, Tararua District would gain the most benefit from a reduction of GDP loss under PC2.

⁴ Recall that the counterfactual baseline in this case is not no nitrogen regulation, but rather the current situation in which compliance with One Plan requirements is low, so Scenario 1 assumes a forcing of farms to comply with the original Table 14.2.

Figure 2 Real GDP impacts within each district

Annual changes from 2019 baseline in Year 20, in \$ million (in real terms) and in percent

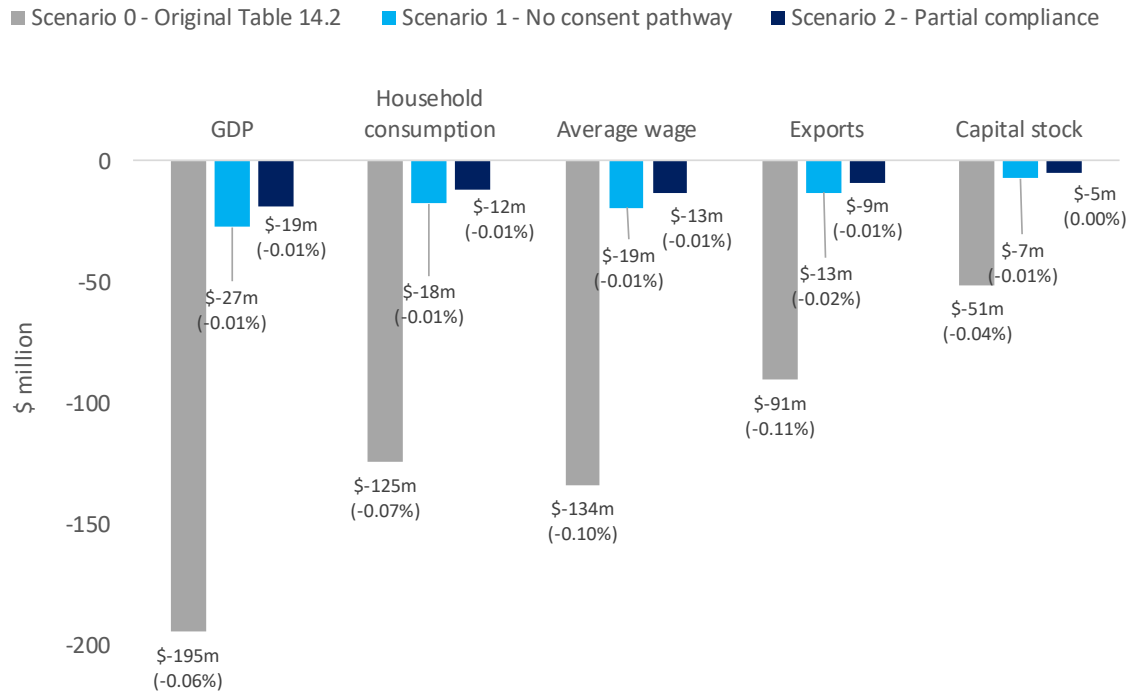


Source: NZIER

58. Figure 3 shows a similar pattern of impacts across the macro-economic aggregates at the national level. However, for GDP impacts the national dollar values are slightly smaller than for the combined four districts in the Horizons' jurisdiction, as some of the costs borne at the local level are offset by gains outside the four districts, which do not count towards the districts' net impact but do count towards a lower national impact. For all the other macro-economic aggregates, the national figures are larger than the corresponding figures across the four districts, reflecting much smaller proportionate changes on much larger values.

Figure 3 Main macroeconomic impacts for all New Zealand

Annual changes compared with 2019 baseline in Year 20, in percent and in \$ million (real terms).



Note: Percentages in the graph differ at the 3rd decimal place

Source: NZIER

59. Table 1 summarises the impacts on jobs at the district level for the three modelled scenarios. This shows how the reduction in GDP in the districts is matched by a reduction in jobs. Again, the impact of the PC2 changes shown in Scenarios 1 and 2 are far smaller than those in the current One Plan with original Table 14.2.

Table 1 Change in the number of jobs at the district level

Annual changes in jobs compared with 2019 baseline in Year 20, in percent and number

Region	Scenario 0 – Original Table 14.2		Scenario 1 – No consent pathway		Scenario 2 – Partial compliance	
	in %	Jobs	in %	Jobs	in %	Jobs
Rangitikei	-0.64%	-37	-0.10%	-6	-0.1%	-4
Manawatū	-0.65%	-62	-0.10%	-10	-0.1%	-6
Taranua	-3.34%	-200	-0.35%	-21	-0.2%	-14
Horowhenua	-0.79%	-73	-0.12%	-12	-0.1%	-9
All 4 districts	-1.22%	-373	-0.16%	-48	-0.11%	-33
Rest of Horizons region	-0.26%	-191	-0.04%	-29	0.0%	-19

Source: NZIER

60. Table 2 summarises the impacts on household spending at the district level for the three modelled scenarios. This shows how the reduction in GDP in the districts reduces overall consumption spending. The impacts of the PC2 changes shown in Scenarios 1 and 2 are far smaller than those in the current One Plan with original Table 14.2.

Table 2 Real household spending impacts at the district level

Annual changes compared with 2019 baseline in Year 20, in percent and in \$ million (real terms).

Region	Scenario 0 – Original Table 14.2		Scenario 1 – No consent pathway		Scenario 2 – Partial compliance	
	in %	in \$ million	in %	in \$ million	in %	in \$ million
Rangitikei	-1.29%	-6.0	-0.20%	-0.9	-0.13%	-0.6
Manawatū	-1.31%	-9.6	-0.20%	-1.5	-0.13%	-1.0
Taranua	-6.33%	-41.3	-0.68%	-4.5	-0.44%	-2.9
Horowhenua	-1.56%	-12.3	-0.25%	-1.9	-0.19%	-1.5
Total districts	-2.62%	-69.2	-0.33%	-8.8	-0.23%	-6.0
Rest of Horizons region	-0.56%	-26.1	-0.08%	-3.9	-0.06%	-2.6
Rest of New Zealand	-0.02%	-29.3	0.00%	-5.0	0.00%	-3.5
National	-0.07%	-124.5	-0.01%	-17.7	-0.01%	-12.07

Source: NZIER

61. Our CGE model shows more results about impacts on other sectors in the regional economy. Many of the impacts are very small, and further details are provided in the appendix to this evidence. In brief, compliance with the original Table 14.2 would principally reduce contributions to GDP of dairy farming, real estate and agricultural

services across the four districts, of vegetable growing in Horowhenua and dairy product manufacturing in Tararua. As some input resources will be diverted from dairy farming and vegetable growing to other land use industries, there will be smaller offsetting gains for sheep and beef farming, meat manufacture and other services. Compliance with the recalibrated Table 14.2 under PC2 produces a similar pattern of costs and gains, but at a much lower scale.

62. Overall our CGE modelling tells a consistent story: on all macro-economic measures, the impact of complying with the original One Plan (Scenario 0) is much more costly than that of complying with either of the PC2 scenarios. The cost impact of full compliance under Scenario 1 is less than that under Scenario 0 by such a large margin that the result could accommodate substantial change in input assumptions without overturning the relative result. The difference between Scenario 2 (discretionary pathway) and Scenario 1 is rather more marginal. Overall, on the evidence presented here, there would be substantial benefit in adopting the proposed PC2.

I. SUBMISSIONS AND EXPERT CONFERENCING

63. I have not seen any submissions specifically questioning the macro-economic impacts of the proposed PC2, beyond some mentioning the contribution of an industry or business to local economic activity and employment, and the potential consequences of loss of employment as a result of new compliance requirements. There was, however, an expert witness conference on macro-economics which concluded with some areas of disagreement, which I would like to briefly respond to here.
64. In the conference other experts said that the 20-year scenario in the CGE modelling decreased the ability to assess how costs due to environmental policy would impact on the community during transition. I agree that a 20 year then and now comparison does not shed any light on what happens in the transition, but that just raises the question of how practically to forecast that transition? That would involve forecasting future transition paths, and that would involve gathering data and making assumptions or informed guesses about a wide range of factors that could influence the forecast. That is challenging at the best times, even more so in the midst of a global pandemic, the long term outcome of which is still anyone's guess. As the purpose of our modelling is to assess the differences between the current One Plan and the proposed PC2, I believe it is more useful to focus on the changes in the regulation and eliminate all assumptions

and other “noise” from the comparison. The CGE modelling is not a forecast but it is a way of focusing on the differences between the original One Plan and proposed alternative.

65. Other experts also suggested running the model for different timeframes and different scenarios being developed by other submitters. Our CGE model could certainly be run to accommodate other time frames and scenarios, but while the numbers may change, the relative comparisons between the different options probably would not be much different, if at all, given the nature of the equations inherent in the model. We have not seen alternative scenario formulations from submitters, or alternative modelling provided from them. Economic analysis in resource management settings depends on alignment with other technical information from other disciplines and tends to come at the end of a long supply chain of other expert statements, so the timing of this work did not allow viewing alternative scenario settings. I note that last month the RMA Review Panel issued a report on reforming the resource management legislation with a view to improving its effectiveness and reducing the cost of its operation, so while there is no end of scenario modelling that could be undertaken, it is reasonable that the Council limit its modelling, while remaining open to considering other modelling provided by other interested parties.
66. Other experts also raised questions that were more about on-farm financial matters than the macro-economic effects. They queried the shock in the CGE model being directed through revenue impacts and missing out costs, but the equations which drive the adjustments in the model do include costs for every industry in the model: shocks can be input through revenue or productivity changes, but costs will still adjust through the model.
67. They suggested the model was missing out impacts on capital expenditure caused by regulatory compliance and described it as treating capital as a free good, but this is incorrect as CGE models are price-driven and every inter-industry response to a stimulus or shock faces the price of inputs such as labour and capital in determining the new equilibrium position.
68. They also highlighted potential impacts on farm debt as a result of compliance, such as where dairy farms make large scale capital investments, such as feed pads which may cost \$1,000 a cow to install. These issues are more in the domain of farm level impacts

than macro-economic impacts and it is true that the CGE model does not model them in detail, but it does account for mean capital costs at the industry level, and can be expected to cover “average” regulatory compliance costs in its equations. A regulation would need to require incredibly high compliance costs to shift the average industry cost level sufficiently high to render the CGE equations unfit for purpose. With most regulations there is a range of potential compliance options from low cost to high cost and the lowest cost can be expected to be adopted most widely, with only a few farms needing the high cost option (such as feed pads). The high cost option is not the mean, and even when it is used it may be adopted for a range of reasons other than compliance.⁵

69. A CGE model is a macro-economic model that is used to measure how impacts of shocks spread throughout an economy. It is not designed to measure farm level impacts or the effects on farmers’ financial position. Its focus is on how shocks affect the productivity of resources, and hence how they are redistributed across sectors in pursuit of highest returns and finding a new equilibrium. A CGE model is indifferent to who does the farming, as it assumes that if individual farms become unprofitable, the resources in them will find new productive uses under new ownership. The CGE model’s ability to trace impacts across an economy and account for resource price changes and reallocation (which input-output based multipliers cannot do) makes them an appropriate model to estimate the macro-economic impacts of the proposed PC2.

J. CONCLUSIONS

70. I conclude that the economic consequences of adopting the proposed PC2 to replace the original Table 14.2 in the One Plan are likely to be beneficial compared to retaining the original Table, which has compliance costs so high that compliance rates are currently low and having little effect in restraining nitrogen loss into the environment from intensive land uses in the Horizons’ region. The costs of compliance under PC2 are lower by such a wide margin compared to the costs of compliance with the original Table 14.2 that the results would be robust against changes in input assumptions. Compared to the current situation where compliance rates are low, PC2 offers the

⁵ There are plenty of articles in the farming press indicating feed pads can be a worthwhile investment quite apart from their role in capturing and containing livestock effluent, as they can be used to protect waterlogged soils from pugging and to provide better dietary and health monitoring of livestock, reducing veterinary bills.

prospect of achieving environmental improvement at lower cost than persisting with the current situation.

Peter William John Clough

4 September 2020

K. REFERENCES

Dairy.NZ. 2017. New Zealand dairy statistics 2016/2017, <https://www.dairynz.co.nz/media/5788533/nz-dairy-statistics-2016-17-web.pdf>

Ford, Stuart. 2017. Farm scale economic impact analysis of One Plan intensive land use provisions. The Agribusiness Group.

NZIER. 2018. The macroeconomic impacts of the One Plan's intensive land use provisions. NZIER report to Horizons Regional Council

Parminter, Terry. 2018. Regional macroeconomic report, memo from KapAg Ltd for Horizons Regional Council.

L. APPENDIX – CGE MODELLING DETAILS

71. We examine alternative pathways to complying with PC2 through NZIER's CGE model, which is consistent with the UN System of National Accounts, the basic framework used for estimating GDP at the national and regional levels, and also incomes accruing to business owners and employees across different industries and the economy as a whole. Our model traces the indirect or flow-on effects for supplying industries (e.g. agricultural services, fertiliser production, transport, etc.) and downstream industries (primary processing, retail, construction, etc.).
72. Our modelling also considers how resources (especially labour and capital) shift between the primary sector and other industries (manufacturing, services, etc.) as the dairy cattle farming and vegetable growing industries becomes less competitive and profitable in the face of higher costs to meet nitrogen loss targets.
73. Using these direct and indirect effects, we determined the flow-on effects throughout the wider Horizons economy and the national economy on GDP, employment, wages, and household spending. This gives us the macroeconomic impacts that you are interested in for your review.
74. For economic impact assessment we used NZIER's CGE model. Two important benefits of using a CGE model are that:
 - (a) It captures linkages in the economy between the sector being studied and the rest of the economy, and
 - (b) It allows for expanding demands and constrained production inputs to cause prices and resource allocations to adjust across the economy.
75. This adjustment characteristic distinguishes CGE models from the commonly encountered alternative of economic multiplier analysis based on input-output models of the economy, which are widely recognised as overstating flow-on effects and overall impacts.⁶ NZIER has used CGE modelling over the last five years to investigate climate

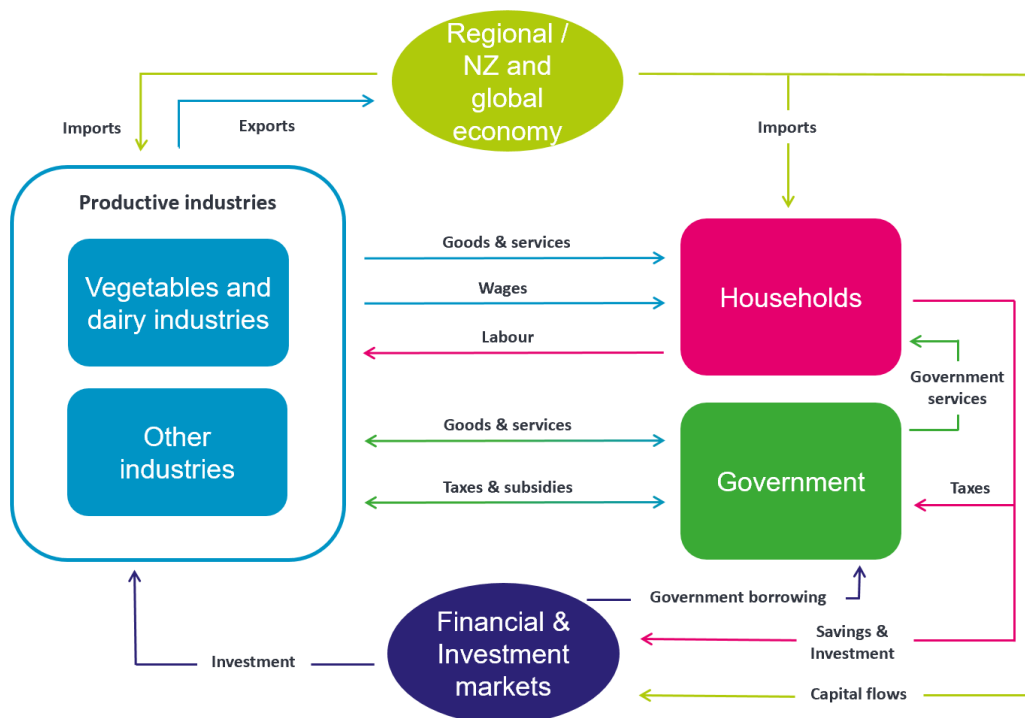
⁶ Further explanation on the limitations of multipliers is provided by the Australian Bureau of Statistics, which no longer publishes them. See <https://www.abs.gov.au/ausstats/abs@.nsf/Previousproducts/5209.0.55.001Main%20Features4Final%20release%202006-07%20tables>

change policies, trade policies, industry policies, responses to the Global Financial Crisis, expansion of irrigation, impacts of one-off events and increased domestic savings.

76. The NZIER CGE model is based on a similar model developed and maintained at the Centre of Policy Studies (CoPS) from Victoria University, Melbourne, a leading international centre of CGE research. The model database is based on the 2013 Statistics New Zealand input-output tables, which contain information on 106 industries and 201 commodities. The database is calibrated to the latest year using Statistics New Zealand's national accounting macroeconomic data. The CGE model includes the government, consumption, imports and exports. It also includes factors of production: labour, capital, land and intermediate products (products used to produce other products).
77. NZIER's regional CGE model TERM-NZ⁷ is a bottom-up model of the New Zealand economy. TERM-NZ is based on a Statistics New Zealand's Input-Output table that identifies the structure of the industries involved. TERM-NZ contains information on 149 industries, 149 commodities and 88 districts (68 local authorities and 20 Auckland board areas) which can be combined into regional and national territories. Each district is modelled as its own economy, but all districts are connected through trade and flows of capital and labour. A visual representation of TERM-NZ is shown in Figure 4. It highlights how the model can capture the complex and multidirectional relationships between the various parts of each regional economy and how they interact with the rest of New Zealand and rest of the world.

⁷ TERM-NZ stands for "The Enormous Regional Model" of the New Zealand economy. It was developed at NZIER by Dr. Erwin Corong and others based on the original Australian TERM model created by Professor Glyn Wittwer of the Centre of Policy Studies, Victoria University-Melbourne, Australia. <http://www.copsmodels.com/term.htm>. NZIER maintains close connections with the Centre, ensuring that our modelling techniques reflect international best-practice.

Figure 4 Our CGE model represents the circular flows between all the agents and activities in the economy



Source NZIER

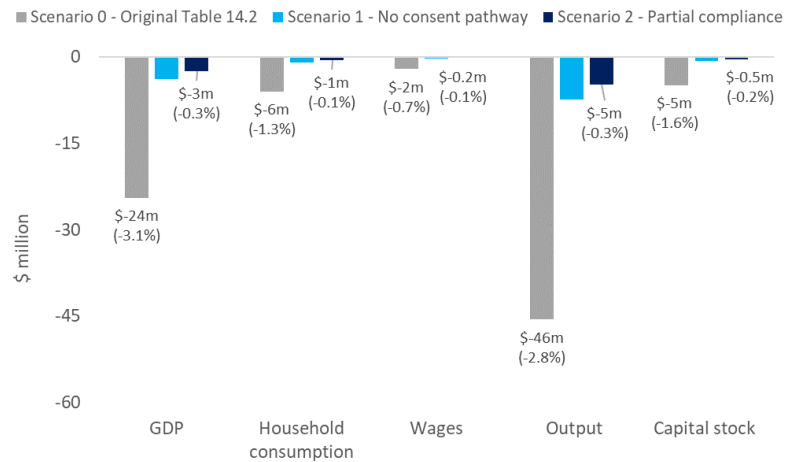
78. The model is able to account for resource scarcity, for example, not having enough employees, and it is also able to adjust relative prices, so that prices rise for commodities in demand. The analysis is static and does not account for the time path of investment or annual variations in investment or outcomes.
79. Our assumptions for the long-run in our CGE modelling are the following:
80. National employment is fixed in the long-run, but labour is completely mobile between industries and regions, and real wages adjust. This is consistent with the idea that, both the labour force and the rate of employment are, in the long run, determined by mechanisms outside the model.
81. Household and government expenditures move together to accommodate a fixed balance of trade as a share of GDP.
82. Rates of return are exogenous and capital is mobile between industries and regions. This mobility can occur either in the form of machinery etc. being physically moved, or capital in one industry/region being allowed to depreciate without replacement while investment builds up the stock of another industry/region.

83. Foreign currency prices of imports are naturally exogenous (i.e. formed outside the model and input into it as assumptions). Real government consumption is also exogenous. Other exogenous variables include rates of production tax, technological coefficients, national population, and national labour supply.
84. Other industries will benefit at the margin from the contraction in the dairy cattle farming and vegetable growing industries, as more resources (labour, capital, land) become available for producing other goods and services. The economic effects from the contraction of the dairy and vegetable growing industries are not just contained within these industries; they are more widely felt throughout the economy. The indirect impacts of the nitrogen loss targets from Table 14.2 (original and recalibrated) in dairy and vegetable growing are widespread across other industries within the local economies.

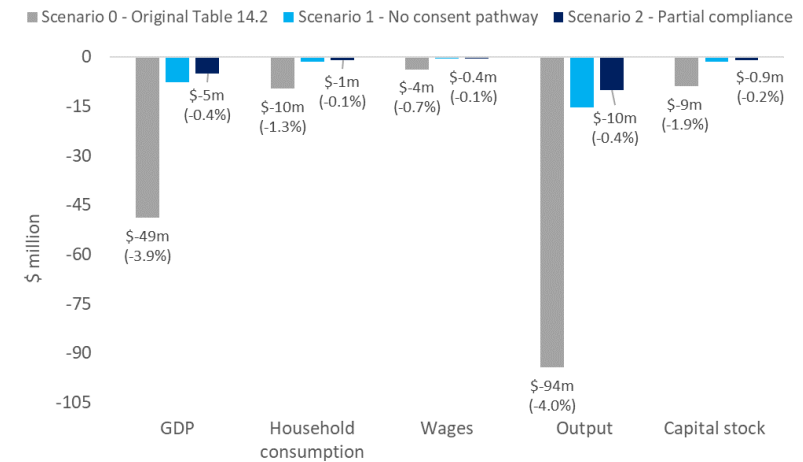
Figure 5 Difference in macroeconomic impacts between scenarios for each district

Annual changes compared with 2019 baseline in Year 20, in \$ million (real terms) and in percent.

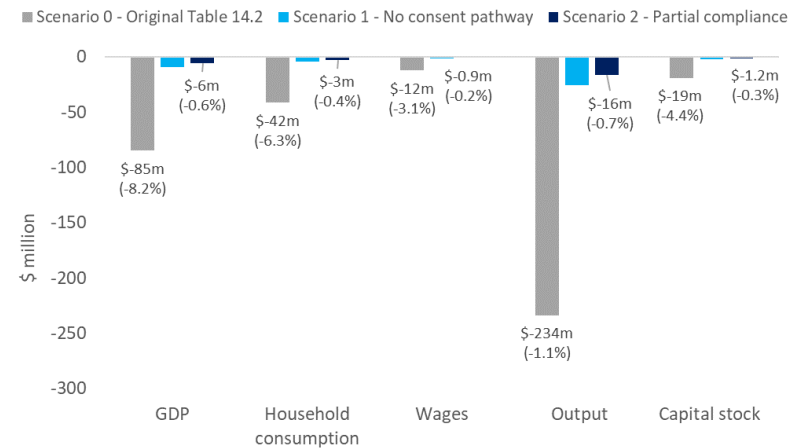
Rangitikei



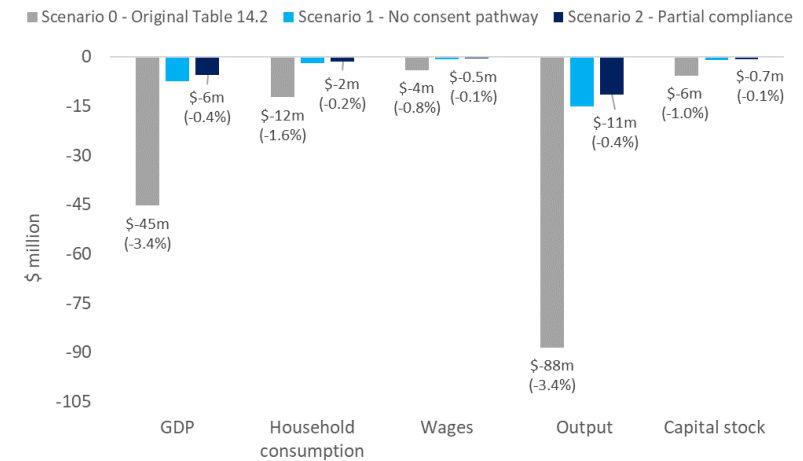
Manawatu



Tararua



Horowhenua



Source: NZIER