

**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 KERRY MAYES ON BEHALF OF THE MANAWATŪ-
WHANGANUI REGIONAL COUNCIL**

ECONOMICS



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STATEMENT OF EVIDENCE OF KERRY MAYES**A. INTRODUCTION**

- [1] My name is Kerry Arthur Mayes. I am employed by WSP as a Technical Principal – Valuations and Economics and have been in this position since August 2019.
- [2] I hold a Master of Commerce with First Class Honours in Operations Research from The University of Canterbury. I have worked as an economics professional for 30 years, including as a Director of Corporate Finance for a tier two Investment Bank.
- [3] I have been engaged by Manawatū-Whanganui Regional Council (**Horizons**) to prepare evidence in support of Proposed Plan Change 2 to the Manawatū-Whanganui One Plan (**PC2**). This evidence covers the economic impacts of adopting the farm practice changes required by PC2.
- [4] I was not involved at the Council-level hearing for PC2. Technical reporting on the farm scale economic impacts of PC2 was provided by my colleague Mr Stephen McNally, from WSP. Mr McNally prepared a s 42A report (and supplementary s 42A report), which was supported by a report on the costs of changes in nitrogen leaching maxima by Dr Terry Parminter.¹

B. BACKGROUND

- [5] PC2 was proposed by Horizons to address issues that had arisen in implementation of the nutrient management framework within the One Plan. An overview of the reasons why implementation of the rules has become challenging – essentially updates to Overseer and a policy framework in conflict – is set out in the evidence of my colleague, Dr Jolly.
- [6] PC2 seeks to resolve both these issues. It was designed to be a short-term solution to recalibrate Table 14.2, in line with an updated version of Overseer and to provide a workable consenting pathway for IFLU which do not meet Table 14.2 (i.e. to address the issues with the policy framework) pending

¹ Parminter, T. KapAg, January 2018. An Impact Assessment of One Plan policies and rules on farming systems in the Tararua District and the Manawatū-Whanganui Region.

resolution of a new freshwater plan to give effect to the National Policy Statement for Freshwater Management 2020.

- [7] The initial economic modelling for PC2 was carried out in 2020 by Mr McNally, drawing on the skills of a team consisting of experts in soil/nutrition, farm budget and economics (of which I was a part). Mr McNally developed a farm scale financial model methodology for determining the impact of Good Management Practices (**GMPs**) and Best Management Practices (**BMPs**) on the economics of intensive farming land use activities, including Commercial Vegetable Growing (**CVG**) and pastoral farming. I provided economic input for that modelling, in particular the calculation of the Net Present Values (**NPV**) and the uncertainty analysis.
- [8] The farm scale modelling was described in the Farm Scale Financial Impact Model Report (the **Modelling Report**), by Mr McNally and Dr Jolly, which is attached to my evidence as **Attachment A**.² I was a contributing author.

C. CODE OF CONDUCT

- [9] 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.

D. EXECUTIVE SUMMARY

- [10] I have updated the model developed to assess the economic impacts of PC2 to reflect the changes to the economics since the initial modelling was undertaken. In particular, I have updated costs to June 2023 dollars,

² WSP Horizons Regional Council Proposed Plan Change 2: Farm Scale Financial Impact Model (4 September 2020).

reviewed the economic outcome analysis, and updated the uncertainty analysis.

[11] While I understand that the decisions version of PC2 (**DV-PC2**) proposed over the course of these appeals changes some of the provisions, these changes do not alter the economic impacts of compliance with GMPs. This means that the key conclusions of farm scale modelling undertaken for the Council-level hearing remain very similar. That is:

- (a) The cost impact of implementing PC2 remains variable across the CVG farms studied. While all the farms showed a net reduction in profitability, in all cases, partial gross margins remained positive.
- (b) Sensitivity analysis shows that CVG remains highly sensitive to external variables affecting their gross margins (such as yield and price).

E. SCOPE OF EVIDENCE

[12] My evidence focuses on the farm scale economic impact model which analyses the direct cost and benefits of adopting the GMPs and/or BMPs required by PC2. It primarily updates the work of Mr McNally at the Council-level hearing of PC2.

[13] I explain how the model developed for the purpose of the Council-level hearing has been updated to reflect likely changes to costs and revenues. I have reviewed the conclusions of Mr McNally using this updated model (2023), and set out the results of that review in this evidence.

[14] In addition to my own observations, I have relied on the statements of evidence of Dr Anne-Maree Jolly and Professor David Horne. Both Dr Jolly and Professor Horne have provided information relating to implementation of GMP and BMP on which I have relied for the purpose of the updated farm scale impact modelling.

F. INITIAL PLAN CHANGE 2 MODELLING**Methodology**

- [15] A comprehensive explanation of the initial economic modelling conducted for PC2 to evaluate the financial aspects of CVG (Commercial Vegetable Growing) and pastoral farming can be found in Mr McNally's Modelling Report. Mr McNally's modelling resulted in partial gross margins, and sensitivity analyses were also carried out. Two sets of analyses were completed: the first assessed the cost of adopting all GMPs, while the second assessed the cost of adopting all BMPs.
- [16] In the context of CVG, we modelled ten two-year crop rotations involving various vegetables grown in Horowhenua, including potatoes, onions, intensive vegetables, and brassicas. Eight of these crop rotations were sourced from the Bloomer et al. 2020 report, while Dr Jolly contributed two additional crop rotations for comparison purposes.
- [17] Prior to modelling the on-farm cost impact of practice changes on IFLU (Intensive Land Use) activities, GMP and BMP were defined, tabulated, and modelled with Overseer to assess their effectiveness in reducing nitrogen leaching.
- [18] Each model applied the required system change to a two-year repeating farm cost model, extrapolating across 20 years. This allowed Mr. McNally and the WSP team to calculate NPVs of the management system change examples. The baseline year for assessment against the change impact was set as 2013/14.
- [19] CVG cost modelling inputs were then benchmarked using data from a leading commercial vegetable grower who generously provided detailed information about their business, crop management practices, and farm-scale operational and capital cost and return records.
- [20] In the case of dairy farming, the 2020 dairy farm financial modelling built upon Mr Parminter's work. It employed the cluster farm approach, using five representative dairy systems to assess the financial impact of adopting dairy

farm GMP. Professor Horne provided the GMPs for modelling purposes and conducted the reduction in nitrogen leaching modelling.

- [21] While Mr Parminter's approach aimed at driving farms to achieving compliance with Table 14.2, Mr. McNally modelled the cost of the discretionary pathway by applying a range of GMPs, representing a 'worst-case' scenario. The GMPs for each cluster farm were provided by Professor Horne.
- [22] The base cluster farms used in the Modelling Report represent farms across the Tararua targeted catchments affected by PC2. These areas have the largest number of unconsented dairy farms and were therefore considered suitable and representative for PC2 modelling.
- [23] For this modelling, a modified partial gross margin/partial farm budget approach was used. This approach allows for comparing options when making decisions about future farming practices. It focuses on farm activities directly affected by management practice changes and excludes aspects of a farm enterprise that are independent of these changes.
- [24] The partial gross margin assesses the direct costs and returns for specific crops or farming activities, calculating the net cost/benefit of change (i.e., revenue minus operational costs). This approach, often referred to as a partial farm budget, is extensively explained in Section 7.1 of the Modelling Report.
- [25] The model employs Monte Carlo simulation for sensitivity analysis. This methodology assigns statistical distributions to key inputs and measures the resulting uncertainty in key outputs.
- [26] I consider that the partial gross margin approach is a valid means of investigating the direct impact of a regulatory system change, such as PC2. Regardless of the approach taken (and acknowledging that other models were considered at the Council-level hearing), the Hearing Panel concurred that there were compliance costs, but these would be less burdensome under PC2, including alternative approaches, compared to complying with

Table 14.2 with no other pathways. This conclusion aligns with the findings of the Modelling Report.

Key findings

- [27] The results from the Modelling Report can be summarised as follows:
- (a) The cost impact of implementing PC2 was variable across CVG and dairy farms studied, but all showed a net reduction in profitability. Despite this, the partial gross margin remained positive in all cases.
 - (b) CVG and dairy farms are highly sensitive to external variables affecting the partial gross margin such as yield and price. A proportion of marginal farms might have become unviable as a result of PC2, particularly where pre-existing high debt and thereby capital servicing was in place.
 - (c) The cost of meeting the original Table 14.2 in the operative One Plan would have required more substantial farm changes, including reduction in overall productivity to get to point of compliance, or to transition out of that land use.
 - (d) The higher net profitability under PC2 compared to where enterprises are driven to meet Table 14.2 under the operative One Plan (with no alternative viable consenting or transition pathway) meant that a more favourable position is available through the PC2 provisions and the discretionary pathway.
 - (e) The alternative to PC2 is that farmers would need to comply with the original Table 14-2, with very limited (if any) prospect of obtaining consent to either operate or transition out of the land use. While there are compliance costs associated with PC2, in contrast to an approach that does not allow consent at all, they are a significant improvement.
- [28] Overall, the Modelling Report confirmed that PC2 was a positive influence, in that it shifted farmers away from being unconsented/'unconsentable' and closer to the point of positive profitability within the regulatory scheme.

G. UPDATES TO MODELLING – RISK ASSESSMENT TOOL

- [29] I understand that changes are proposed by Horizons to the DV-PC2 to account for a new non-Overseer based consent pathway. This pathway involves the use of a 'risk assessment tool'. The risk assessment tool for CVG is described in detail in Professor Horne and Dr Jolly's evidence.

CVG

- [30] As discussed in her evidence, Dr Jolly has modelled the on-farm nitrogen loss for CVG when using the risk assessment tool and GMP and/or BMP are adopted which reduce risk nitrogen to low. Her modelling analysed the entire Bloomer et al data set of 62 crop rotations. However, for the cost modelling I have followed Mr McNally's work and only examine eight crop rotations.
- [31] My approach has been to use the same approach underpinning the 2020 work apart from only modelling the eight Bloomer et al crop rotations as it is only those rotations that have feed into Dr Jolly's Overseer modelling.
- [32] From an economic perspective, this shift in approach regarding the DV-PC2 provisions has not altered the actions needed to implement GMPs. Consequently, the crop rotation scenarios that were originally developed for the prior modelling remain unchanged for the updated analysis.
- [33] In summary, the key updates to the CVG farm scale model are as follows:
- (a) Dr Jolly confirmed the required GMP/BMP for each crop rotation when using the risk assessment tool. Updates to the partial gross margins resulted to only include the GMP and/or BMP required for each individual crop rotation.
 - (b) Updates were made to costs, which were based on Stats NZ's Farm Expenses Price Index for Horticulture and Fruit Growing Farms. Escalations of costs from 2020 (or earlier) have been calculated from the most appropriate index within this set of Indices.

- (c) The Weighted Average Cost of Capital, which is used for discounting future cash flows, has been updated with current estimates of Inflation and the Risk-Free-Rate.
- (d) Capital costs are modelled to include replacement of these assets at the end of their useful life rather than the 20-year horizon used in the previous modelling. The main reason for doing this was to simplify the calculation of Annualised NPV (**ANPV**). ANPV allows easier conceptualisation of the change in profitability.
- (e) There were eight core rotations from the previous analysis (with the remaining two just used for comparison purposes). Each of these crop rotations is based on 10 ha with a two-year cycle of crops. We have updated costs and benefits of these eight rotations. The only other adjustment was the correction to three rotations where a crop was originally removed from the rotation, but the revenue was not taken into account correctly within the model.

[34] The following table summarises the modelling results for the eight rotations. The columns show the expected cost of implementing GMP in ANPV terms and the percentage of this cost to the historical expected Gross Margin. Then shown is the Expected Gross Margin under GMP and the variance of that Gross Margin.

	GMP Cost \$ANPV	GMP Cost (% of Historic)	GMP Expected Gross Margin \$ANPV	Range of Gross Margin
Potatoes	-\$9,735	-16%	\$51,177	119%
Onions	-\$9,752	-16%	\$50,069	120%
Cauliflower Broccoli	-\$7,115	-1%	\$328,751	32%
Cauliflower Potato	-\$12,244	-5%	\$317,658	31%
Pumpkin Cauliflower	-\$12,872	-7%	\$231,737	40%
Spring Onion Spinach	-\$75,644	-25%	\$231,965	33%
Lettuce Cabbage Maize	-\$65,946	-25%	\$198,067	38%

	GMP Cost \$ANPV	GMP Cost (% of Historic)	GMP Expected Gross Margin \$ANPV	Range of Gross Margin
Spinach Spring Onion Oats	-\$73,107	-27%	\$204,613	37%

[35] The results fall into three groups:

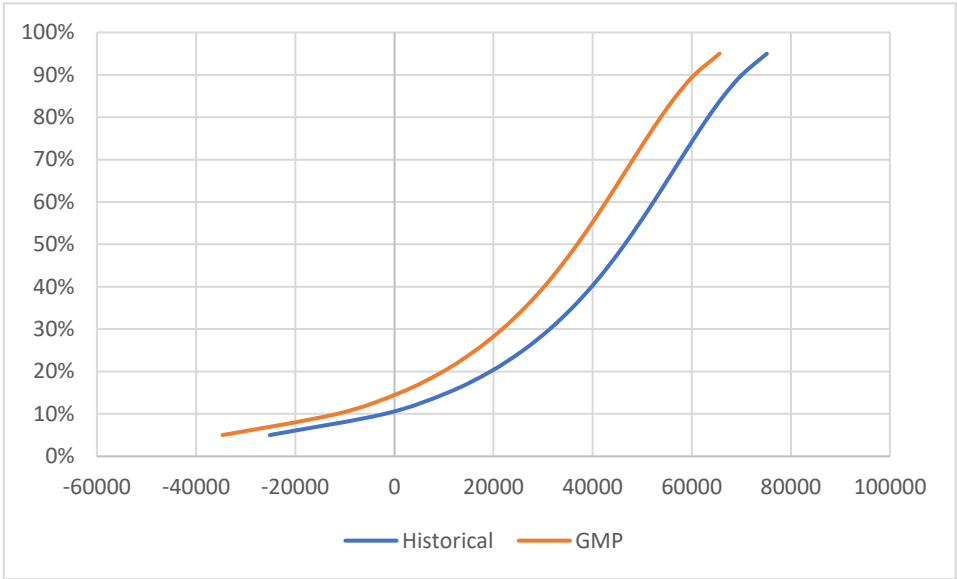
- (a) Potatoes and Onions.
- (b) Cauliflower Broccoli, Cauliflower Potato, and Pumpkin Cauliflower.
- (c) Spring Onion Spinach, Lettuce Cabbage Maize, and Spinach Spring Onion Oats.

[36] Potatoes and Onions rotations have a low cost of GMP implementation, but it accounts for approximately 16% of the partial gross margin. However, 16% is small in comparison to the approximately 120% range in partial gross margin variability due to normal uncertainties.

- (a) Potatoes

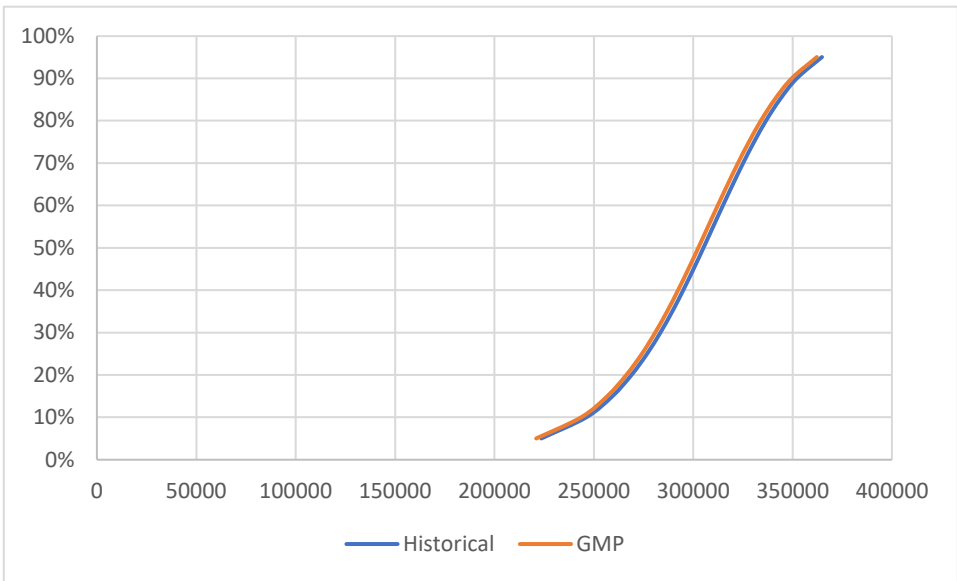


(b) Onions

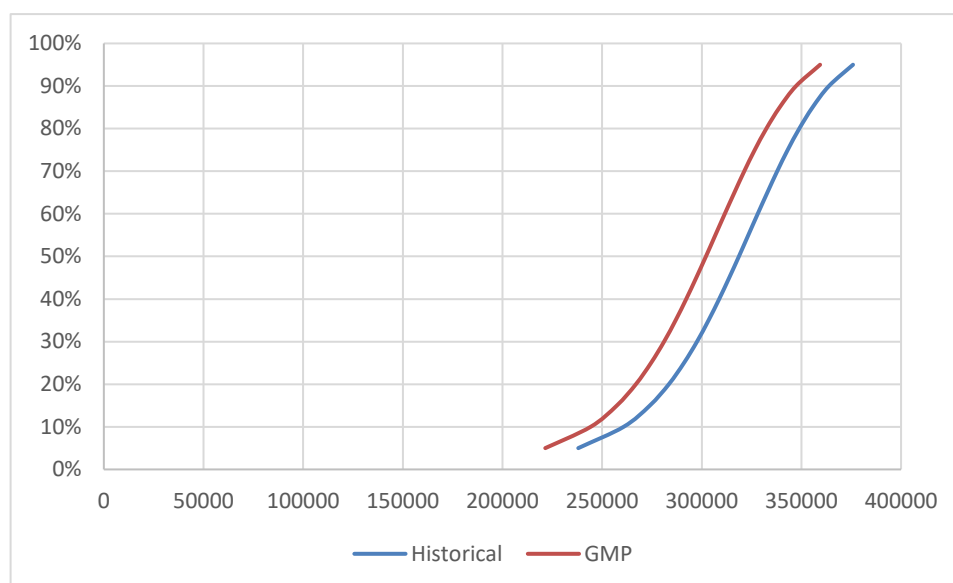


[37] Cauliflower Broccoli, Cauliflower Potato, and Pumpkin Cauliflower GMP implementations have a small impact on partial gross margin (between 1%-7% of partial gross margin). These remain profitable (partial gross margin of approximately \$230-330k) with lower ranges of partial gross margin variability (approximately 30-40% - partly due to the diversification of crops).

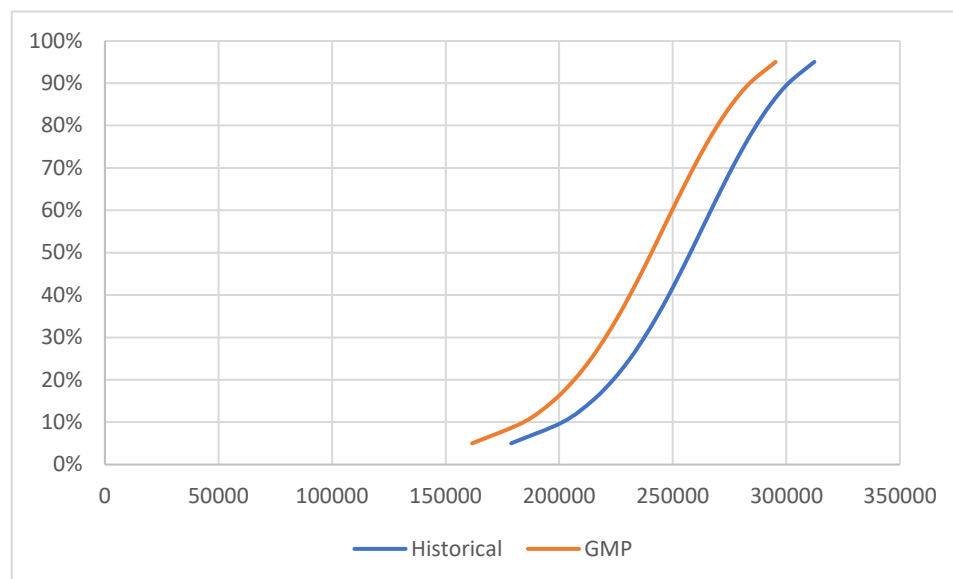
(a) Cauliflower Broccoli



(b) Cauliflower Potato

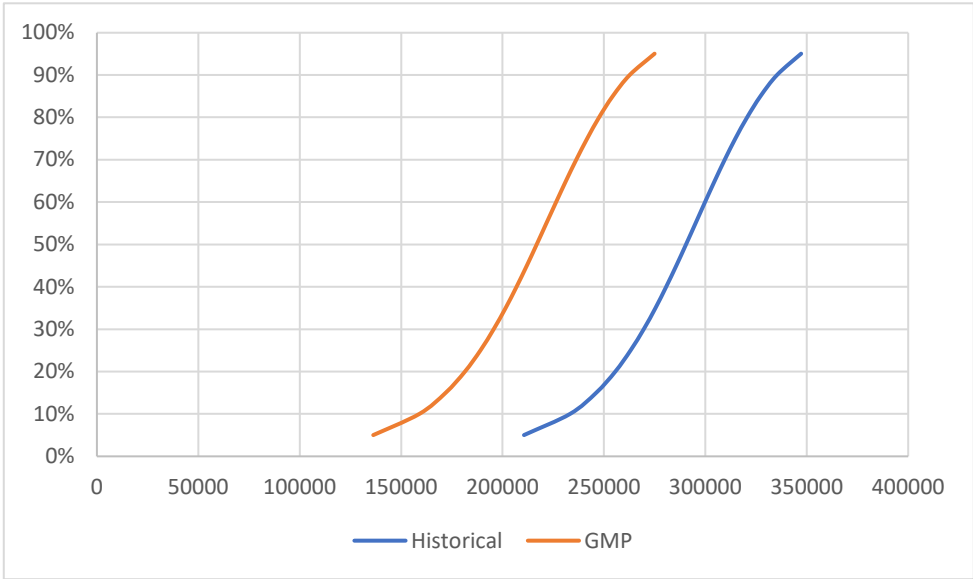


(c) Pumpkin Cauliflower

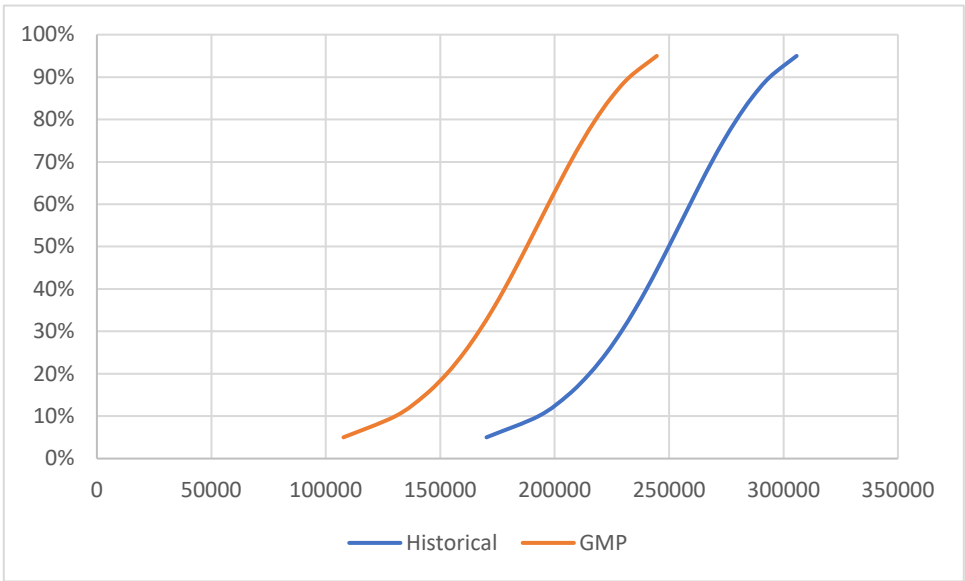


- [38] Spring Onion Spinach, Lettuce Cabbage Maize, and Spinach Spring Onion Oats GMP implementations all reflect the removal of a crop from the rotation (cabbages). This results in a 25-27% reduction in partial gross margin. These rotations remain profitable (\$200-230k) and also have lower ranges of partial gross margin variability (33-38%).

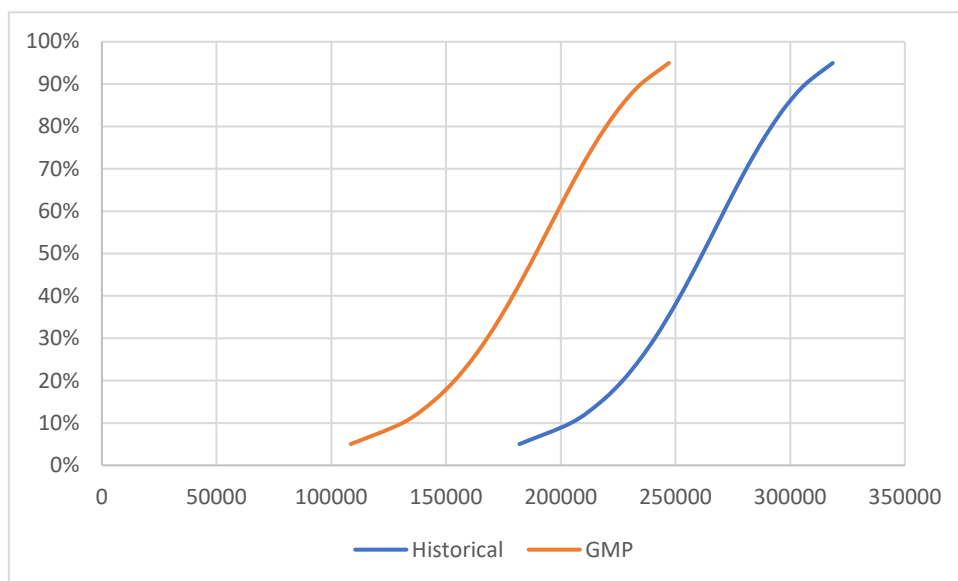
(a) Spring Onion Spinach



(b) Lettuce Cabbage Maize



(c) Spinach Spring Onion Oats



[39] In summary, the latest results show a broader range of outcomes from the crop rotation examples to achieve GMP than the 2020 work. The NPV and new ANPV figures for farms adopting GMPs and BMPs to obtain resource consent under PC2 show that there will be compliance costs associated with adopting those practices and that these will vary in magnitude and in relativities to historical practice. In all cases the partial gross margin remains positive.

[40] It is also important to note, as Mr McNally did in his Council-level reporting, that the historical operation (effectively a “no regulation” scenario) is not an appropriate counterfactual to compare the PC2 costs against. The appropriate and correct counterfactual is the economics of operative One Plan provisions, where farmers have been expected to be restricting nitrogen leaching from their farming operations for some time.

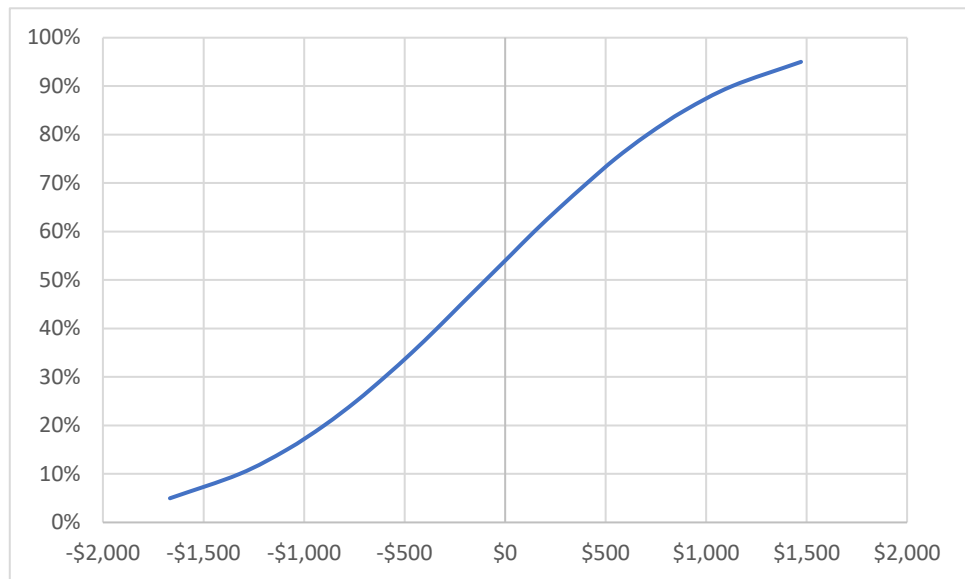
Dairy

[41] The farm clusters from Mr Parminter’s work provides relevant background to using Professor Horne’s case study system for the risk matrix work being progressed. However, unlike the CVG cost models which were simply updated from the 2020 cost models, the dairy models were all new models. This is due to Mr Parminter’s cluster farm approach not being representative

within the risk assessment tool (all five clusters fall within the same sector in the risk framework).

- [42] Due to constraints on time and on data availability, while we intended to model a range of farm systems covering the range of the risk matrix, I have only been able to analyse one farm system. This system shows the implementation of GMP for the central risk matrix cell, the same cell that covers most CVG operations.
- [43] The key updates to the dairy farm scale model include:
- (a) Like the CVG cost models following on from Dr Jolly's risk assessment tool Overseer models, the dairy cost modelling has followed on from Professor Horne's risk assessment tool Overseer modelling.
 - (b) Professor Horne provided the GMPs for a representative dairy system which sits within one of the central cells of the framework (PAW moderate rainfall 1000 – 1300) which represents many of the unconsented Tararua dairy farms. These unconsented farms represent a large proportion of the pastoral farm impacted by PC2 and I note that the Tararua Water Management Sub Zones have the largest number of unconsent dairy farms, and therefore this is deemed suitably representative for use within PC2.
 - (c) Using a similar format to that of the original partial gross margins the change in cost between the One Plan and PC2 was modelled and NPV and ANPV have been calculated to represent the use of the pastoral risk assessment tool.
 - (d) Costs were updated, based on Stats NZ's Farm Expenses Price Index for Dairy Farms. Escalations of costs from 2017 (or later) have been calculated from the most appropriate index within this set of Indices.
 - (e) The Weighted Average Cost of Capital, which is used for discounting future cash flows, has been updated with current estimates of Inflation and the Risk-Free-Rate.

- (f) Capital costs are modelled to include replacement of these assets at the end of their useful life rather than the 20-year horizon used in the previous modelling. The main reason for doing this was to simplify the calculation of ANPV, which allows easier conceptualisation of the change in profitability.
- [44] In summary, the economic implications of this scenario have been modelled on the same partial gross margin approach as CVG. Here, Professor Horne provided us with the on-farm practice changes to achieve GMPs and BMPs, and WSP costed those changes. WSP then assessed the NPV and ANPV of the partial gross margins and added Monte Carlo simulation for sensitivity analysis.
- [45] The results of my assessment of the scenario modelled are as follows:
- (a) Capital costs of changing to GMP are \$10,000 for consenting, which is assumed to last 10 years; and \$7,876 for irrigation improvements with an assumed life 30 years, totalling \$17,876 in capital costs.
- (b) Changing to GMP and/or BMP would result in savings in fertiliser costs. These were assessed at \$19,170 for nitrogen fertiliser and \$1,581 for non-nitrogen fertiliser.
- (c) However, the cost of importing supplementary feed to offset the reduction in grown feed availability was assessed at \$20,387.
- [46] The overall result of adopting GMP and/or BMP in the modelled scenario was assessed as (for whole farm) was a capital cost of \$17,876 and an increase of annual costs of \$364.
- [47] Calculating the ANPV per hectare results in an expected reduction in annual profitability of \$97. This estimate has a 90% confidence interval of -\$1,570 to \$1575. As such, the expected value is not significant.
- [48] The following graph shows the 90% confidence range of the per hectare ANPV. The mean ANPV (-\$97) is where the line crosses the 50th percentile.



- [49] Modelling of the dairy scenario suggests that, while there is an impact on profitability resulting from the adoption of the on-farm practice management changes required to achieve the necessary risk reductions to comply with the risk matrix proposed, that impact is not statistically significant.
- [50] However, as only one sector of the risk matrix was modelled, further modelling may be required to allow for the extrapolation of those results to other sectors of the risk matrix.

6 October 2023

Kerry Arthur Mayes

H. REFERENCES

- Parminter, T. KapAg, January 2018. An Impact Assessment of One Plan policies and rules on farming systems in the Tararua District and the Manawatū-Whanganui Region.

I. ATTACHMENT A

WSP Horizons Regional Council Proposed Plan Change 2: Farm Scale Financial Impact Model (4 September 2020).

Project Number: 5-P1366.00

Horizons Regional Council

Proposed Plan Change 2

Farm Scale Financial Impact Model

4 September 2020

CONFIDENTIAL



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2	26 Aug 2020	CB SJM	SJM	SJM	Draft v2
3	31 Aug 2020	AMJ SJM	Client inputs	SJM	Final draft for client review
4	4 Sept 2020	AMJ, SJM	Client reviewed	SJM	FINAL

Revision Details

Revision	Details
2	Added updated sensitivity graphs to Appendix I and modified analysis text
3	Incorporation of final edits and feedback comments from client
4	Additional comments and finalisation of formats



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Disclaimers and Limitations

This report ('Report') has been prepared by WSP exclusively for Horizons Regional Council ('Client') in relation to Plan Change 2 Farm scale cost impact modelling ('Purpose') and in accordance with the Plan Change 2 Economics Analysis Short Form Agreement dated 12 February 2020. The findings in this Report are based on and are subject to the assumptions specified in the Report, Project Change Notice 1 dated 6 March 2020 and Project Change Notice 2 dated 2 May 2020. WSP accepts no liability whatsoever for any reliance on or use of this Report, in whole or in part, for any use or purpose other than the Purpose or any use or reliance on the Report by any third party.

Reliance on client-supplied data

In preparing the Report, WSP has relied upon data, surveys, analyses, designs, plans and other information ('Client Data') provided by or on behalf of the Client. Except as otherwise stated in the Report, WSP has not verified the accuracy or completeness of the Client Data. To the extent that the statements, opinions, facts, information, conclusions and/or recommendations in this Report are based in whole or part on the Client Data, those conclusions are contingent upon the accuracy and completeness of the Client Data. WSP will not be liable in relation to incorrect conclusions or findings in the Report should any Client Data be incorrect or have been concealed, withheld, misrepresented or otherwise not fully disclosed to WSP.

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Dr Anne-Maree Jolly, Rural Environmental Consultant, WSP, holds a PhD in Soil Science and is a Certified Nutrient Management Advisor with extensive experience in pastoral farming systems and Overseer®. Anne-Maree has undertaken the background research, provided the contribution to interpreting farm and growing systems practices into Overseer® nutrient leaching models and generating systems change data to support the farm scale financial cost and benefit analysis.

Stephen McNally, Head of Primary Industries, WSP, has a 34-year career within the agriculture and horticulture sectors including field advisory roles on nutrient budgets, system management in crop production and marketing and infrastructure and land use change decision processes. Stephen has developed the farm scale cost benefit model format and has been the overall director of the development of WSP report and evidence.

Contributing authors and reviewers WSP New Zealand Ltd,

Courtenay Bremner, Water Resource Scientist, developed the growing degree day analysis and maps.

Kerry Mayes, Principal Economic Advisor, WSP has provided the sensitivity analysis of the cost benefit farm scale models.

Nicholas Adams, Rural Infrastructure, WSP, has reviewed the farm scale cost benefit models.

Dr Deborah Maxwell, Senior Hydrologist, WSP has reviewed the final draft report.

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1 Executive Summary

The focus of the WSP proposed Plan Change 2 (PC2) Farm Scale Financial Impact Model report was to consider the on-farm economic implications for existing intensive farming land use (IFLU) activities within Horizons Regional Council (Horizons) priority catchments. Those IFLU activities that do meet the cumulative nitrogen leaching maximums (CNLM) within the recalibrated Table 14.2 would be considered for consent under the existing controlled activity rules. The activities that do not meet the recalibrated Table 14.2 CNLM will require application for resource consents under either of the PC2 discretionary activity pathway.

A further option recently considered as part of the pre-hearing process was a controlled activity pathway for IFLU activities that have nitrogen leaching values in excess of Table 14.2 where best management practice (BMP) is adopted and a specified nitrogen leaching reduction is met. This additional proposed pathway has been considered in a later section of this report.

There is a risk of entrenched thinking when considering the impact of the regulatory change with reference to a 'before' and 'after' situation that incorrectly assumes farmers and growers are not already regulated (in this case, under the Manawatu-Whanganui One Plan). To avoid that entrenched thinking WSP adopted a hypothesis approach to gauge the significance of the changes required.

WSP considered the following propositions: -

The adoption of good management practice (GMP) or BMP that can meet the notified PC2 recalibrated Table 14.2 cumulated nitrogen leaching maximum figures, or approach it in a reasonable time scenario, when modelled at a farm financial level, and when rolled up to an accumulated district industry assessment than, have less impact than,

- a) the required farm practice and productivity changes necessary to meet the original Table 14.2 in the operative One Plan, and,*
- b) other natural variables and sensitives that impact a farming viability decision.*

Adopting GMP or BMP, therefore, should not negatively impact the district and those operating within it.

To test this hypothesis, WSP has built a farm scale cost impact model and made changes in each input factor that can be linked directly to the notified PC2 but isolates out factors that are pre-existing such as level of indebtedness or enterprise costs that are not changed by the PC2 such as rates, insurance or minor land ownership costs.

To allow WSP to confidently model the cost impact of practice changes on IFLU activities, both GMP and BMP needed to be defined, tabulated and modelled with Overseer® to determine the effectiveness of each possible change in reducing nitrogen leaching.

Due to restricted access to actual enterprise Overseer® modelling in use within the commercial vegetable growing (CVG) sector WSP developed their own initial set of Overseer® models. The models developed looked at eight different rotations with the adoption of GMP and BMP covering potatoes, onions, leafy greens, pumpkin and brassicas typical of the Horowhenua production area.

Once further information from Bloomer et al (2020) was released by the industry for CVG it allowed clarification of some aspects of the Overseer® models and the way the impact of PC2 was being contemplated. For example, it highlighted the choice of base year relative to when the One Plan became operative in December 2014 would influence the reduction in modelled nitrogen losses through the adoption of GMP and BMP. It was also identified that not all possible GMPs were adopted as part of the Bloomer et al (2020) Overseer® modelling. Only the use of catch crops with nitrogen fertiliser usage were adopted. WSP retained their own Overseer® modelling with only some data being selectively updated to parallel agreed points of alignment with Bloomer et al (2020) data, where it was appropriate.

WSP then undertook farm scale cost impact analysis arising from the farm systems change models. The impact scenarios that need to be considered occur across highly diverse land uses where multiple variables exist between

enterprises. These variables could be the way they are structured financially, prior decisions that may already be affecting their viability and the daily changes that impact farming decisions within vagaries of markets and natural climate variables.

The focus in WSP modelling has been limited to making assessment of factors within production systems directly influenced by PC2, with a focus on cumulated nitrogen leaching reductions. The gross margin approach adopted looks at net cost/benefit of change i.e. revenue less operational cost less annualised capital. This approach only assesses the overall enterprise profit margin and compares cost/benefit change against assessed enterprise margin.

In parallel with a two-year Overseer® model, WSP applied system changes to a two-year repeating cycle across 20 years, for a Net Present Value (NPV) at 6% discount rate. The modelling process and input data has been tested against limited grower derived data for CVG and prior studies for dairying. Sensitivity analysis has been applied across line items in the gross margins to account for variability within systems.

Typically, the overall cost impact of change on CVG is in the order of \$2,000/ha reduced profitability when viewed against an approximate net margin of 5-10%. If growers were required to meet the recalibrated Table 14.2 through the adoption of GMP and/or BMP, seven out of ten example crop rotations modelled would be able to achieve this trigger value. On the other hand, when looking at the discretionary pathway all rotations would be able to apply for consent with the financial implications being less compared to being forced to meet the recalibrated Table 14.2.

The cost benefit was variable across the dairy farms studied but was negative in all cases. Dairy farmers are likely already highly sensitive to solvency issues due to pre-existing debt servicing. One objective particularly with dairy farming, other than positive cashflow, is capital gains of the enterprise. Capital value is proportional to net production returns, so a higher profitability helps hold enterprise value and leads to more favourable lending ratios. The higher net profitability for the discretionary pathway compared to the earlier work of others that drove enterprises to meet the original Table 14.2 means a more favourable position is available through the discretionary pathway under PC2 and the recalibrated Table 14.2. The previous costs impact would have also included the likelihood of some enterprises having to exit the industry as there was no transitional pathway available.

The cost of change relationship WSP was able to model when compared to estimated whole of enterprise profitability is less significant for the CVG examples but is more significant for dairying cluster examples where the profitability margins are typically slimmer.

Sensitivity analysis was undertaken, and tornado graphs provided as a visualisation of the ranked sensitivities. These sensitivities are calculated in relation to a 20-year NPV cost impact of the practice changes proposed under GMP or BMP. The sensitivities looked at each of the gross margin line items (such as yield, price, machinery, monitoring, etc) plus capital and the statistical likelihood of each factor's influence on the base NPV.

The analysis shows which factor is most significant in the NPV in relation to all possible high/low combinations. The sensitivity takes into account the assumed ranges each factor could take, e.g. yield fluctuations arising from climate factors (+/-12.5%), market price swings (+/-25%) and changes in input costs (+/-10%).

In general, all the scenarios across CVG GMP and BMP and dairy are most sensitive to yield and price (i.e. revenue earned), which is consistent with the hypothesis posed that normal challenges facing primary production are more significant over a 20-year period than the cost impact of the changes required to meet PC2 rules.

It should be noted that the higher net profitability for the PC2 discretionary pathway compared to the earlier work of others that drove enterprises to meet Table 14.2 under the operative One Plan means a more favourable position is available through the PC2 amendments and the discretionary pathway.

WSP supports this pathway but believes nitrogen loss reductions need to be significant and all suitable GMP and any suitable BMP for that individual property will need to be adopted. GMP and BMP will need to target all suitable contaminants on an individual property, not just nitrogen. The consent application would require Overseer® nutrient budgets as well as a comprehensive farm environment plan.

2 Introduction

2.1 Background

The Horizons Regional Council One Plan (One Plan) became operative in December 2014.

One policy outcome was the requirement for existing intensive farming land uses (as defined by the One Plan) to obtain a resource consent if they were located within defined priority catchments. The type of consent required under the One Plan (controlled activity or restricted discretionary) depends on whether the intensive farming land use (IFLU) met the cumulative nitrogen leaching maximum (CNLM) in Table 14.2, which assigns CNLM value to each Land Use Capability (LUC) class.

Table 14.2 was developed prior to 2007 and by the time the One Plan became operative the model behind the nitrogen loss allowance (Overseer®) had received several updates with the main update occurring more recently when there was the change to account for drainage.

In March 2017, the Environment Court ruled that the way Horizons was implementing the One Plan was not consistent with the requirements of the policy and rule framework. By this time Overseer® and Table 14.2 were significantly out of alignment, making it extremely difficult for intensive land use farmers and growers to meet the required CNLM targets. Around this time, it was becoming increasingly apparent that the policy framework was not working in the manner intended, with competing directive policies effectively rendering the restricted discretionary consenting pathway infeasible by continuously looping back to the requirement of meeting Table 14.2.

On the back of the Environment Court decision, Horizons decided to move forward with a Plan Change – PC2. The following three objectives are to be considered as part of PC2:

- Update the CNLM in Table 14.2 to reflect improvements in the nutrient modelling software tool Overseer®;
- Reinforce good management practices as part of IFLU activities; and
- Provide a workable pathway for landowners to apply for discretionary activity resource consent for IFLU activities that cannot achieve Table 14.2 cumulative leaching maximums.

2.2 Scope of WSP Report

WSP New Zealand, formerly Opus International Consultants, provides infrastructure, environmental, planning and advisory services across a wide range of government, regulator and private sector clients. WSP New Zealand incorporates a Primary Industries unit that specialises in advisory services to the New Zealand agri-sector through a team of experienced engineers, scientists and advisors, linked to a global network of WSP Global agricultural advisors.

WSP was engaged to provide the following services to Horizons regarding PC2.

As a first step, a review of prior reports and evidence prepared by other consultants and provided to WSP by Horizons was undertaken. This was followed by the development of a refined farm scale cost model for CVG and dairying that uses farm system changes as inputs to determine the scale of the impact of PC2. This work was built on the farm system changes modelled by others previously for Horizons (including for PC2) and, where gaps existed in their approach, WSP. The initial focus was on the effects on CVG which had the least information available, and then dairying in the catchments as defined by the One Plan using real data where available and estimated data was used where actual data was not available. WSP re-calculated the effects when GMP were applied, with GMP as defined by the GMP work conducted by Bloomer et al (2020) and Prof Dave Horne as provided at expert conferencing.

The WSP approach acknowledged that activities in the priority catchments are already regulated by the One Plan but intensive land use farmers/growers currently had no viable pathway to apply for resource consent if their activities exceeded the CNLM in Table 14.2.

The focus of WSP was to consider the economic implications for those IFLU activities in relation to the CNLM within recalibrated Table 14.2 as notified in PC2. These activities would either meet the recalibrated Table 14.2 enabling the controlled activity pathway, or require consent as discretionary activities, or satisfy the more recently tabled controlled activity pathway where BMP and a particular percentage drop on nitrogen leaching is applied.

The results of WSP farm scale cost and benefit modelling provides a view on the impact to applicants but also, when scaled up by hectareage data, on the extent of the combined productive areas in each District. This then provided inputs that fed into NZ Institute of Economic Research's (NZIER) District and Regional Scale Computable General Equilibrium (CGE) economic model.

WSP in addition has supported Horizons staff, their other advisors in considering submission points and attended pre-conferencing to explain modelling and test assumptions.

Based on this report, WSP will provide expert witness support, including appearing before the panel of independent commissioners on PC2 appointed by Horizons.

3 Basis of Our Analysis – Using a Hypothesis

Several land management techniques and systems are available to farmers and growers across a broad range of pastoral systems and crop types depending on the nature of the intensive land use. Even within the acknowledged limitations of Overseer® to model all land management scenarios accurately (explored later in this report) these land management practices can be modelled to a sufficient level of reliability to provide an effective method to make decisions on nutrient discharge from intensive land use activities.

It is demonstrated later in this report that each activity can be costed within a partial farm budget or crop gross margin analysis to show the impact on the net return from that crop. WSP have formed a view on capital expenditure and the impact on overall enterprise profitability and stability under the proposed plan change (PC2) while bearing in mind that these existing land uses already operate under a set of operative rules in the One Plan. The focus has been on the incremental impact of the plan change on existing land uses, not the impact of introducing regulation (a new plan) afresh or new land uses that fall under a different set of rules within the One Plan.

It is well known that there are several variables within the use of data for Overseer® that require a high level of operator expertise to produce acceptable outputs. Also, there are variations across farming enterprises in terms of ownership, indebtedness and scale, along with seasonal swings in growing conditions and market influences that all impact a business operator's decision making. Some enterprises own property while others lease land and others are a combination of both.

In modelling the impact of PC2 at farm-scale, the expectation to take account of these variables means a range in degree of impact is generated with a scale of sensitivity to practice changes rather than a single representative number for financial impact.

There is a risk of entrenched thinking when considering the impact of the regulatory change that considers a 'before' and 'after' situation that incorrectly assumes farmers and growers are not already regulated (in this case, under the One Plan). To avoid that entrenched thinking WSP adopted a hypothesis approach to gauge the significance of the changes required. It takes the form of a null hypothesis, i.e. assumes that the change proposed in PC2 will have little or no impact at farm level.

WSP considered the following propositions: -

The adoption of GMP or BMP that can meet the notified PC2 recalibrated Table 14.2 cumulated nitrogen leaching maximum figures, or approach it in a reasonable time scenario, when modelled at a farm financial level, and when rolled up to an accumulated district industry assessment than, have less impact than,

- c) the required farm practice and productivity changes necessary to meet the original Table 14.2 in the operative One Plan, and,*
- d) other natural variables and sensitives that impact a farming viability decision.*

Adopting GMP or BMP, therefore, should not negatively impact the district and those operating within it.

To test this hypothesis WSP have built a farm scale model (using Excel spreadsheets) and made changes in each input line that can be linked directly to notified PC2 but isolates out factors that are pre-existing such as level of indebtedness or enterprise costs that are not changed by the PC2 such as rates, insurance or minor land ownership costs. These costs are considered to exist regardless of the recalibration of Table 14.2 or amendment of policies.

WSP explains below that the hypothesis is almost consistently met across all farming types. Most operations will see a higher gross margin cost when compared to the enterprise changes need to meet the operative One Plan but will not necessarily become unprofitable enterprises, and that the cost is an acceptable impact when taking into account the environmental and community expectations to continue to operate.

Some farming operations are more significantly impacted than others by PC2 (when compared to the operative One Plan) but that is mostly due to some pre-existing farm business decisions. A proportion of farms may become unviable, and this is particularly the case where pre-existing high debt and thereby capital servicing is in place.

However, the sensitivity analysis shows that marginal operations are already highly sensitive to external variables such as market and climate swings.

4 WSP Modelling Approach

4.1 Introduction

WSP's scope was to develop a farm financial model to determine the impact of the practice changes that could occur on-farm to address the Table 14.2 requirements. In order to build a farm scale cost impact modelling platform, WSP initially considered an approach that relied in part on GMP details for CVG to be addressed in the Bloomer et al (2020) Overseer® modelling and report. Due to several factors this information was not available early in the WSP work program. Therefore, WSP were required to research and define what GMP and BMP for CVG and model these practice changes within Overseer®. From this work WSP were able to determine whether representative example crop rotation models would meet the recalibrated Table 14.2.

WSP have not completed detailed nutrient modelling of actual full CVG enterprises to the extent necessary to feed into the Horizons water quality modelling. This task was assigned to PDP and Page Bloomer Associates (Bloomer et al 2020). For their cost impact modelling, WSP have only undertaken a series of example crop rotation models that do not include an enterprise's total land management footprint and activities.

WSP applied their same farm scale cost impact model approach to look at the change factors as applied to dairying, and for consistency, used the previous reports by Parminter (2018a, 2018b, and 2018c) for source information on cost and benefits.

Through discussion with Horizons and other experts during the WSP work, it was decided that sheep and beef and arable intensive farming would be set aside from detailed enterprise cost modelling. They were considered as less significant elements in the Horizons priority catchments due to a) being of much smaller total land areas within those catchments and b) the changes in farm practices were less significant in comparison to dairying and CVG.

The practice changes that applied to sheep and beef had common elements from both dairying (minus effluent management) and CVG due to the irrigated cropping used on a grazing operation. The practice changes that could be adopted on an arable/cropping farm were considered to be parallel to elements of a CVG operation.

The modelling approach taken for sheep and beef and arable has been further discussed in Sections 7.4 and 7.5 of this report.

4.2 Component Parts of Farm Scale Impact Model Approach

Figure 4-1 represents the complexity of the inputs and outputs that have been considered by WSP. Effectively there are several interconnected models, with some able to be considered black boxes in that the workings are not necessarily fully understood across each contributing expert. Nonetheless, the outputs and data flow from one to the next can be considered sufficiently representative within the limitations of specific enterprise data availability and in the knowledge that the Resource Management Act (RMA) accepts that it might not be practical to model down to a feasible granularity.

The central element to the WSP farm scale cost impact modelling is the approach taken to quantify the practice changes in response to PC2 in an existing intensive land use operation. That cost model needs to cope with variability in background factors such as cost fluctuations, market sensitivities and consideration of the base or starting positions for analysis.

Prior to the cost model, the practice changes need to be well understood from a nitrogen leaching perspective and that is achieved using Overseer®, which is subject to variables in how operators take account of farm practice changes.

The outputs of the cost model feed forward in the overall regional scale economic modelling, being conducted by NZIER, which has its own variables and sensitivities to deal with.

All of these "black boxes" need to be considered in the context of the PC2 rules and options for controlled and discretionary pathway activities. As such the mapping of the WSP approach in diagrammatic form is complex, although Figure 4-1 helps to show the relative position of each consideration and the flow of information.

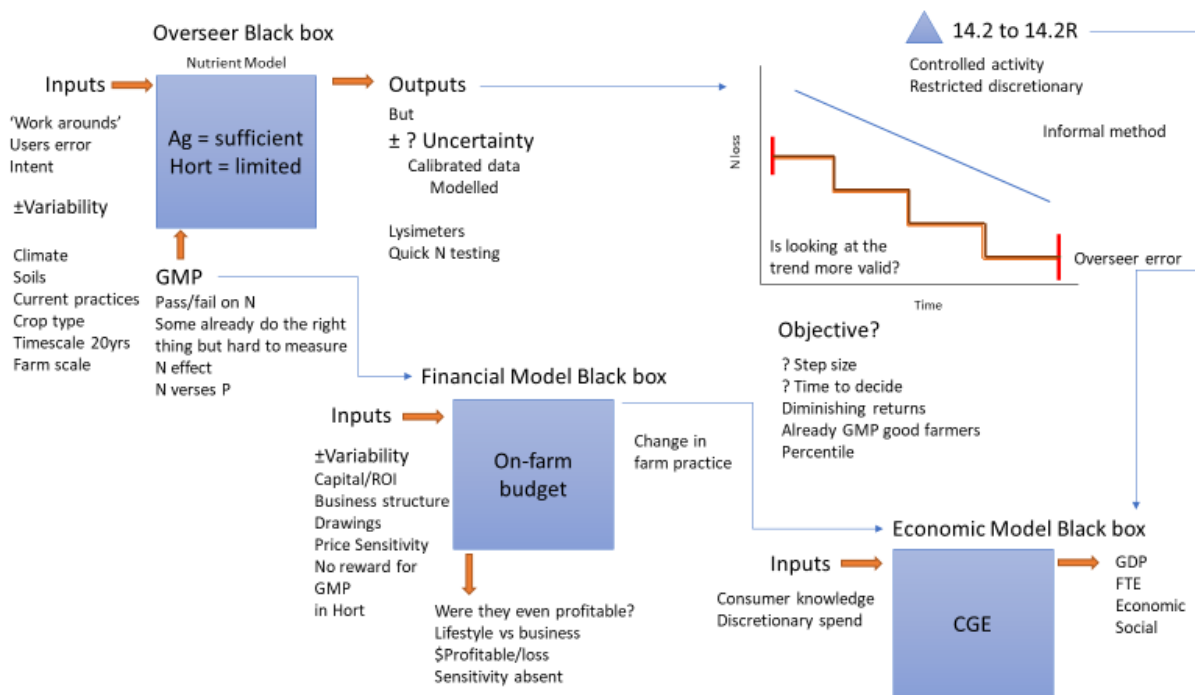


Figure 4-1 Schematic diagram of the complexity of the inputs and outputs that have been considered by WSP as part of their modelling approach.

4.3 Good Management Practices

A key part of PC2 is the emphasis on GMP. The term GMP has a range of definitions, however Horizons have defined it within PC2 as 'evolving practical measures and methods, including those established in industry-based standards, which are used at a sector or community level to minimise the effects of discharges to land and water'.

A number of practice changes can also be classified as BMP. There is no Horizons definition of BMP, however, BMPs are commonly understood to be a tier above GMP. BMP are deemed more costly as individual interventions and/or require a significant system change for adoption within the farming operation.

GMP and BMP Modelling

The adoption of practice change is an important part of achieving the outcomes of the PC2. However, practice change needs to be accounted for within the on-farm modelling.

Overseer®, the primary tool used to model nutrient loss, provides challenges when modelling GMP with a number of the simpler GMPs already taken into account within the model. In some cases, complex GMPs and BMPs can be modelled within Overseer® while others cannot. Those associated with fertiliser, irrigation, and change in cultivation practices, the use of catch crops and the adoption of GMPs or BMPs that reduce the effective area (such as controlled trafficking and buffer zones) can all be modelled to some degree.

However, questions are continuously raised around the accuracy of the Overseer® model when being used for CVG and the adoption of GMPs. In addition, the newer nitrogen mitigations such as using lower leaching summer fodder crops are presently unable to be modelled within Overseer®.

The implication of not all GMPs being modelled accurately leads to on-farm improvements being made with little to no modelled improvements being indicated in an Overseer® model. These limitations lead to uncertainty and difficulties for farmers and growers to meet Table 14.2 and therefore make the incentives for adoption of these practice changes more challenging but not insurmountable as there can be methods adopted to address the model's inherent limitations.

The GMPs adopted on-farm are the key measures that feed into the farm scale financial model. WSP defined several modelling stages for the possible management changes that could occur on IFLU operations. The stages were as follows:

- The change from no on-farm GMP to adopting available GMPs;
- The change from no on-farm GMPs to a mix of GMPs and BMPs;
- The adoption of just BMP; and
- The implications of adopting management changes that are considered innovations.

These stages allowed WSP to align the farm scale cost impact modelling to different pathways under PC2. WSP has modelled the financial costs for the first three points above.

It should be noted, the fourth stage of adopting innovations as they stand within current industry knowledge are outside the definition of GMP and BMP. It is WSP opinion that such mitigations could provide significant environmental improvements but at a considerable cost so have not been included in the modelling until further evidence of their effectiveness is able to be determined.

Defining Practice Change

A range of GMPs or BMPs can be adopted by any individual farmer or grower. However, the adoption of all GMPs or BMPs may not be suitable/practicable. For example, the system being run may not be suitable to specific GMPs, the ownership status of the land may not suit the adoption of certain GMPs or BMPs (i.e. capital input changes to leased land), and the system being run may not require the adoption of some GMPs or BMPs.

GMPs do not necessarily target a sole contaminant. Although many growers and farmers need to adopt GMPs targeting nitrogen loss in order to meet the requirements of Table 14.2, there are a range of GMPs that focus on phosphorus, sediment and/or *E. coli* losses which may or may not be adopted depending on consenting pathway options. There is also a group of GMPs that are likely to have an indirect effect on nitrogen loss (such as grass buffer strips), and therefore may be considered for adoption when considering options for meeting Table 14.2.

GMP and BMP identified in Table 4-1 and Table 4-2 below focus on reducing nitrogen either directly or indirectly, while GMPs in Appendix D highlight a range of practices that can be adopted for all key contaminants. For a discretionary consent to be granted, it is expected that a range of non-nitrogen GMPs will be adopted in addition to nitrogen targeting GMPs.

Most of the practices defined by WSP have already been outlined as a GMP or BMP in the Horticulture New Zealand Code of Practice for Nutrient Management 2014. Valuable inputs have also been provided to WSP by Dan Bloomer to get a better understanding of the work Page Bloomer Associates completed with a range of Levin vegetable growing operations. A significant local grower has also given their inputs for the purpose of this work. Finally, several GMPs and BMPs outlined in the NZGAP Farm Environment Plan template (2019) have been adopted as being suitable for Horowhenua commercial vegetable growers. The defined values of the required width of a grass buffer strip were identified in the Erosion and Sediment Control Guidelines for Vegetable Production (Barber, 2014).

WSP has taken the approach of defining an extensive list of GMPs and BMPs rather than keeping the list of options narrow. This approach has been used so that growers have a complete understanding of what Horizons may classify GMP or BMP and, therefore, what is required when growing vegetables within a priority catchment. To differentiate between a good or best management practice, GMP has been defined as a practice that a grower or farmer is already doing and if not, one that they should be doing if deemed suitable for their system. BMP has been defined as practice changes that either have a greater system impact, a greater financial cost to implement or maintain, are newer technologies, or similar to a GMP but more involved (such as different levels of soil testing for CVG).

Table 4-1 *GMP fed into Overseer® scenario models.*

1. GMP soil

- 1.1. *Minimise soil tillage as much as practicable*
- 1.2. *Minimise fallow periods between crops*
- 1.3. *Incorporate crop residual where possible*

- 1.4. *Planting of buffer strips at the bottom of each paddock (3 m)*
- 1.5. *Planting of buffer strips at the sides of each paddock (1.5 m)*
- 1.6. *Planting catch crops in between vegetable rotations*
2. **GMP nutrients**
 - 2.1. *Soil testing for base fertiliser every two years*
 - 2.2. *Soil testing for nitrogen at the beginning of each crop planting using quick N test*
 - 2.3. *Yearly deep N tests (600 mm) to determine the level of residual nitrogen remaining in the soil*
 - 2.4. *Matching soil testing results to plant requirements*
 - 2.5. *Split fertiliser application*
 - 2.6. *Using most suitable types of fertiliser for crops*
 - 2.7. *Applying fertiliser only where it is required, follow instructions for application, avoid waterways*
3. **GMP water and irrigation**
 - 3.1. *On site soil moisture monitoring is conducted on crops that require 'wet' soils*
 - 3.2. *Irrigation scheduling is tied in the soil moisture monitoring*
 - 3.3. *Irrigation is applied to maintain soil moisture between wilting point and field capacity where possible*
 - 3.4. *Irrigation applied allows achievement of the yield target for fertiliser applied*

Table 4-2 *BMP fed into Overseer® scenario models.*

4. **BMP soil**
 - 4.1. *Planting of buffer strips at the bottom of each paddock (6 m)*
 - 4.2. *Planting of buffer strips at the sides of each paddock (1.5 m)*
 - 4.3. *Use control trafficking where appropriate*
5. **BMP nutrients**
 - 5.1. *Soil testing for base fertiliser every year*
 - 5.2. *Soil testing for nitrogen before each side dressing for fertiliser using quick N test*
 - 5.3. *GPS monitoring all fertiliser applications: proof of placement*
 - 5.4. *Nutrient levels are managed and informed by soil tests to match rainfall/irrigation and yields*

For dairy farming systems, GMPs and BMPs have been provided to WSP by Prof. Dave Horne on behalf of Horizons. The GMPs taken into account for the financial modelling are highlighted in Table 4-3. The reference to cluster farms is explained in use of the source information adopted from Parminter (2018a, 2018b, and 2018c) where he examined the common dairying farm system types and produced an amalgamated farm scale cost model approach. WSP have adopted his base information and terminology in the modelling of the discretionary pathway impact modelling.

Table 4-3 GMP and the adoption by the cluster farms.

GMP List for Dairy Farms	<i>Cluster 1</i>	<i>Cluster 2</i>	<i>Cluster 3</i>	<i>Cluster 4</i>	<i>Cluster 5</i>
Effluent					
<i>Increase area</i>	x	x	x	x	x
<i>Remove nitrogen from effluent block</i>	x	x	x	x	x
Nitrogen Fertiliser					
<i>Apply in smaller amounts</i>	x	x	x	x	x
<i>Apply less nitrogen annually</i>	x	x	x	x	x
<i>Move applications from high risk months (April to August)</i>	x	x	x	x	x
Supplements					
<i>Use more lower crude protein supplements</i>	x	x	x	x	x
Crops					
<i>Reduce or remove area of summer crop</i>	n/a	x	n/a	x	x
<i>Change summer crop to lower leaching variety</i>	x	n/a	x	n/a	n/a
<i>Remove winter crops</i>	x	x	x	x	x
Animals					
<i>Increase grazing off over winter months</i>	x	x	x	x	x
<i>Cull cows more aggressively and earlier</i>	x	x	x	x	x
<i>Dry cows off earlier</i>	x	x	x	x	x
Irrigation					
<i>Improve scheduling with moisture monitoring</i>	n/a	n/a	n/a	x	n/a
<i>Modify trigger and target values</i>	n/a	n/a	n/a	x	n/a
<i>Apply less water</i>	n/a	n/a	n/a	x	n/a

4.4 Financial Impact Modelling

WSP has developed a farm scale cost impact model which has been used to demonstrate the financial implications of PC2 for intensive land uses; with changes applied to factors linked to GMP to determine the impact of the changes to the regulatory framework. The model method has particularly focused on CVG as that was the area least defined through the previous reports WSP reviewed. The model approach was also able to be applied to dairy land use changes. Irrigated sheep and beef and arable have been addressed below in Sections 7.4 and 7.5 of the report.

Four scenarios of the consent and financial impact of PC2 have been considered for new analysis or adoption of previous expert's approaches. The scenarios proposed by Horizons are outlined below:

- Baseline: Comply with the current Table 14.2 (controlled pathway)
- Scenario 1: Comply with the recalibrated Table 14.2 (controlled pathway)
- Scenario 2: Substantial compliance with the recalibrated Table 14.2, with remainder rapidly moving towards compliance with the table before year 20 (discretionary pathway)
- Scenario 3: Substantial compliance, with those not complying being on an improving trend towards the table before year 20 (discretionary pathway)

The model is not specific to individual properties or growers, rather it looks at generic systems which occur in the district.

The outputs of the farm financial model required by NZIER for their District and Regional scale CGE model include:

- Area of land (ha);
- Total production (kg);
- EBIT (\$/ha);
- Profit per unit area (\$/ha);
- Employment (number in dollar value);
- Fertiliser use (tonne/ha); and
- Percentage commercial vegetables in catchment.

The farm scale impact model input data for NZIER has, therefore, been assembled using the 2018 land use maps available through Horizons to multiply up the farm scale scenario to a district level. The NZIER 2019 database is then used to look down at district scales and production categories.

4.5 Commercial Vegetables

Overseer® Modelling

Due to restricted access being placed on the Bloomer et al (2020) Overseer® modelling until July 2020, in the course of developing this report, WSP developed their own set of Overseer® models (v6.3.2) using the best information available to it (Bloomer et al 2020, Clark 2019, O'Brien 2019, Reid and Morton 2019, and The Agribusiness Group 2014). These models were developed so that practice change could be identified, and the cost of those changes modelled. The developed models looked at eight different rotations (covering potatoes, onions, leafy greens, pumpkin and brassicas, typical of the Horowhenua production area) with the adoption of GMP and BMP. The specific crop rotations are highlighted in Appendix B. All rotations used come from Bloomer et al (2020).

Bloomer et al (2020) highlighted that practice change pre 2019 and post 2019 was modelled. WSP chose a different base year (original models) of 2014 based on when the One Plan became operative (December 2014). The difference in base years will impact the reduction in modelled nitrogen losses through the adoption of GMP and BMP.

The first set of completed models determined the nitrogen losses to water of eight crop rotations prior to any implementation of GMP. These scenarios have been labelled the 'original' crop rotations and can also be referred to as the base year. Once the original/base models were completed two modelling exercises were undertaken. Firstly, Overseer® models were completed looking at how a single change in GMP (Table 4-1) impacted the CNLM for an operation. Secondly, Overseer® models looking at how the implementation of all GMPs at a single time reduced nitrogen leaching. This exercise determined whether Table 14.2 could be met. The exercise was then repeated using

the adoption of suitable BMPs (Table 4-2). All assumptions associated with the Overseer® modelling are highlighted in Appendix C and an example of Overseer modelling is highlighted in Appendix E.

For each example crop rotation, the following approach was used:

- Model 1: Creating a baseline model in Overseer® to determine how the crop rotation aligns with the current Table 14.2 and the recalibrated Table 14.2;
- Model 2: Single practice change (e.g. fertiliser modifications) at GMP were fed into the baseline model (model 1) to determine how a single change element affected the crop rotation and the alignment with the current Table 14.2 and recalibrated Table 14.2 after farm practice refinement;
- Model 3: Single practice change (e.g. fertiliser modifications) at BMP were fed into the baseline model (model 2) to determine how a single change element affected the crop rotation and the alignment with the current Table 14.2 and recalibrated Table 14.2 after farm practice refinement;
- Model 3: GMPs (Table 4-1) were fed into the baseline model (model 1) simultaneously to determine how the crop rotation aligns with the current Table 14.2 and recalibrated Table 14.2 after farm practice refinement; and
- Model 4: BMPs (Table 4-2) were fed into model 2 simultaneously to determine how the crop rotation aligns with the current Table 14.2 and recalibrated Table 14.2 after additional farm practice refinement.

The change in cost of each of the inputs onto the farm budget were then used within the farm financial model to help quantify the cost of implementing GMP or BMP on a commercial vegetable property.

Review of Page Bloomer Associates Overseer® Models

On receiving access to the Bloomer et al (2020) Overseer® models, a comparison was undertaken between those and the work already completed by WSP. Several different approaches regarding crop yields and fertiliser application rates were noted and minor updates to the WSP models were made to reflect the differences and to ensure consistency across experts. However, in determining the extent of improvement possible in nitrogen leaching, the Bloomer et al (2020) Overseer® models had not adopted all possible GMPs. Bloomer et al (2020) focused on adopting the use of catch crops and the GMPs and BMPs associated with nitrogen fertiliser usage. The issue of different base years was also identified as part of the WSP review, specifically that WSP has used a base year prior to the One Plan becoming operative 2013/14, so the magnitude of improvements is greater than since 2019 as used by Bloomer.

Given the differences in base year and GMP adoption, the Bloomer et al (2020) models were not adopted within the WSP report and the WSP models were retained with some data being selectively updated to reflect Bloomer et al (2020), where it was appropriate (such as yields and GMP/BMP nitrogen fertiliser usage). WSP are aware the Bloomer report was reviewed by Plant and Food and his models updated to incorporate their feedback with the report being reissued.

4.6 Dairy Farms

Using previously completed work by Parminter (2018a, 2018b, and 2018c), five dairy systems (clusters of dairy system types) have been modelled to determine the farm financial impact of adopting dairy farm GMP. GMPs for dairy farming and the reduction in nitrogen leaching modelling has been defined and completed by Prof. Dave Horne for Horizons.

Table 4-3 highlights the individual GMPs suitable to reduce nitrogen leaching and whether an individual cluster has adopted the practice change.

WSP has not had a role in the development of the dairy farming clusters or the GMP list. WSP has taken the Parminter reports (2018a, 2018b, and 2018c) and used the data within the reports to cost the impact of GMP adoption.

5 Adoption of Practice Change and Subsequent Nitrogen Losses

Current literature quantifying nitrogen losses from commercial vegetable systems in New Zealand is limited relative to the extensive information available for pastoral systems, particularly dairy systems. The majority of commercial vegetable literature is based on work completed prior to 2003 and so may be out of step with current growing practices, though many points are likely still relevant today.

A key finding within the literature is that recovery of nitrogen fertiliser is low in commercial vegetable systems due to the sparse and poorly developed root systems of vegetable crops which decrease nitrogen use efficiency (Williams et al 2003). Therefore, while the use of nitrogen fertiliser is important for crop growth and meeting desired yields, over-fertilisation will greatly increase nitrogen losses (Williams et al 2003 and Crush et al 1997). Williams and Tregurtha (2003) determined that it was possible to reduce nitrogen fertiliser application rates to reduce nitrate leaching and improve environmental outcomes while still achieving the high yields desired by growers.

Several New Zealand studies undertaken between 1997 and 2003 concluded that fertiliser practices for growing vegetables were poor and needed to change to reduce the environmental footprint of commercial vegetable growers (Williams et al 2003, Williams and Tregurtha 2003, and Crush et al 1997). Their opinion was that if the following practices were adopted when growing vegetables, nitrogen losses would be significantly reduced:

- Fertiliser recommendations need to allow for residual nitrogen within the soil profile;
- Fertiliser management practices should be altered, including reduced rates and improved timing of applications;
- Cover crops should be used to retain nitrogen in the topsoil;
- Nitrogen budgets should be completed prior to planting; and
- Controlled-release fertiliser should be used when appropriate.

For vegetable growers, unlike pastoral farmers, the range of options to reduce nitrate leaching and improve nitrogen use efficiency is minimal and mostly associated with nitrogen fertiliser practices.

The recommendations that were stated two decades ago are now becoming the basis of GMPs for commercial vegetable growers. WPS consider that adoption of GMPs targeting nitrogen fertiliser applications can still maintain high yields while growers strive to meet Table 14.2 requirements.

5.1 Nitrogen Reductions from the Adoption of GMP or BMP in Commercial Vegetables

WSP's modelling shows that the predicted cumulative nitrogen leaching values for the original farm practices in 2013/14 ranged between 22 kg N/ha to 226 kg N/ha (Table 5-1 and Figure 5-1) for a range of brassica, intensive vegetable and potato crop rotations. Most of these values are well above CNLM values required for a controlled activity consent under the operative One Plan. Currently, Table 14.2 has a maximum allowable nitrogen loss of 25 kg N/ha on LUC class 1 land at year 20. The adoption of the recalibrated Table 14.2 would lead to the maximum allowable nitrogen loss increasing to 43 kg N/ha on LUC class 1 land (Appendix A).

Table 5-1 Original crop rotation nitrogen losses and the impact of adoption one GMP practice change at a time.

Crop rotation	N loss kg N/ha				
	Original	Fertiliser	Catch Crop	Reduced Area	Cultivation
potatoes	22	19	11	21	n/a
onions	95	84	61	90	n/a
cauliflower broccoli broccoli	220	123	195	216	222

cauliflower potato cauliflower	134	52	93	113	132
pumpkin cauliflower broccoli	226	159	n/a	215	216
spring onion spinach lettuce maize cabbage	103	46	34	101	102
oats lettuce cabbage spinach oats	160	n/a	148	n/a	n/a
oats lettuce cabbage maize	160	102	8	155	157
maize spinach lettuce spring onion oats	116	n/a	108	n/a	n/a
maize spinach lettuce spring onion cabbage	116	37	119	111	117

Note: n/a means the practice change has not been applied

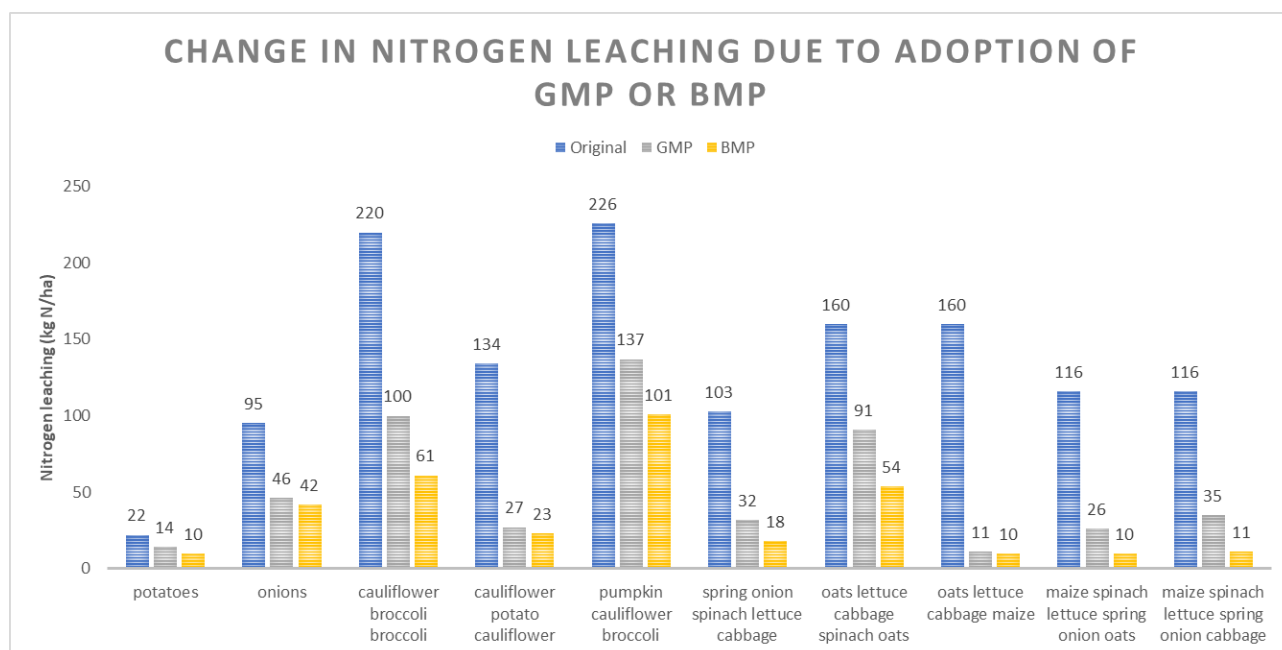


Figure 5-1 A comparison in nitrogen leaching losses value due to the adoption of GMP or BMP.

The Addition of Good Management Practice

The GMPs that can be modelled in Overseer® are driven by four key inputs (practice changes) –fertiliser, catch crops, reduction in effective area and cultivation method. As shown in Table 5-1, Table 5-2 and Figure 5-1 individual practice changes can reduce nitrogen losses to water. However, most of the reductions were not significant enough to meet the requirements of Table 14.2 either with the current CNLM or with the recalibrated CNLM. The adoption of a number of practice changes is required to meet the nitrogen requirements associated with a controlled activity consent under Table 14.2. An additional break down of practice change impact on nitrogen loss to water has been provided in Appendix F.

The adoption of the GMPs highlighted in (Table 4-1) resulted in a significant reduction of cumulative nitrogen leaching for all crop rotations. The magnitude of the reduction in nitrogen leaching is dependent on the magnitude of practice change and how much the practice impacted on original nitrogen loss e.g. removing winter nitrogen has a far greater impact on reducing nitrogen losses than removing spring nitrogen applications. This is due to lower soil temperature, less plant growth and more drainage events during the winter months. Reductions varied anywhere between 36-94% for the adoption of GMP (Table 5-3). The adoption of GMP when growing lettuce and cabbages saw the greatest reduction in nitrogen loss, while the adoption of GMP when growing potatoes saw the lowest reduction of nitrogen loss. However, it was still considered significant at 36%. The lettuce cabbage rotation resulted in the largest reduction because two catch crops were added into this rotation. Oats filled a fallow period at the beginning of the rotation while spinach was substituted for maize. The substitution of a leafy green crop, which requires high nitrogen inputs to a maize crop which has the potential to remove large amounts of nitrogen, has been shown in the WSP modelling to impact on the nitrogen loss number greatly.

If a grower only had LUC class 1 land, two of the different rotations have nitrogen leaching values that would meet the original Table 14.2 while four additional rotations would be able to meet the recalibrated Table 14.2. This leaves four

rotations unable to meet either the current or proposed nitrogen loss allowance. When adopting a 20% margin of error (the accepted margin of error of Overseer® (Parliamentary Commissioner for the Environment, 2018)) within the Overseer® model, two more rotations would be able to meet Table 14.2 and one rotation would be able to meet the recalibrated Table 14.2 (Table 5-3).

As LUC decreases (i.e. higher LUC number) the nitrogen allowance decreases according to Table 14.2 of the One Plan. From this, when the LUC class changes from 1 to 2, two of the different rotations have nitrogen leaching values that would meet the original Table 14.2, while four additional rotation would be able to meet the recalibrated Table 14.2. This leaves four rotations unable to meet either the current or proposed nitrogen loss allowance. When adopting a 20% margin of error within the Overseer® model, no additional rotations would be able to meet the current or recalibrated Table 14.2 (Table 5-3).

The dominant LUC classes for commercial vegetable growers in Horowhenua are LUC classes 1 and 2, however, there are some areas of LUC class 3 land being used for commercial vegetables. Therefore, on class 3 land, two of the different rotations have nitrogen leaching values that would meet the original Table 14.2, while two additional rotations would be able to meet the recalibrated Table 14.2. This would leave six rotations unable to meet either the current or proposed CNLM allowance. When adopting a 20% margin of error within the Overseer® model, two more rotations would be able to meet the recalibrated Table 14.2.

The Addition of Best Management Practice

When BMPs are applied, additional reductions in cumulated nitrogen leaching has been observed. The practice changes modelled are outlined in Table 4-2. Reductions varied anywhere between 55-94% for the adoption of BMP (Table 5-3). Key practice changes were a change in nitrogen fertiliser usage, the addition of wider buffer zones and controlled trafficking. These changes lead to modification in fertiliser inputs and the effective cropping area in Overseer® and are, therefore, adequately represented in the Overseer® model.

If a grower only had LUC class 1 land, six crop rotations have nitrogen leaching values that would meet the original Table 14.2 while one additional crop rotation would be able to meet the recalibrated Table 14.2. This leaves three rotations unable to meet either the current or proposed CNLM allowance. When adopting a 20% margin of error within the Overseer® model, no additional rotations would be able to meet the current or recalibrated Table 14.2.

If a grower only had LUC class 2 land, five crop rotations would have nitrogen leaching values that meet the original Table 14.2, while one additional crop rotation would be able to meet the recalibrated Table 14.2. This leaves four rotations unable to meet either the current or proposed CNLM allowance. When adopting a 20% margin of error within the Overseer® model, one more rotation would be able to meet the current or recalibrated Table 14.2.

If a grower only had LUC class 3 land, five crop rotations would have nitrogen leaching values that meet the original Table 14.2, while one additional crop rotation would be able to meet the recalibrated Table 14.2. This leaves four rotations unable to meet either the current or proposed CNLM allowance. When adopting a 20% margin of error within the Overseer® model, no additional rotations would be able to meet the current or recalibrated Table 14.2.

Table 5-2 Original crop rotation nitrogen losses and the impact of single BMP practice changes.

Crop rotation	N loss kg N/ha				
	Original	Fertiliser	Catch Crop	Reduced Area	Cultivation
<i>potatoes</i>	22	19	n/a	18	n/a
<i>onions</i>	95	84	n/a	75	n/a
<i>cauliflower broccoli broccoli</i>	220	97	n/a	178	n/a
<i>cauliflower potato cauliflower</i>	134	37	n/a	94	n/a
<i>pumpkin cauliflower broccoli</i>	226	137	n/a	178	n/a
<i>spring onion spinach lettuce maize cabbage</i>	103	43	n/a	82	n/a
<i>oats lettuce cabbage spinach oats</i>	160	n/a	n/a	n/a	n/a
<i>oats lettuce cabbage maize</i>	160	84	n/a	126	n/a

<i>maize spinach lettuce spring onion oats</i>	116	n/a	n/a	n/a	n/a
<i>maize spinach lettuce spring onion cabbage</i>	116	14	n/a	92	n/a

Table 5-3 The effect of GMP and BMP on different crop rotations and LUC category.

Crop rotation	LUC 1 GMP					LUC 1 BMP			
	Original	GMP	% Reduction	BMP	% Reduction	Table 14.2	Table 14.2 R	Table 14.2	Table 14.2 R
potatoes	22	14	36	10	55	Y	Y	Y	Y
onions	95	46	52	42	56	N	N	N	Y
cauliflower broccoli broccoli	220	100	55	61	72	N	N	N	N
cauliflower potato cauliflower	134	27	80	23	83	N	Y	Y	Y
pumpkin cauliflower broccoli	226	137	39	101	55	N	N	N	N
spring onion spinach lettuce maize cabbage	103	32	69	18	83	N	Y	Y	Y
oats lettuce cabbage spinach oats	160	91	43	54	66	N	N	N	N
oats lettuce cabbage maize	160	11	94	10	94	Y	Y	Y	Y
maize spinach lettuce spring onion oats	116	26	78	10	91	N	Y	Y	Y
maize spinach lettuce spring onion cabbage	116	35	70	11	91	N	Y	Y	Y

Crop rotation	LUC 2 GMP				LUC 2 BMP			
	Original	GMP	BMP		Table 14.2	Table 14.2 R	Table 14.2	Table 14.2 R
potatoes	22	14	10		Y	Y	Y	Y
onions	95	46	42		N	N	N	N
cauliflower broccoli broccoli	220	100	61		N	N	N	N
cauliflower potato cauliflower	134	27	23		N	Y	N	Y
pumpkin cauliflower broccoli	226	137	101		N	N	N	N
spring onion spinach lettuce maize cabbage	103	32	18		N	Y	Y	Y
oats lettuce cabbage spinach oats	160	91	54		N	N	N	N
oats lettuce cabbage maize	160	11	10		Y	Y	Y	Y
maize spinach lettuce spring onion oats	116	26	10		N	Y	Y	Y
maize spinach lettuce spring onion cabbage	116	35	11		N	Y	Y	Y

Limitations of the Modelling

The Overseer® modelling undertaken to determine the impact of GMP, and BMP adoption has several known limitations that need to be taken into consideration when reviewing this report.

At the outset, the Overseer® modelling presented in this report and appendices is not considered appropriate to be used for catchment scale water quality modelling as it represents a snapshot of nitrogen improvements through the adoption of GMP and BMP. The WSP Overseer® models were developed to support the farm scale cost impact model and while they provide useful insight into the ability of growers to comply with Table 14.2 in certain circumstances, the modelling is not intended to be in-depth or representative enough for use within the water quality modelling. The information to support water quality modelling was undertaken by PDP and Page Bloomer Associates (Bloomer et al 2020).

The modelling is not looking at an overall individual property, or enterprise combining several properties, but rather models nitrogen losses for a selective group crop rotation examples that commonly occur on CVG operations in Horowhenua. Modelling rotations results in a nitrogen loss value for each specific rotation being modelled. These values may produce higher or lower nitrogen losses outcomes compared to that of modelling the nitrogen loss from a whole property or total enterprise, which is required for consent applications.

Property scale modelling when undertaken as part of a consent application (where full disclosure of all aspects of the enterprise are made available) provides a single nitrogen loss value for the entire property irrespective to how many rotations are present and compared to Table 14.2.

It should be noted that crop rotations are highly influenced by market forces, seasonal changes and abnormal events (e.g. a population explosion of hares eating out hectares of seedlings) so attempting a specific operational system model would likely produce output data that can vary significantly between years.

When considering a full enterprise nutrient model where all information is available, crop rotations that leach lower levels of nitrogen can be used to offset rotations that leach higher levels of nitrogen. There is also the option of implementing mitigations or innovations which are outside the definition of GMP and BMP. Such mitigations could provide significant environmental improvements but at a considerable cost. These include:

- Nitrogen removal through a constructed wetland;
- Removing high nitrogen leaching crops out of the priority catchments; and
- Retirement of 'unsuitable' land such as LUC class 3 and above.

It is WSP opinion that such mitigations could provide significant environmental improvements but at a considerable cost so have not been included in the modelling until further evidence of their effectiveness is able to be determined.

The limited number of soil types that could have been used within the WSP Overseer® modelling was contemplated. Within the Horowhenua region several soil types are present and all of them have different nitrogen leaching potentials. The decision to use only two soil types within the models was to ensure consistency between the WSP outputs and Bloomer et al (2020).

6 The Nitrogen Shift

Prior to adoption of the One Plan, it was reported by others that nitrogen levels within the priority catchments were at critical levels leading to significant water quality degradation. Table 14.2 within the One Plan was designed to see reductions in nitrogen losses from intensive land uses across 20 years and, therefore, assist in progressing towards the achievement of the maintenance and enhancement of water quality. One of the features of Table 14.2 was the nitrogen allowances moving incrementally down at each of the associated time interval (years 1, 5, 10 and 20).

The CNLM were set by reference to GMP as then understood (Dr Monaghan's evidence 2009 One Plan hearings) and that if those practices were adopted, and some are better known as BMP today then Table 14.2 would be achievable by most farmers.

When the adoption of any change in farming practice is required by implementation of legislation there is normally a bell shape curve that represents the rate of adoption. It reflects those that are early adopters (maybe those best placed to take risks), the bulk sitting in the middle of the curve with often a conservative view but acceptance of the need for change, followed by the slow adopters or laggards, some of whom may never change due to capacity or attitude.

Regulations may provide additional benefit farming or growing operations, the environment and the community acceptance, often by pointing at those who are laggards in adopting change. The biggest gains are however generally achieved by shifting the middle of the bell curve to the right as soon as possible and with the maximum adoption of positive changes. This shift can be modelled off the success and leadership shown by the early adopters. If the laggards do not adopt the changes that are required (or cannot due to their system not being suitable for the given location) it may as a consequence be the case that they become non-viable and exit from their current land use.

Shifting the bell curve to the right results in both positive and negative impacts on any farming operation. Key positives include the adoption of GMP (and in some cases BMP), and the granting of a resource consent which provides a farmer or grower certainty around their operation. Further, the reductions of nitrogen losses on farm is anticipated to lead to long-term improvements on water quality.

With any induced change negative aspects can result. For the earlier adopters and the bulk of the curve, the key negative from the adoption of GMP, and other contaminant loss mitigations, will be the cost associated with the change.

If landowners choose not to proceed with changes in practice or do not apply for a resource consent under the One Plan, costly enforcement action may result, the value of the property could decrease due to being unconsented, or the property could exit from being an intensive land use.

7 The Financial Numbers

In this section the farm scale cost impact results arising from WSP farm systems analysis are set out. The work has been completed based on a set of assumptions that help define the approach, as well as the limitations that exist in trying to quantify the impact of the PC2 changes. The impact scenarios that need to be considered occur across highly diverse land uses where multiple variables exist between enterprises. These could be the way they are structured financially, prior decisions that may already be affecting their viability, and the daily changes that impact farming decisions within vagaries of markets and natural climate variables.

Any modelling theory needs to be accepted as representative of the 'real world' but based on scenarios and benchmarks that give it validity even though it still needs caution in application to all the unique landowner's situations.

There are however a number of previous studies (The Agribusiness Group, 2017, NZIER 2018, and Parminter 2018a, 2018b and 2018c) that have applied generally accepted practices in respect to cost impact modelling. WSP consider that its approach provides more robust cost impact modelling by thoroughly stating assumptions and taking account of sensitivity to cost fluctuation trends when extrapolating 1 or 2 year budgets across a 20 year period.

7.1 A Modified Gross Margin Approach

A gross margin looks at the direct costs and returns for a particular crop or mix of crops and calculates a net cost/benefit of change i.e. revenue less operational costs. This type of approach is more commonly termed a partial farm budget and is used to compare options when making decisions on future farming practices.

Generally, gross margin is a short term (1 to 2 years) cost benefit model that needs to be stacked end to end or in parallel for a whole of enterprise assessment over a longer term.

A gross margin approach does not normally consider business operating expenses (overheads) that are independent to the process of growing and selling the crop. Nor does it consider the farm asset ownership structure or business operating overhead costs such as interest, capital (expenditure or depreciation) and minor items like insurance and rates.

A modified gross margin approach is needed to determine the cost of change in a way that also considers the necessary capital investments, such as tractors or land improvements, that are associated with the adoption of GMP or BMP. For the purpose of this cost impact assessment these capital items have been amortised over the life of the asset and brought into a Net Present Value (NPV) calculation as an annual cost.

WSP is aware that for some operations, enterprise specific overhead costs are significant (especially debt servicing) but for the purpose of this exercise these are considered independent of the implementation of PC2.

While overall capital value may be substantial, as stated above, only the increase in capital has been considered in the costs of change. If money needed to be borrowed where new capital outlay was required, this may add to existing debt servicing.

Based on available industry information, prior work done by others and specific operational information obtained during the course of the WSP work program we have been able to estimate overall enterprise profit margins that take into account additional overheads. For the purposes of establishing the context of the calculated cost of change NPV these figures have been compared to estimated enterprise profitability. This is an acceptable means of investigating the magnitude of impact of a regulatory system change such as the notified PC2.

There is an understanding that some farming enterprises rely on capital gains to improve their debt to equity ratios. This capital gain is often a significant benefit when facing a downturn in profitability. However, other than a lending benefit to increase equity to debt ratio, capital gain realisation is only possible on sale of the enterprise. The capital value of an enterprise is normally a multi-faceted calculation, which includes the extrapolation of the likely profitability over time and an assessment of the likely alternative use of the land for some other activity if it was sold. This alternative activity may be significantly different to the current food production enterprise. In other regions of New Zealand, for example, there has been a change to housing developments which has skewed rural land values.

The underlying value of food production capacity is an important factor to remember; loss of productive land and the loss of opportunity to use high class soils is subject to current legislative review outside of this plan change.

The focus in WSP modelling has, therefore, been limited to making assessment of factors within production systems directly influenced by PC2, with a focus on cumulated nutrient leaching reduction.

7.2 Commercial Vegetables

Commercial Vegetable Methodology

The farm scale impact modelling focus commenced with addressing CVG. The review of prior reports (The Agribusiness Group, 2017, NZIER 2018, Ridler 2018, and Horizons Regional Council 2019) was undertaken to get an understanding of the issues and what work has been completed to date. Commercial vegetable growing cost impact modelling was an area identified as benefiting from further attention following the receipt of submissions on PC2. Horizons Regional Council had also by that time agreed a process by which it could access CVG information to assist in further modelling.

There are significant complexities in identifying a representative CVG operation due to multiple crops available for an enterprise to grow. An example of this is one large operation having 23 discrete crop types currently produced across a substantial land area both within and outside the defined sensitive priority catchments. These range from the tried and true leafy greens and brassicas, through to emerging culinary herbs and new types of crops deriving from changes in market demographics (such as bok choy). The choice of which crop to grow may change within weeks depending on the subtleties of the market consumer preferences, climate events and other external factors. A gross margin represents the critical cost and return elements underlying a CVG enterprise built on a set of possible crop rotation examples. For WSP models we have aligned the gross margins to the 2 year cycles that have been represented in the Overseer® output reports produced by Dr Jolly. As each rotation generates a different profit level and is influenced differently by the adoption of GMPs and BMPs we have averaged the gross margin outputs to better produce a CVG district that has multiple and varied cropping patterns.

As highlighted above, WSP explored a typical set of example rotations of vegetable crops, based on Bloomer et al (2020), and WSP's own knowledge of the CVG sector. Not all vegetable crops typically grown are able to be modelled in Overseer® but there are sufficient examples that can be modelled that have been used to inform a cost of change viewpoint. However, when selecting crop rotations to model in the gross margin analysis, WSP did their best to specify crops that could be modelled in Overseer®. All but two (pumpkin and spring onions) could be directly modelled.

In the gross margin approach some features of crop production were assessed as being less sensitive to changes in management practices, such as agri-chemicals when compared to highly correlated elements such as fertiliser costs. Therefore, the key focus of this work has been on features that can be varied in alignment with Overseer® nitrogen modelling; i.e. fertiliser expenditure, cropped areas, nutrient budget planning and monitoring, change in cultivation practices, labour inputs, and crop sales (yield x sale price).

The farm cost models compared the 2014 base year practices to the cost of change through GMP or BMP adoption within each change in practice. The model looked at change in revenue arising from changes in practice, i.e. less/more yield arising from cropped area or management interventions such as catch crops that became saleable items. One-off capital items that were required to implement management practice changes have also been accounted for, e.g. upgraded mechanisation, land improvements such as grassed boundary strips and fertiliser sheds to reduce wastage.

In parallel with a two-year Overseer® model, a two-year repeating cycle across 20 years has been applied to each rotation, for an NPV at 6% discount rate. The modelling process and input data has been tested against limited grower derived data for CVG as the New Zealand CVG sector was reluctant to engage.

Total enterprise cost of capital was not modelled, although it is likely some enterprises are highly geared and, therefore, vulnerable to additional costs, especially smaller vegetable production blocks and some dairy farms. The total level of debt has not been considered as attributable to PC2, except for the capital expenditure associated with the change practices. This capital outlay was treated as an annualised cost through the NPV analysis.

Sensitivity analysis has been applied across line items in the gross margins to account for variability within systems; an expected typical range has been adopted of, 10% on operational and capital costs, 12.5% on yield (based on seasonal growing degree days (GDD) assessment (Figure 7-1)), 25% on sale prices (based on long term records from Lincoln University Financial Budget Manual 2018, Askin and Askin 2018).

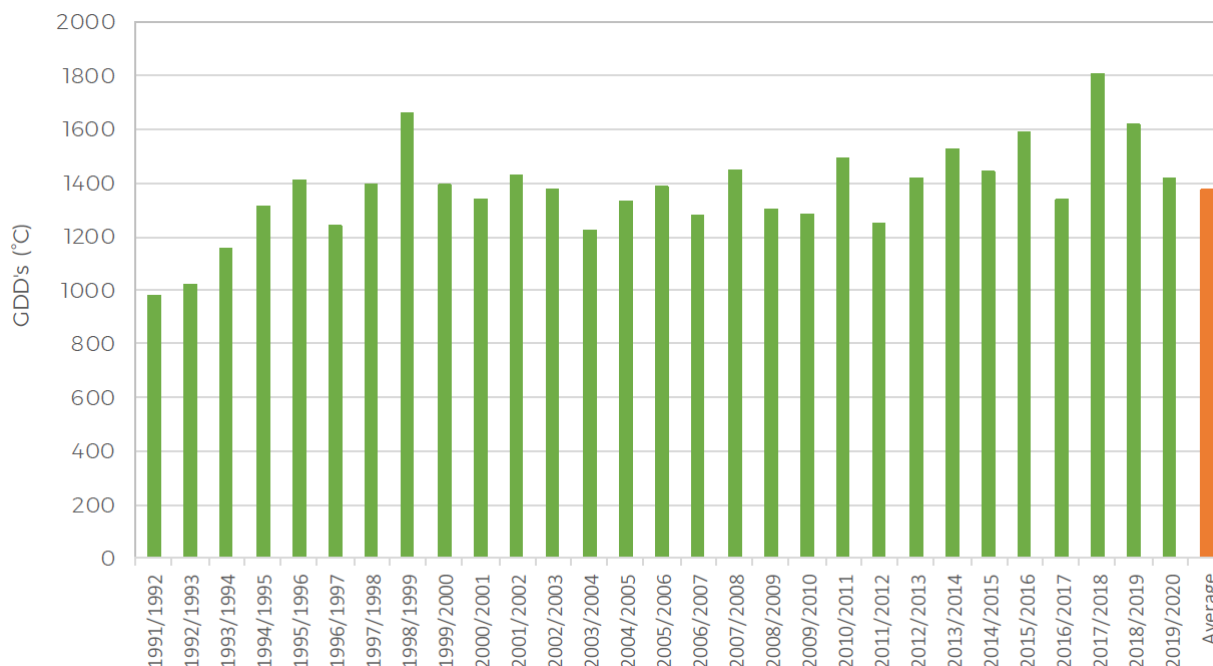


Figure 7-1 Annual Growing Degree Days (10°C) in the Levin area based on the air temperature recorded at Levin AWS for the period Jan 1991 to May 2020 (analysis completed on growing season 1 July to 30 June).

Commercial Vegetables Findings and Discussion

Sensitivity was modelled using the @RISK software tool. @RISK (pronounced “at risk”) is an add-in to Microsoft Excel analyses risk variables using Monte Carlo simulation. @RISK shows virtually all possible outcomes for any situation — and ranks how likely they are to occur. This allows demonstration of which element the enterprise is most sensitive to. The model makes over 10,000 comparison of combinations of each variable within prescribed standard deviations against all the line items. These are then distributed around a base NPV. “Tornado” graphs are plotted allowing a visualisation of what variable has the greater impact on NPV (Figure 7-2).

The sensitivity analysis revealed variations for each rotation but generally was most sensitive to yield and revenue, not cost of change practices. Exceptions were where gross margins are low and cost of changed practices were most significant.

A feature of smaller CVG operations is the sale price. Anecdotally these growers are more likely to sell at farmer’s markets where close to retail prices is obtained. This is compared to larger commercial operations which are pinned down to accepting wholesale prices. Lower sales at higher prices was likely to be an upside for these smaller enterprises however their limited ability to finance changes, especially BMP capital investment, becomes more difficult to achieve.

If growers were required to meet the recalibrated Table 14.2 through the adoption of GMP and/or BMP, seven out of ten rotations modelled would be able to achieve this (Table 5-3). Based on this modelling data, the financial implications of adopting practice change are highlighted in Table 7-1. When looking at the discretionary pathway all rotations would be able to apply for consent with the financial implications being less compared to being forced to meet the recalibrated Table 14.2 (Table 7-2).

Typically, the overall cost impact of change (as a 20-year NPV) is in the order of \$2000/ha reduced profitability when viewed against an approximate enterprise margin of \$6,613 to \$13,226 (5-10%).

Importantly, in the context of this plan change the cost of meeting the current Table 14-2 which had even lower CNLM would have required more substantial farm changes including reduction in overall productivity to get to point of compliance or transition out of that land use.

Table 7-1 Commercial vegetables financial summary for the growers required to meet the recalibrated Table 14.2 (controlled pathway).

CVG Scenario 1	ha	NPV \$/ha/yr	Revenue \$/ha/yr	Margin ~@5%	Margin ~@10%
Horowhenua district (106,400 ha)					
potatoes (identified ha)	85	-\$761	\$41,852	\$2,093	\$4,185
onions		-\$2,174	\$37,802	\$1,890	\$3,780
Average		-\$1,468	\$39,827	\$1,991	\$3,983
Potato onion average		-124,738	3,385,295	\$169,265	\$338,530
cauliflower potato cauliflower		-\$2,610	\$142,467	\$7,123	\$14,247
spring onion spinach lettuce maize cabbage		-\$1,656	\$140,130	\$7,007	\$14,013
maize spinach lettuce spring onion oats		-\$1,465	\$124,333	\$6,217	\$12,433
maize spinach lettuce spring onion cabbage		-\$1,678	\$135,537	\$6,777	\$13,554
oats lettuce cabbage maize		-\$1,071	\$105,414	\$5,271	\$10,541
pumpkin cauliflower broccoli	Does not meet Table 14.2				
cauliflower broccoli broccoli	Does not meet Table 14.2				
oats lettuce cabbage spinach oats	Does not meet Table 14.2				
Average		-\$1,685	\$129,576	\$6,479	\$12,958
Other CVG average (mapped ha)	460	-\$775,008	\$59,605,052	\$2,980,253	\$5,960,505
Average for district CVG ha	545	-\$899,746	\$62,990,347	\$3,149,517	\$6,299,035

Number of hectares for CVG comes from WSP developed map (Appendix J). Example gross margin Appendix G.

Table 7-2 Commercial vegetables financial summary for the discretionary pathway.

CVG Scenario 3	ha	NPV \$/ha/yr	Revenue \$/ha/yr	Margin ~@5%	Margin ~@10%
Horowhenua district (106,400 ha)					
potatoes (identified ha)	85	-\$761	\$41,852	\$2,093	\$4,185
onions		-\$1,095	\$38,671	\$1,934	\$3,867
Average		-\$928	\$40,262	\$2,013	\$4,026
Potato onion average		-\$78,880	\$3,422,228	\$171,111	\$342,223
cauliflower potato cauliflower		-\$2,610	\$142,467	\$7,123	\$14,247
spring onion spinach lettuce maize cabbage		-\$1,656	\$140,130	\$7,007	\$14,013
maize spinach lettuce spring onion oats		-\$1,463	\$124,333	\$6,217	\$12,433
maize spinach lettuce spring onion cabbage		-\$1,678	\$135,537	\$6,777	\$13,554
oats lettuce cabbage maize		-\$1,071	\$105,414	\$5,271	\$10,541
pumpkin cauliflower broccoli		-\$2,649	\$127,172	\$6,359	\$12,717
cauliflower broccoli broccoli		-\$2,730	\$155,906	\$7,795	\$15,591
oats lettuce cabbage spinach oats		-\$2,017	\$127,148	\$6,357	\$12,715
Average		-\$1,978	\$132,263	\$6,613	\$13,226
Other CVG average (mapped ha)	460	-\$909,650	\$60,841,153	\$3,042,058	\$6,084,115
Average for district CVG ha	545	-\$988,530	\$64,263,380	\$3,213,169	\$6,426,338

7.3 Dairy Farms

The same modified gross margin approach has been adopted for dairy, but system changes were based on the five clusters highlighted in Parminter (2018b and 2018c). These clusters were previously “driven” to Table 14.2 predominantly by dropping animal stocking rates by culling cows. By putting the stocking rates back to “normal” levels, WSP was able to model the discretionary pathway only by adopting the GMP in Table 4-3. A one-year repeating cycle across 20 years has been used for NPV at 6% discount rate. Like that with CVG, total enterprise cost of capital was not modelled, although it is likely some enterprises are highly geared and, therefore, vulnerable to additional costs.

Through discussions with Terry Parminter on his earlier reporting, WSP established that the cluster approach has only been developed and used in the Upper Manawatu priority sub-catchments. It has been agreed through discussion with Assoc Prof Dave Horne and Mr Parminter suitable to apply to other priority sub-catchments in other districts of the Horizons region, so long as the variances around unquantified effects of the different soil types and different climate zone are acknowledged. The most significant area that differs from the original work (Parminter, 2018c) has been identified as the Manawatu sand country. As such, the cost of change modelling in this area is conservative. The other areas are smaller relative to the original work of Parminter (2018c). In the financial summary provided to NZIER, the percentage change is, therefore, the same across all districts but the magnitude of cost is of course multiplied by the area (ha) of dairy farms in each district.

The cost benefit was variable across the five clusters but was negative in all cases (Table 7-3). It should be noted that the earlier work (Parminter, 2018c) that drove enterprises to Table 14.2 show that major impacts were necessary on dairy farms that included substantial reduction in herd numbers as a means to meet the CNLM limits.

The introduction of the PC2 amendments means a more favourable position arises from a lower cost impact, with higher net profitability for the discretionary pathway to get to a point of compliance without needing to transition out of that land use.

One objective with farming other than cashflow is capital gains. Capital value is proportional to net production returns, so a higher return helps hold enterprise value and leads to more favourable lending ratios. For some enterprises with high existing debt this may still leave them in a vulnerable position. Dairy farmers are likely to be highly sensitive to solvency issues due to pre-existing debt servicing.

Table 7-3 Dairy farming financial summary for discretionary pathway.

<i>Dairy</i>	<i>ha</i>	<i>NPV \$/ha/yr</i>	<i>NPV, cluster \$/yr</i>	<i>Revenue \$/ha/yr</i>	<i>Revenue, cluster \$/yr</i>	<i>Base enterprise margin \$/ha/yr</i>
Tararua district (436,100 ha)	58,656					
<i>cluster 1 20% of dairy ha</i>	11731	-\$274	-\$3,214,349	\$5,594	\$65,624,333	\$1,934
<i>cluster 2 10%</i>	5,866	-\$46	-\$269,818	\$6,746	\$39,569,338	\$2,387
<i>cluster 3 15%</i>	8,798	-\$89	-\$783,058	\$5,536	\$48,707,942	\$1,293
<i>cluster 4 10%</i>	5,866	-\$134	-\$785,990	\$7,181	\$42,120,874	\$2,407
<i>cluster 5 45%</i>	26,395	-\$73	-\$1,926,850	\$5,376	\$141,900,595	\$1,533
Average (weighted /ha)		-\$119		\$5,761		\$1911
Average of dairy 58,686 ha			-\$6,980,064		\$337,923,082	\$112,091,616
Manawatu district (262,400 ha)	20,013					
Average of dairy 20,013 ha			-\$2,381,547		\$115,296,894	\$38,244,843
Horowhenua district (106,400 ha)	5,066					

Average of dairy 5,066 ha		-\$602,854	\$29,185,733	\$9,681,126
Rangitikei district (447,900 ha)	8,342			
Average of dairy 8,342 ha		-\$992,698	\$48,059,096	\$15,941,562

Number of hectares for dairy comes from WSP developed map (Appendix K). Example gross margin Appendix H.

7.4 Irrigated Sheep and Beef

The sheep and beef farm cost modelling are parallel to the dairy operations where similar farm practice changes around fertiliser and land use occur. The exception is not dealing with farm dairy effluent on sheep and beef farms.

Irrigated sheep and beef land area was discussed during expert caucusing and the areas recorded as likely to be farmed in this intensive manner (Appendix L) are in the order of 440 ha, after counting just the irrigated land within larger sheep and beef farms (that does not include 50 ha of municipal effluent). In discussion with Beef and Lamb experts, if a nitrogen loss model was built across a whole sheep and beef enterprise i.e. including the low intensity areas as well as the small intensive irrigated block, it was estimated they would likely be under recalibrated Table 14.2. If the focus was just on the irrigated block, then with any system changes to improve nitrogen loss spread across the whole enterprise budget the cost impact would be small. Therefore, taking a small area (in the order of 440 ha) multiplied by small impact it is suggested the overall impact was minor in relation to dairy and CVG.

7.5 Arable/Cropping

The areas of arable are also low within the priority catchments (Appendix M). The practice changes around planting and managing crop production for arable/cropping farms are similar to the CVG sector, particularly in relation to land management techniques such as fertiliser management, cultivation practices, and cropped land versus enterprise size.

Within the assessment of economic impact of the costs of change the inputs to a wider regional scale impact model are, therefore, very small for arable/cropping relative to dairy and CVG which have more significant shock potential and, therefore, in-depth farm financial modelling has not been completed.

7.6 Summary of Financial Results and Sensitivity

Interpretation of sensitivity visualisations

The following example tornado graphs (Figure 7-2 and Figure 7-3) provides a visualisation of the ranked sensitivities in relation to a 20-year NPV cost impact of the practice changes proposed under GMP or BMP. A full set of visualisations for CVG and dairy is provided in Appendix I. Each bar (such as yield, price, machinery, monitoring, etc) represents the statistical likelihood of each factor's influence on the base NPV. This indicates which factor is most significant in the NPV in relation to all possible high/low combinations. The sensitivity takes into account the assumed ranges each factor could take, e.g. yield fluctuations arising from climate factors (+/-12.5%), market price swings (+/-25%) and changes in input costs (+/-10%).

There is some variance in the ranking of the other factors but generally the examples plotted show they are least sensitive to the operational cost changes (monitoring, machinery, fertiliser). Capital expenditure in year one, such as establishing grassed margins or controlled traffic tractors sit mid-range. Note the NPV uses a 6% discount rate. Where a factor does not appear on the graph or in the adjoining table it is because it does not meet the minimum sensitivity level within the granularity of the visualisation, i.e. the NPV is not significantly sensitive to this factor.

In general, all the scenarios across CVG GMP and BMP and dairy are most sensitive to yield and price (i.e. revenue earned), which is consistent with the hypothesis posed that normal challenges facing primary production are more significant over a 20-year period than the cost impact of the changes required to meet PC2 rules. Even with the cost of the PC2 it needs to be remembered that the alternative was to have to comply with the original Table 14-2 with very limited (if any) prospect of obtaining resource consent, and no ability to seek consent to transition out of the land use.

Figure 7-2 highlights that for this example the crop rotation (potatoes) it is most sensitive to the yield and sale price of the catch crop that is grown between the main crops. The cost of the management practice changes is represented in

the monitoring, capital and machinery costs that sit mid-range in the sensitivity. This rotation is least sensitive to the main crop yield, prices and fertiliser.

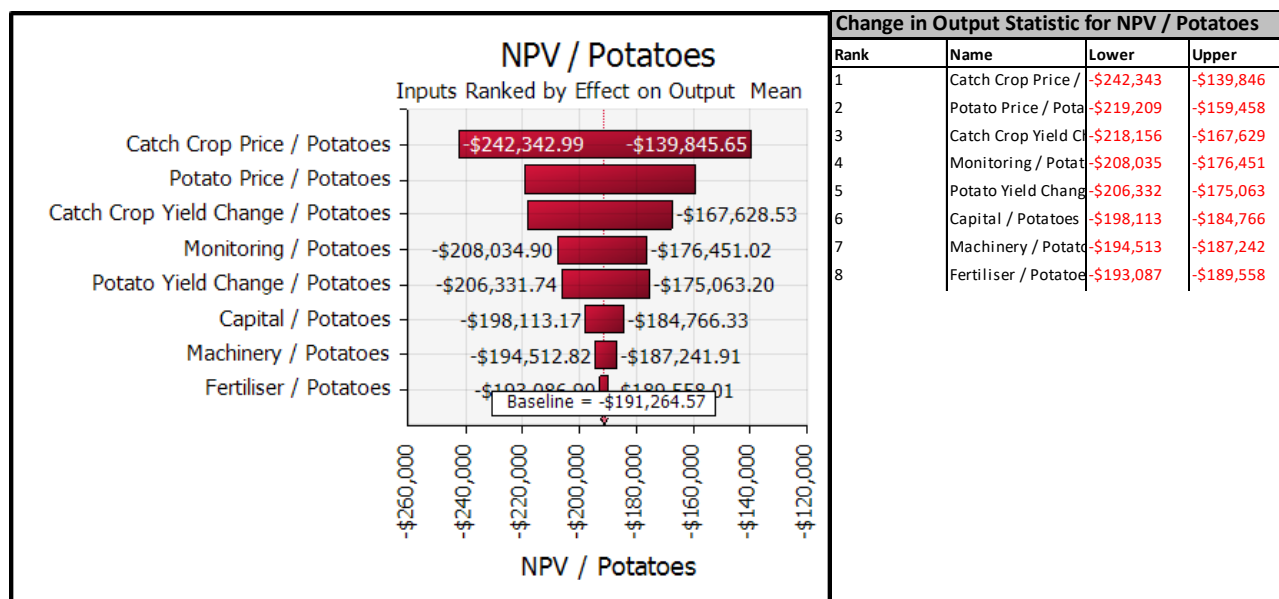


Figure 7-2 Example of a Tornado graph. Highlighting the potatoes catch crop rotation with the adoption of GMP.

It should be noted that, even with high revenue from catch crops or the main crops, a positive outcome, i.e. above the NPV \$0-dollar line is statistically improbable.

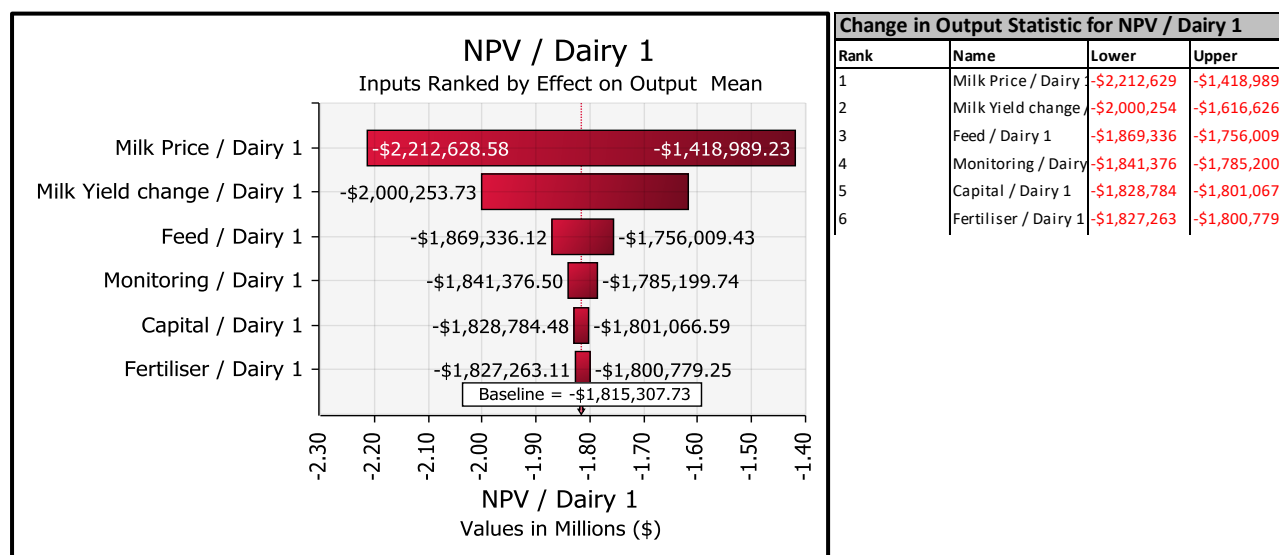


Figure 7-3 Example of a Tornado graph. Highlighting the dairy cluster 1 model with the adoption of GMP.

The tornado graph examples shown are typical for all the CVG and dairying data in Appendix I where each crop rotation or dairy cluster the sensitivities are indicated. However, the negative NPVs in the sensitivity analysis (shown as 20-year impacts) when converted to \$/ha/yr as shown in the financial models (Table 7-1, Table 7-2 and Table 7-3) are still relatively minor compared to the underlying level of enterprise profit margin range estimates. In WSP's opinion this would suggest that the PC2 changes even through there is a cost impact it would not be this factor that would drive these enterprises out of business.

8 The Other Contaminants

While the One Plan nutrient management framework was focused on land use activities with the potential for high nitrogen leaching, there are also requirements within the plan around the management and reduction of the loss of phosphorus, sediment and E. coli from within the priority catchments (for example stock exclusion rules). However, the policy and rules place the current emphasis strongly on nitrogen rather than the other three contaminants.

8.1 Land Use Impact of Contaminants

Phosphorus

Phosphorus is another key nutrient required within any agricultural or horticultural system. Like nitrogen, it can easily be lost from a system. As phosphorus tends to bind to soil particles, the process of loss is generally through surface runoff of sediments rather than through leaching. Increased phosphorus levels in a water body decreases water quality through eutrophication, which reduces the biodiversity and health of the water body. When an algae bloom occurs, the water body can become unsafe to collect food from and may not be suitable for swimming.

Bacteria

Escherichia coli (E. coli) in fresh water can indicate the presence of pathogens from animal or human faeces. The pathogens can cause illness for anyone who ingests them. Therefore, the presence of high E. coli makes a water body unsuitable for many activities including swimming, food collection and drinking water. On agricultural land, the easiest way to keep E. coli levels low within a water body is to fence waterways so that stock is excluded, helping to confine effluent behind riparian grassed or planted strips.

In pastoral systems, waterways may or may not be fenced depending on the livestock present. The presence of E. coli in horticultural systems is limited and depends on if livestock is used for inter-grazing or if unpasteurised organic fertilisers are applied.

Sediment

Cultivation techniques for cropping and vegetable production can result in various forms of erosion, with sediment more readily lost from steeper topography compared to flat areas. When sediment is lost it commonly takes phosphorus with it. When sediment enters a water body it settles on the river- or lake-bed. As sediment levels increase the aquatic life on the riverbed is slowly smothered and water clarity is reduced. Thus, like excess nutrient levels in a water body excess sediment reduces the life supporting capacity of waterway.

Comparison between Land Uses

As highlighted in Table 8-1, although all assessed land uses have been defined as intensive, each responds to contaminants differently.

All four intensive land uses have the potential to lose significant amounts of nitrogen if not managed correctly. When animals are present nitrogen loss is driven by the high point concentration within urine patches. A single dairy cow urine patch can contain as much as 1,000 kg N/ha while beef is approximately 600 kg N/ha and sheep is lower again at 300 kg N/ha. For CVG production the greatest nitrogen risk is through the use of excessively high levels of nitrogen fertiliser. Arable properties can either be a mix of these same risks having issues with animals being present and high nitrogen fertiliser inputs on crops.

The presence of animals impacts the loss of all contaminants. Because there are no animals on CVG properties, E. coli is not an issue. Where arable has no livestock present the outcome is the same as commercial vegetables. However, where dairy cows or beef cattle can access a water body E. coli and phosphorus and potentially sediment can all increase in concentrations.

The environmental risk of phosphorus on most farming systems is directly linked to the environmental risk of sediment losses. This is especially true as the topography increases or when there is risk of any type of erosion processes. On dairy farms and intensive sheep and beef farms where the topography is generally flat, phosphorus loss is greater than sediment loss due to the majority of intensive grazing areas having high available soil phosphorus

levels. Although commercial vegetables and intensive arable are also grown on flat topography, cultivation techniques and the presence of bare soil for long periods of time can lead of significant amounts of sediment to be lost.

Table 8-1 *Environmental risk of potential different intensive land uses without adoption of GMP or other mitigations.*

	Dairy	Commercial Vegetables	Irrigated Sheep & Beef	Arable
Nitrogen				
Phosphorus				
E coli				
Sediment				

9 The Alternatives

9.1 Other Possible Options

As WSP worked through the defining practice change as GMPs or BMPs for CVG, the development of Overseer® models to attempt to quantify nitrogen losses, and modelling the cost of change, it became clear that achieving the recalibrated Table 14.2 was possible for some of the CVG crop rotations modelled by WSP through the adoption of either GMP or BMP. However, there is a cost of implementing GMP and BMP. While this cost is significantly less than the controlled activity pathway in the operative One Plan, it is WSP opinion that growers would not be 'put out of business' through compliance with the PC2.

Although it has been shown that the PC2 controlled activity pathway is a variable pathway for several crop rotations by adopting GMP, no modelling has been completed to date at the enterprise level. The assumption is, however, through PC2 and the adoption of the recalibrated Table 14.2, that the alternative BMP controlled activity pathway will become a viable option for some commercial growers within the Horowhenua region, especially those who are solely potato and onion growers. If growers cannot meet the requirements of the controlled activity pathway, the introduction of PC2 will create a discretionary pathway allowing growers to still seek consent to operate under the One Plan.

However, gaining a consent through the discretionary pathway is not a guarantee, as it is under the controlled activity pathway, adding uncertainty to the process. Further, the documentation required in a discretionary pathway consent application is also more onerous, increasing the application cost significantly. Some documents that may be required include:

- Overseer® nutrient budgets;
- Farm environment plan;
- An assessment of effects, including:
 - An assessment of the impact from the property in question;
 - Ground water and or surface water quality reports; and
 - An assessment of impacts from cultivate nitrogen leaching allowance within the catchment and the role the property in question is having on the catchment.

To gain a discretionary consent a property will need to assessment of potential effects on water quality in the near environment and in the wider water management sub-zone as stated in the One Plan. This is an inherently difficult task due to the diffuse nature of contaminant movement through and across the soil profile from farming activities. Therefore, water quality reports and assessment of effects become time consuming and costly tasks. To off-set negative impacts, a farmer or grower will be required to make significantly more practice changes compared to a controlled activity in order to show reductions in nitrogen loss over time. In some cases, the adoption of GMP and BMP may not be enough to gain a consent, therefore, additional mitigations will be required. The types of mitigations required will be more costly and may require significant system changes.

During the PC2 expert causing process Horizons has considered an additional consenting pathway that sits between meeting Table 14.2 (controlled activity) and the discretionary pathway. That is, where a CVG activity adopts BMP and achieves a nitrogen loss reduction.

WSP supports a regulatory approach utilising BMP but considers that required reductions need to be significant. All suitable GMP and any suitable BMP for that individual property will need to be adopted at the time of consent. Good management practice and BMP will need to target all suitable contaminants on an individual property, not just nitrogen. The consent application would require Overseer® nutrient budgets as well as a comprehensive farm environment plan.

Through the Overseer® modelling work completed by WSP on BMP, expected reductions from individual crops range between 55-94%, using a starting year of 2014. The base year for CVG consent applications needs to be prior to when the One Plan became operative. Therefore, the base year would be 2013/14 or the year earlier to align with dairy farms (2012/13). A later starting year would disadvantage any CVG who began adopting GMP prior to gaining consent.

However, the acknowledgement needs to be noted that for some CVG, data is unlikely to be available across many operations for a 2013/14 base year.

WSP has completed rotation models that feed into the farm financial modelling, and not enterprise models for looking at water quality improvements. Therefore, it is difficult for WSP to define an expected enterprise nitrogen reduction. However, based off the available information, for CVG a minimum reduction of between 35% and 45% could be expected across an enterprise. This is higher than the suggested reduction of Bloomer et al (2020), who considered that a 23% to 35% reduction was possible. However, there are key differences in the WSP and Bloomer et al (2020) models, including the starting year used and Bloomer's approach of adopting fewer available practice changes.

In regard to timeframes for adoption, most GMP and BMP practice change can be adopted within a short time frame, some almost immediately within a current production cycles (1-2 years) with others requiring a longer transition of up to 5 years. The time for adoption is related to capacity in the management of the enterprise, completion of current production sequences and available working capital. The exception being anything to do with animal genetics and breeding programmes (which may take up to 10 years), the building of significant infrastructure (such as herd homes which have a significant cost attached), and the implementation of controlled trafficking (where the machinery upgrades that are required have a significant financial cost) in which case BMP may be implemented at the time when machinery is due to be upgraded. These timeframes may seem short, but the One Plan became operative in 2014. While the consenting framework made it difficult for consents to be granted, this should not have stop unconsented farmers and growers adopting good environmental practices. With a 2013/14 base year any changes that have been made on-farm already is taken into account within this process.

Farm Financial Example: BMP CVG

Table 9-1 sets out the farm scale cost impact of adopting BMP across CVG that might arise from the proposed alternative controlled activity approach. The cost impact is considerably higher than the GMP options tabled in this report but are still mostly below the estimated enterprise margins. The biggest impact is the potato/onion rotations. In some instances, for the leafy greens and brassicas the residual profit is minimal and therefore the impact on the enterprise would be substantial. The BMP models that have been used are conservative in that all available practice changes are adopted in one crop rotation cycle (a 2-year Overseer® model period). If some of the practice changes are adopted across a longer period, up to 10 years, that may influence positively the overall impact when calculating a 20-year NPV.

Table 9-1 Commercial vegetables financial summary for the alternative controlled activity pathway.

CVG BMP adoption	NPV \$/ha/yr	Revenue \$/ha/yr	margin ~@5%	margin ~@10%
<i>potatoes</i>	-\$2,017	\$40,912	\$2,046	\$4,092
<i>onions</i>	-\$2,174	\$38,802	\$1,890	\$3,890
<i>cauliflower potato cauliflower</i>	-\$5,355	\$139,266	\$6,963	\$13,926
<i>spring onion spinach lettuce maize cabbage</i>	-\$5,699	\$136,981	\$6,849	\$13,698
<i>maize spinach lettuce spring onion oats</i>	-\$3,684	\$122,137	\$6,107	\$12,214
<i>maize spinach lettuce spring onion cabbage</i>	-\$4,310	\$132,491	\$6,625	\$13,250
<i>oats lettuce cabbage maize</i>	-\$3,271	\$103,045	\$5,152	\$10,304
<i>pumpkin cauliflower broccoli</i>	-\$5,126	\$124,314	\$6,216	\$12,432
<i>cauliflower broccoli broccoli</i>	-\$5,550	\$152,402	\$7,620	\$13,440
<i>oats lettuce cabbage spinach oats</i>	-\$4,446	\$124,290	\$6,215	\$12,430

9.2 Farm Environmental Plans

A farm environment plan (FEP) is a tool that helps farmers and growers recognise on-farm environmental risks and set out a programme to manage those risks. Each FEP is unique to an individual property and reflects the local climate and soils, the type of farming operation, and the goals and aspirations of the land user. The development of the plan needs to be a joint effort between the farmer/grower and a suitable qualified person such as a Certified Nutrient Management Advisor (CNMA). The level of complexity of an FEP is largely dependent on the size of the property, the operation being run, and regulations in which the property is required to operate under. To get the best out of an individual FEP the plan needs to remain live, be reviewed frequently and updated after a certain length of time. It also needs to be independently audited and verified so that agreed practice changes and contaminate mitigations are occurring on-farm.

A well put together FEP can provide farmers and growers strong guidance on where contaminants are lost from a property and how changes can be made to reduce or even off-set contaminant loss. Key features a good FEP include:

- Property details;
- Property goals;
- Farm maps identifying all significant infrastructure and natural features (e.g., waterways);
- Highlighting the current farm practices including all GMPs the farm is currently doing which reduce contaminant loss;
- Farm maps highlighting all critical source areas of all contaminant losses (nitrogen, phosphorus, sediment and E. coli);
- An assessment of risk from on-farm practices and activities resulting in reduced water quality including nitrogen, phosphorus, sediment and E. coli. Assessment includes, but is not limited to, nutrients, waterways, topography, soil, current farm policies, effluent, water usage and irrigation;
- Identification of time-bound actions in place to mitigate impacts of farming practice on the environment including the adoption of additional GMPs and other mitigations; and
- Evidence (such as photographs) of critical source areas or current practices where improvements are to be made.

Currently Horizons requires a Nutrient Management Plan (NMP) as part of an IFLU consent application. Although PC2 highlights that an NMP is required to cover nitrogen, phosphorus, sediment and E. coli loss the name can be misleading and gives the impression that only nutrients are required to be addressed. Therefore, the requirement of a FEP rather than an NMP should be considered as an option to be adopted by Horizons.

Currently each industry group, several suppliers and individual consultants have their own template for a FEP. While having a suitable template available is important, the key differential in getting real on-farm change comes down to the engagement of the farmer or grower and the quality of the consultant supporting the farmer or grower through the consenting process.

Due to the nature of the One Plan, the development of a FEP is not enough to gain a resource consent. Although a FEP is required for either the controlled or discretionary consenting pathway, linkages to Table 14.2 are also required. This is irrespective to whether Table 14.2 can be met or not. For a controlled activity consent the FEP must highlight how Table 14.2 will be met. Whereas for a discretionary consent a downward trajectory for nitrogen needs to be proven. The requirements for nitrogen are additional to any requirements for phosphorus, sediment, and E. coli.

Where a controlled activity consent can be granted the level of GMP, BMP or mitigation can be less than what is required for a discretionary consent. By meeting the controlled activity status, the assumption is already made that that single property is meeting the water quality requirements. The application of a discretionary consent does not stop the requirements for reducing nitrogen loss to a water body but reduced the emphasis on nitrogen and places it on the other contaminants to gain water quality improvements.

10 References

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Appendix A One Plan Table 14.2

<i>Period</i>	<i>LUC I</i>	<i>LUC II</i>	<i>LUC III</i>	<i>LUC IV</i>	<i>LUC V</i>	<i>LUC VI</i>	<i>LUC VII</i>	<i>LUC VIII</i>
<i>Year 1</i>	30	27	24	18	16	15	8	2
	51	45	40	29	25	24	11	3
<i>Year 5</i>	27	25	21	16	13	10	6	2
	46	42	35	26	20	16	8	3
<i>Year 10</i>	26	22	19	13	13	10	6	2
	44	37	32	23	20	16	8	3
<i>Year 20</i>	25	21	18	12	12	10	6	2
	43	35	30	21	19	16	8	3

Appendix B Crop Rotations

Based off Bloomer et al (2020), eight individual crop rotations have been selected. The crops included within the rotations modelled included a mix of potatoes, onions, brassica crops and intensive vegetables. The individual rotations were selected based on the fact that most of the crops used are currently represented in Overseer®, therefore, less assumptions around crop type were required.

Through the introduction of GMP all but one rotation has had maize or forage oats introduced into the two-year rotation. Two of the original rotations (Lettuce/Cabbage/Spinach and Spinach/Lettuce/Onions/Cabbage) were each spilt into two rotations when GMPs were introduced. This highlights the different impacts of maize or forage oats at different times across the two-year crop rotation.

The original crop rotations

October		Onions	Cauliflower	Lettuce	Pumpkin			
November	Potato					Spring onion	Lettuce	
December								
January				Cauliflower				
February								
March						Spinach		
April			Broccoli				Cabbage	Spinach
May					Cauliflower			
June						Lettuce		
July		Onions						
August								
September				Potato				
October								Lettuce
November	Potato							
December			Lettuce				Spinach	
January					Broccoli			Spring onion
February								
March			Broccoli					
April						Cabbage		
May				Cauliflower				
June								Cabbage
July		Onions			Lettuce			
August								
September								

The crop rotations after catch crops were added to the rotations

October	Oats	Onions	Cauliflower	Lettuce	Pumpkin			Oats	Maize	Maize
November	Potato					Spring onion	Lettuce			
December										
January				Cauliflower						
February								Lettuce		
March						Spinach				
April		Oats	Broccoli				Cabbage	Cabbage	Spinach	Spinach
May					Cauliflower					
June	Oats					Lettuce				
July		Onions								
August										
September			Oats	Potato						
October									Lettuce	Lettuce
November	Potato					Maize		Maize		
December			Lettuce		Broccoli		Spinach		Spring onion	Spring onion
January										
February				Oats						
March			Broccoli			Cabbage				
April		Oats								
May				Cauliflower						
June	Oats								Cabbage	Oats
July		Onions			Lettuce					
August										
September										

Appendix C Assumptions in Overseer® Modelling

As part of any modelling exercise a range of assumptions are required. Due to the approach taken within the exercise additional assumptions over and above the standard assumptions were required. Key assumptions used are highlighted below.

- One-hectare rotations across a two-year period where model rather than a full enterprise,
- Grass was modelled as oats and, therefore, has been referred as oats through the report,
- Pumpkins were modelled as squash and spring onions as onions,
- No maize or grass/oats fertiliser was used,
- The assumed paddock size was 1 ha 200m x 50m,
- All paddocks were to run lengthways adjacent to a waterway,
- Grass buffers at one end along waterways,
- Summer and winter had different fertiliser applications,
- Change in fertiliser applied equals total nitrogen applied minus buffer minus controlled trafficking,
- Maize and forage oats used when fallow period was three or more month but not during the winter months,
- Maize and forage oats harvested and sold,
- Woodhaven and Agribusiness Group data used for the original rotations (Clark 2019 and The AgriBusiness Group 2014),
- Fertiliser for GMP and BMP came from Bloomer et al (2020) Overseer® models,
- All yields came from Bloomer et al (2020) Overseer® models,
- All crop yields modelled were grown yield not Overseer® average yields, and
- All GMP and BMP where applied in one year. Could also look at the Overseer® models as the nitrogen loss at year 20, therefore, adoption of change can happen across the consenting period.

Appendix D Commercial Vegetables GMP and BMP

1. GMP soil

- 1.1. Soil type, structure, texture and profile is assessed
- 1.2. Identify site specific risks of each paddock (e.g. soil type, slope, proximity to waterways, critical source areas)
- 1.3. Cultivation of soil when soil moisture conditions are appropriate
- 1.4. Minimise soil tillage as much as practicable
- 1.5. Minimise cultivation passes
- 1.6. Minimise fallow periods between crops
- 1.7. Only cultivate on days when the weather conditions are suitable: not when there are high winds
- 1.8. Planting catch crops in between vegetable rotations where fallow period is more than 12 weeks
- 1.9. Incorporate crop residual where possible
- 1.10. Understand how surface water enters and leaves each paddock
- 1.11. Ensure access ways into paddocks are not at the lowest point
- 1.12. Grassing of buffer strips at the sides of each paddock (1.5 m)
- 1.13. Grassing of buffer strips at the bottom of each paddock (3 m)
- 1.14. Have appropriate infrastructure in place to prevent sediment losses (culverts, interception drains, bunds)
- 1.15. Retire or actively manage marginal land to ensure soil conservation measures are in place

2. GMP nutrients

- 2.1. Soil testing for base fertiliser every two years including trace elements, organic carbon and organic matter
- 2.2. Soil testing for nitrogen using quick N test before every planting of crop
- 2.3. Yearly deep nitrogen test (600 mm) to determine the level of residual nitrogen remaining in the soil
- 2.4. Plan fertiliser inputs for each crop taking into account all nutrient inputs (nutrient balance)
- 2.5. Matching soil testing results to plant requirements
- 2.6. Split fertiliser application
- 2.7. Using most suitable types of fertiliser for crops
- 2.8. Applying fertiliser only where it is required, follow instructions for application, avoid waterways
- 2.9. Managed applications of fertiliser taking into account weather and soil conditions
- 2.10. Avoid broadcast fertiliser application where it can be
- 2.11. As much harvestable crop as possible is removed
- 2.12. Fertiliser to be stored and loaded to avoid spillages into waterbodies or transfer into waterbodies
- 2.13. Yearly calibration of fertiliser spreading equipment

3. GMP water and irrigation

- 3.1. Yearly calibration of irrigators' application rates and uniformity checked
- 3.2. Irrigation applied allows achievement of the yield target for fertiliser applied
- 3.3. On site soil moisture monitoring is conducted on crops that require/prefer 'wet' soils
- 3.4. Irrigation scheduling is tied to the soil moisture monitoring
- 3.5. Irrigation is applied to maintain soil moisture between wilting point and field capacity where possible
- 3.6. Water usage is metered
- 3.7. Non-irrigation water is used efficiently (e.g. wash water)

4. GMP other

- 4.1. Maintain records of activities and applications undertaken
- 4.2. Provide training to all operators: Soil testing, irrigation and fertiliser equipment
- 4.3. Develop short and long-time environmental objectives

5. BMP soil

- 5.1. GPS map of soil testing locations and use same locations for each soil test
- 5.2. Yearly soil assessment for compaction (e.g. using penetrometer)
- 5.3. Planting or grassing buffer strips at the sides of each paddock (1.5 m)
- 5.4. Planting or grassing buffer strips at the bottom of each paddock (6 m)
- 5.5. Implement controlled traffic farming where appropriate

6. BMP nutrients

- 6.1. Soil testing for base fertiliser every year including trace elements, organic carbon and organic matter
- 6.2. Soil testing for nitrogen using quick N test before every nitrogen side dressing
- 6.3. Soil nitrogen quick test results to be calibrated against laboratory testing until confident in field data
- 6.4. GPS monitoring all fertiliser applications: proof of placement
- 6.5. The use of current smart fertilisers where appropriate
- 6.6. Spreadmark accredited fertiliser application contractors are used
- 6.7. Machinery is upgraded to be more efficient/accurate
- 6.8. Leaf tests are conducted to determine nutrient levels in relation to fertiliser plans
- 6.9. Nutrient levels are managed and informed by soil tests to match rainfall/irrigation and yields
- 6.10. Obtain advice from a nutrient advisor or agronomist
- 6.11. Fertiliser plans receive annual audits

7. BMP water and irrigation

- 7.1. Variable rate irrigation application within the paddock to maximise efficiency were appropriate
- 7.2. Adopt automated irrigation systems that allow more frequent applications of less water
- 7.3. Irrigation efficiency is measurable at greater than 80% (water stays in topsoil)

8. BMP other

- 8.1. Planting of native vegetation in riparian areas where appropriate

Appendix E Example Extract from Overseer® Modelling

**GMP Cauliflower/Potato/Cauliflower**
Crop - 1ha

N loss: 27 N loss/ha: 27 P loss: 1 P loss/ha: 0.8

BLOCK DETAILS

Area	1 ha	Average temp	13.1° C	Average rainfall	1047 mm/yr	Annual PET	802 mm	Latitude	-40.634523	Longitude	175.24659
Distance from coast	7 km										

SOILS

100%	PAHA_29A.1
1 ha	Pallic

CROP MANAGEMENT

Block type	Crop	Crop rotation final month	September
Cultivated area	95 %	Years in pasture	0
Headlands and tracks	0 %	Prior land use	Crop
Other areas	5 %		

CROPS

**Cauliflower(summer)**

Category	Green vegetables
Crop type	Cauliflower(summer)
Sown	January - Year 1
Yield	47.5T
Cultivation practice at sowing	Minimum till
Residual management method	Retained

**Potato (short)**

Category	Root vegetables
Crop type	Potato (short)
Sown	September - Year 1
Yield	60.8T
Cultivation practice at sowing	Conventional
Residual management method	Retained

**Forage oats (autumn)**

Category	Forages
Crop type	Forage oats (autumn)
Sown	February - Reporting year
Yield	3.8T
Cultivation practice at sowing	Direct drilled

**Cauliflower (winter/spring)**

Category	Green vegetables
Crop type	Cauliflower (winter/spring)
Sown	May - Reporting year
Yield	28.5T
Cultivation practice at sowing	Minimum till
Residual management method	Retained

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Crop																								

RESULTS BY SOIL AND IRRIGATION

SOIL	IRRIGATOR	PERCENTAGE	AREA	NITROGEN					PHOSPHORUS		P LOSS CATEGORIES		
				TOTAL LOST	LOST	DRAINAGE	SURPLUS	ADDED	TOTAL LOST	LOST	SOIL	FERTILISER	EFFLUENT
Paha_29a.1	Irrigation	100%	1 ha	27 kg	27 kg/ha	5.7 ppm	-148 kg/ha	145 kg/ha	1 kg	0.8 kg/ha	N/A	N/A	N/A

SOIL	IRRIGATOR	PERCENTAGE	DRAINAGE	RUNOFF	TO 60CM				PAW	TO 150CM		
					FIELD CAPACITY	WILTING POINT	SATURATION			FIELD CAPACITY	WILTING POINT	SATURATI
Paha_29a.1	Irrigation	100%	481 mm	0 mm	204 mm	102 mm	276 mm		102 mm	519 mm	273 mm	654 mm

MODEL NOTES

Overview

Estimated change in soil test values for samples taken to 15cm:

- Decrease in Olsen P test of 9 units
- Decrease in QT K test of 5 units
- Decrease in QT Mg test of 2 units

NUTRIENT BUDGET

LOSSES FROM ROOT ZONE

	TOTAL LOSS (KG/YR)				LOSS PER HA (KG/YR)			
Nitrogen	27				27			
Phosphorus	1				0.8			

NUTRIENTS ADDED (KG/HA/YR)	N	P	K	S	CA	MG	NA
Effluent added	0	0	0	0	0	0	0
Fertiliser, lime and other	145	0	0	0	0	0	0
Irrigation	1	0	1	1	4	1	4
Supplements	0	0	0	0	0	0	0
Rain/clover fixation	3	0	3	7	4	10	56

NUTRIENTS REMOVED (KG/HA/YR)	N	P	K	S	CA	MG	NA
Leached from root zone	27	0.8	5	10	45	7	25
As product	247	41	298	12	27	14	12
To atmosphere	26	0	0	0	0	0	0
As supplements and crop residues	49	18	20	4	2	5	1

CHANGE IN POOLS (KG/HA/YR)	N	P	K	S	CA	MG	NA
Organic pool	-211	-21	0	-76	0	0	0
Standing plant material	361	72	314	84	30	21	32
Inorganic mineral	0	0	-53	0	-2	-3	-3
Inorganic soil pool	-269	-93	-566	0	-93	-32	-5
Root and stover residuals	-82	-19	-13	-25	-1	-1	-1

Appendix F Adoption of Individual GMP and BMP

Impact of change in fertiliser practice through the adoption of GMP or BMP

Crop rotation	N loss kg N/ha					LUC 1 GMP		LUC 1 BMP	
	Original	Fertiliser GMP	Reduction %	Fertiliser BMP	Reduction %	Table 14.2	Table 14.2 R	Table 14.2	Table 14.2 R
potatoes	22	19	14	19	14	Y	Y	Y	Y
onions	95	84	12	84	12	N	N	N	N
cauliflower broccoli broccoli	220	123	44	97	56	N	N	N	N
cauliflower potato cauliflower	134	52	61	37	72	N	N	N	Y
pumpkin cauliflower broccoli	226	159	30	137	39	N	N	N	N
spring onion spinach lettuce cabbage	103	46	55	43	58	N	N	N	Y
lettuce cabbage spinach	160	102	36	84	47	N	N	N	N
spinach lettuce spring onion cabbage	116	37	68	14	88	N	Y	Y	Y

Impact of the addition of catch crops through the adoption of GMP

Crop rotation	N loss kg N/ha			LUC 1 GMP	
	Original	Catch Crop	Reduction %	Table 14.2	Table 14.2 R
potatoes	22	11	50	Y	Y
onions	95	61	36	N	N
cauliflower broccoli broccoli	220	195	11	N	N
cauliflower potato cauliflower	134	93	31	N	N
pumpkin cauliflower broccoli	226	n/a	n/a	n/a	n/a
spring onion spinach lettuce maize cabbage	103	34	67	N	Y
oats lettuce cabbage spinach oats	160	148	7	N	N
oats lettuce cabbage spinach maize	160	8	95	Y	Y
maize spinach lettuce spring onion oats	116	108	7	N	N
maize spinach lettuce spring onion cabbage	116	119	-3	N	N

Impact of reducing effective cropping area through the adoption of GMP or BMP associated with grass buffers and controlled trafficking

Crop rotation	N loss kg N/ha					LUC 1 GMP		LUC 1 BMP	
	Original	Reduced Area GMP	Reduction %	Reduced Area GMP	Reduction %	Table 14.2	Table 14.2 R	Table 14.2	Table 14.2 R
potatoes	22	21	5	18	18	Y	Y	Y	Y
onions	95	90	5	75	21	N	N	N	N
cauliflower broccoli broccoli	220	216	10	178	19	N	N	N	N
cauliflower potato cauliflower	134	113	16	94	30	N	N	N	N
pumpkin cauliflower broccoli	226	215	5	178	21	N	N	N	N
spring onion spinach lettuce cabbage	103	101	2	82	20	N	N	N	N
lettuce cabbage spinach	160	155	3	126	21	N	N	N	N
spinach lettuce spring onion cabbage	116	111	4	92	21	N	N	N	N

Impact of change in cultivation practice through the adoption of GMP or BMP

Crop rotation	N loss kg N/ha			LUC 1 GMP	
	Original	Cultivation	Reduction %	Table 14.2	Table 14.2 R
potatoes	22	n/a	n/a	n/a	n/a
onions	95	n/a	n/a	n/a	n/a
cauliflower broccoli broccoli	220	222	-1	N	N
cauliflower potato cauliflower	134	132	1	N	N
pumpkin cauliflower broccoli	226	216	4	N	N
spring onion spinach lettuce cabbage	103	102	1	N	N
lettuce cabbage spinach	160	157	2	N	N
spinach lettuce spring onion cabbage	116	117	-1	N	N

Appendix G Example CVG Partial Gross Margin

Key property variables			Previous Practice	Under PC2 Rules	
Net Area			10	10	
Current Farmed area			10	9.79	
Effect of implementing Riparian boundaries			0	0.21	
Capital and One-off Costs					
Constructing riparian boundaries			\$0	-\$2,500	
Machinery			\$0	-\$115,000	
Consent application cost			\$0	-\$10,000	
Irrigation			\$0	\$0	
Capital and One-off Costs			\$0	-\$127,500	
Annual Operational Cost Changes					
Expert planning, monitoring and consenting assistance			\$0	-\$14,200	
Ongoing internal labour required to plan, operate and monitor within consents			\$0	-\$1,360	
Staff training			\$0	-\$5,520	
Fuel costs			-\$13,420	-\$13,138	
Machinery			-\$2,720	-\$3,195	
Monitoring Technology - GPS			\$0	-\$2,400	
Monitoring - Soil testing			\$0	-\$1,416	
Nutrient Budget-Balance			\$0	-\$750	
Cultivation cauliflower			-\$10,550	-\$10,328	
Cultivation pumpkin			-\$11,900	-\$11,650	
Cultivation broccoli			-\$11,200	-\$10,965	
Cultivation lettuce			-\$29,640	-\$29,018	
Fertiliser cauliflower			-\$2,900	-\$2,624	
Fertiliser pumpkin			-\$1,480	-\$1,145	
Fertiliser lettuce			-\$3,460	-\$1,038	
Fertiliser broccoli			-\$3,460	-\$1,606	
Fertiliser equipment maintenance			\$0	-\$500	
Irrigation			\$0	-\$1,000	
Annual Operational Cost Changes			-\$90,730	-\$111,853	
Revenue					
Production of Pumpkin			\$175,000	\$171,325	
Production of Cauliflower			\$480,000	\$469,920	
Production of Lettuce			\$1,511,000	\$1,479,269	
Production of Broccoli			\$432,000	\$422,928	
			\$2,598,000	\$2,543,442	
Analysis	NPV	NPV as \$/ha/yr	Revenue \$/ha/yr	margin ~@5%	margin ~@10%
	-\$529,743	-\$2,649	\$27,172	\$6,359	\$12,718
Term (years)	20				
Discount rate (%)	6				

Appendix H Example Dairy Partial Gross Margin

Revenue	Original	Under PC2 Rules	Change
kg/ha	880	865	15
Total MS kg	87,120	85,635	1,485
Total revenue	\$557,568	\$548,064	-\$9,504
increasing effluent area		\$1,760	\$1,760
cost of consent		\$30,000	\$30,000
Total capital cost		\$31,760	\$31,760
Annual Operational Cost			
Wages	\$102,960	\$102,960	\$0
Livestock costs	\$52,736	\$52,736	\$0
Young stock off	\$0	\$0	\$0
Wintering off	\$15,836	\$22,950	-\$7,115
Fertiliser	\$23,641	\$23,641	\$0
Nitrogen fertiliser	\$14,553	\$8,134	\$6,419
Supplementary feed	\$29,150	\$33,440	-\$4,290
Conserved feed	\$1,089	\$1,089	\$0
Summer cropping	\$5,040	\$4,375	\$665
Re-grassing	\$3,366	\$3,366	\$0
Weeds and pest	\$3,564	\$3,564	\$0
Repairs and maintenance	\$30,096	\$30,096	\$0
Vehicles	\$12,969	\$12,969	\$0
Freight	\$5,049	\$5,049	\$0
Fuel	\$7,722	\$7,722	\$0
Annual costs	\$307,771	\$312,091	-\$4,321
Net Surplus	\$249,798	\$235,973	-\$13,825
Profit/loss \$/ha	\$2,523	\$3,152	-\$140
Cashflow	NPV	NPV	Revenue
	\$/ha	\$/ha/yr	\$/ha/yr
	-\$1,773	-\$89	\$5,536
Term (years)	20		
Interest	6%		

Appendix I Tornado Graphs

Interpretation of sensitivity visualisations

The following tornado graphs provide a visualisation of the ranked sensitivities in relation to a 20-year NPV cost impact of the practice changes proposed under GMP or BMP. Each bar (such as yield, price, machinery, monitoring, etc) represents the statistical likelihood of each factor's influence on the base NPV.

This indicates which factor is most significant in the NPV in relation to all possible high/low combinations. The sensitivity takes into account the assumed ranges each factor could take, e.g. yield fluctuations arising from climate factors (+/-12.5%), market price swings (+/-25%) and changes in input costs (+/-10%).

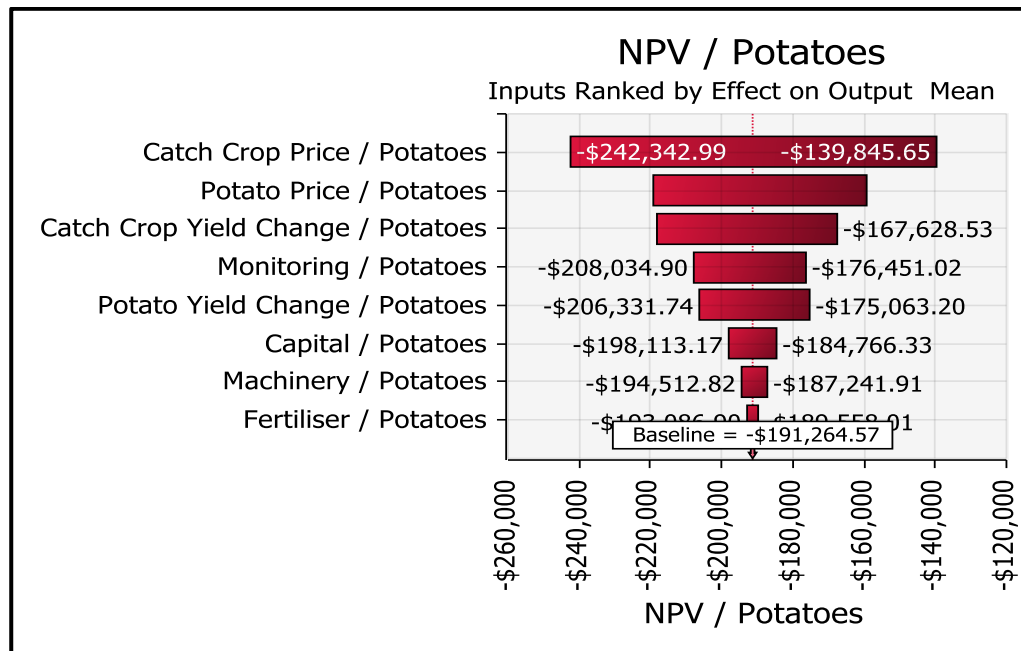
There is some variance in the ranking of the other factors but generally the examples plotted show they are least sensitive to the operational cost changes (monitoring, machinery, fertiliser). Capital expenditure in year one, such as establishing grassed margins or controlled traffic tractors sit mid-range. Note the NPV uses a 6% discount rate.

Where a factor does not appear on the graph or in the adjoining table it is because it does not meet the minimum sensitivity level within the granularity of the visualisation, i.e. the NPV is not significantly sensitive to this factor.

In general, all the scenarios across CVG GMP and BMP and dairy are most sensitive to yield and price (i.e. revenue earned), which is consistent with the hypothesis posed that normal challenges facing primary production are more significant over a 20-year period than the cost impact of the changes required to meet PC2 rules.

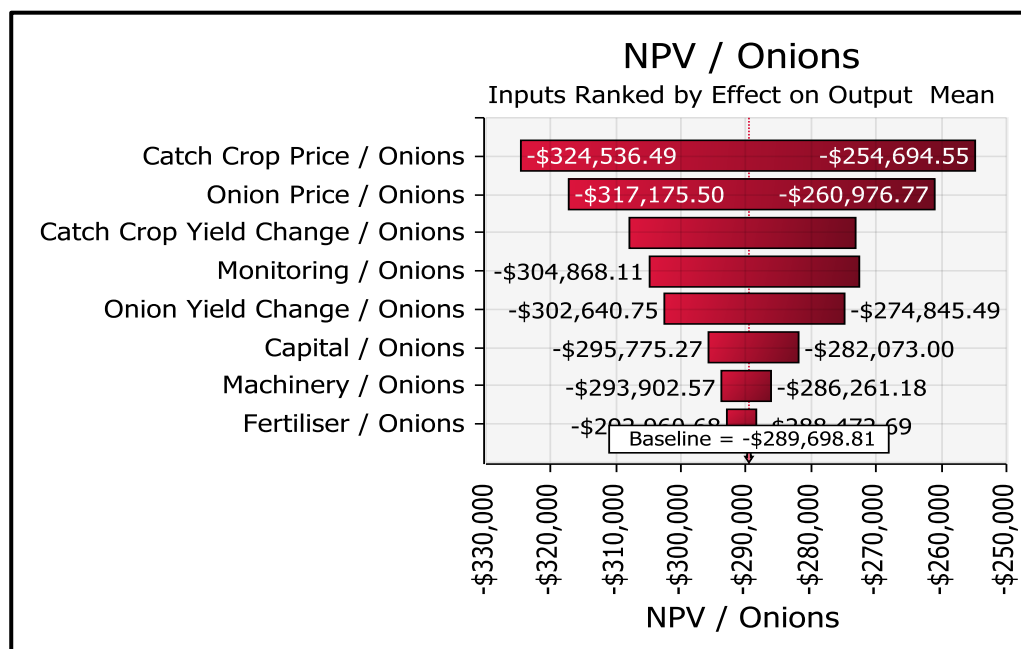
Commercial Vegetables GMP

Tornado graph and table highlighting GMP potato rotation.



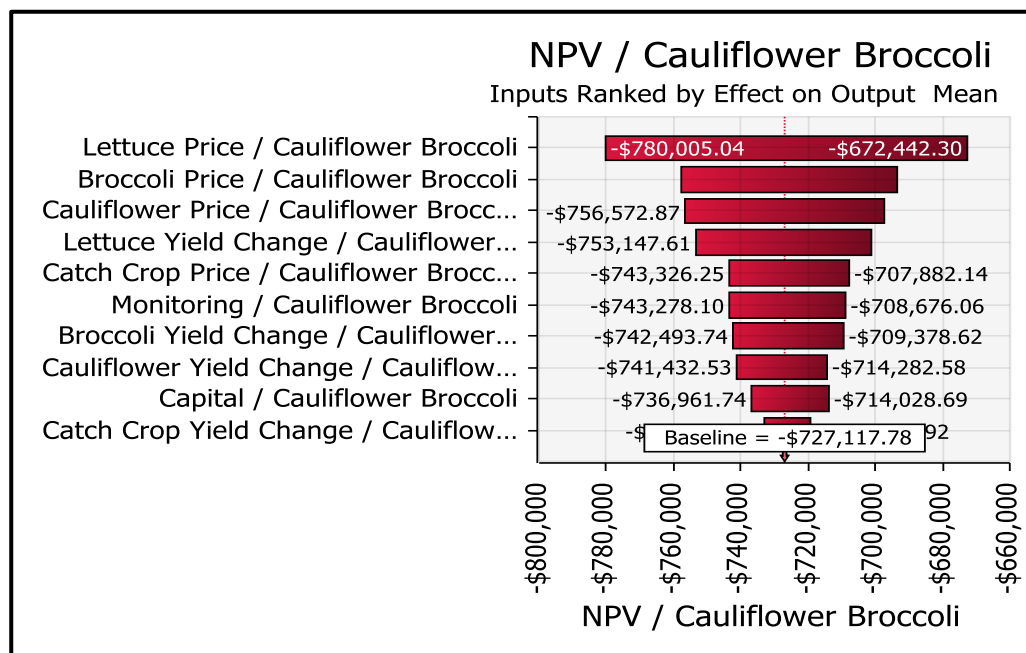
Change in Output Statistic for NPV / Potatoes			
Rank	Name	Lower	Upper
1	Catch Crop Price / Potatoes	-\$242,343	-\$139,846
2	Potato Price / Potatoes	-\$219,209	-\$159,458
3	Catch Crop Yield Change / Potatoes	-\$218,156	-\$167,629
4	Monitoring / Potatoes	-\$208,035	-\$176,451
5	Potato Yield Change / Potatoes	-\$206,332	-\$175,063
6	Capital / Potatoes	-\$198,113	-\$184,766
7	Machinery / Potatoes	-\$194,513	-\$187,242
8	Fertiliser / Potatoes	-\$193,087	-\$189,558

Tornado graph and table highlighting GMP onion rotation.



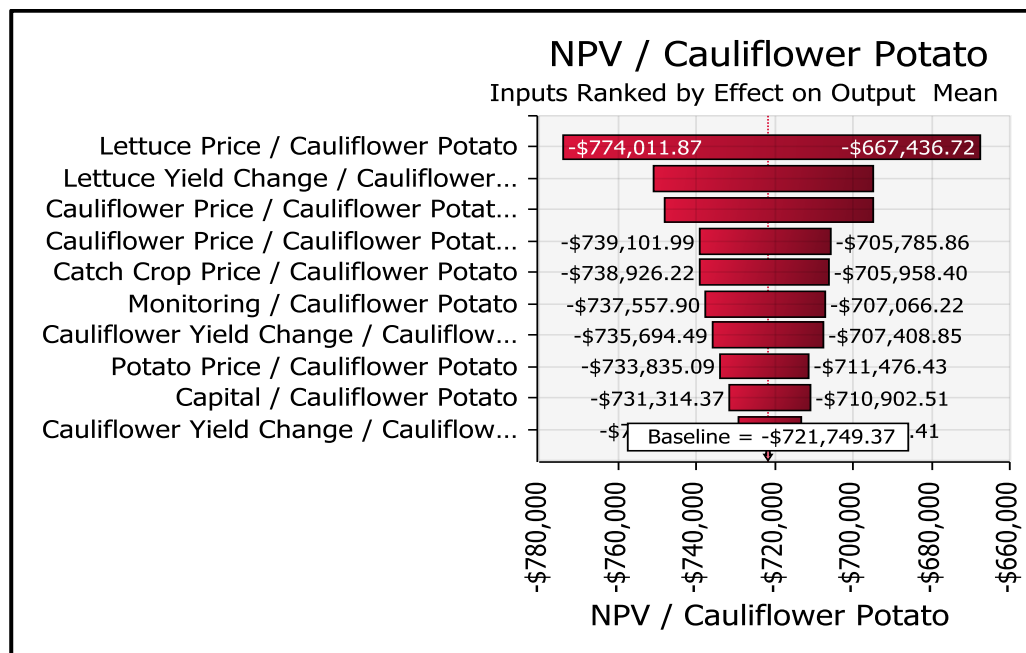
Change in Output Statistic for NPV / Onions			
Rank	Name	Lower	Upper
1	Catch Crop Price / Onions	-\$324,536	-\$254,695
2	Onion Price / Onions	-\$317,175	-\$260,977
3	Catch Crop Yield Change / Onions	-\$308,091	-\$273,217
4	Monitoring / Onions	-\$304,868	-\$272,556
5	Onion Yield Change / Onions	-\$302,641	-\$274,845
6	Capital / Onions	-\$295,775	-\$282,073
7	Machinery / Onions	-\$293,903	-\$286,261
8	Fertiliser / Onions	-\$292,961	-\$288,473

Tornado graph and table highlighting GMP cauliflower, broccoli, and broccoli rotation.



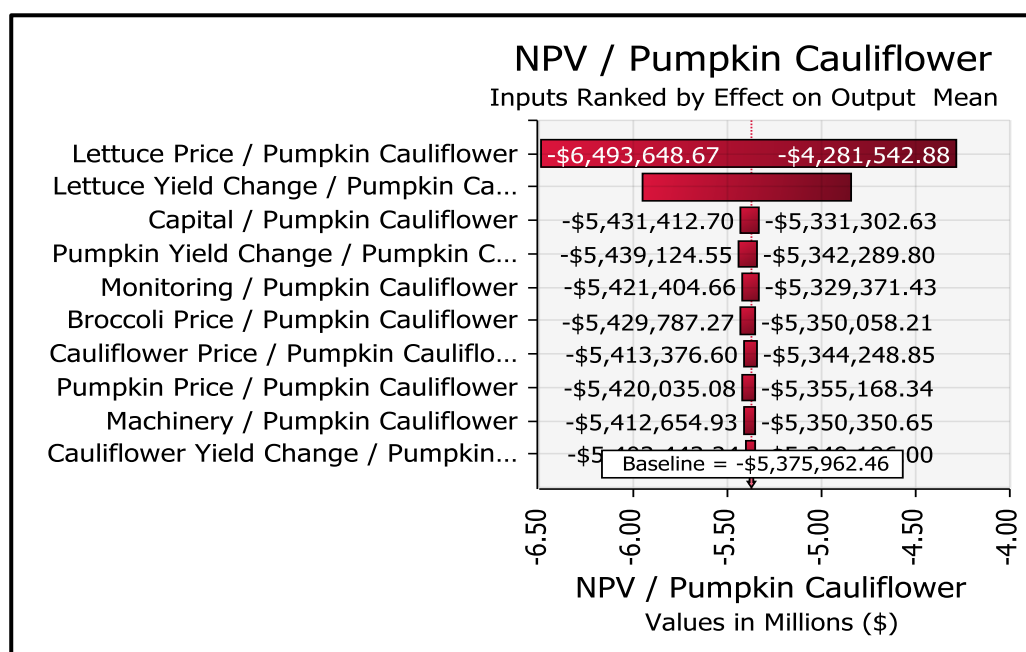
Change in Output Statistic for NPV / Cauliflower Broccoli			
Rank	Name	Lower	Upper
1	Lettuce Price / Cauliflower Broccoli	-\$780,005	-\$672,442
2	Broccoli Price / Cauliflower Broccoli	-\$757,707	-\$693,241
3	Cauliflower Price / Cauliflower Broccoli	-\$756,573	-\$697,543
4	Lettuce Yield Change / Cauliflower Broccoli	-\$753,148	-\$700,946
5	Catch Crop Price / Cauliflower Broccoli	-\$743,326	-\$707,882
6	Monitoring / Cauliflower Broccoli	-\$743,278	-\$708,676
7	Broccoli Yield Change / Cauliflower Broccoli	-\$742,494	-\$709,379
8	Cauliflower Yield Change / Cauliflower Broccoli	-\$741,433	-\$714,283
9	Capital / Cauliflower Broccoli	-\$736,962	-\$714,029
10	Catch Crop Yield Change / Cauliflower Broccoli	-\$733,194	-\$719,190

Tornado graph and table highlighting GMP cauliflower, potato, and cauliflower rotation.



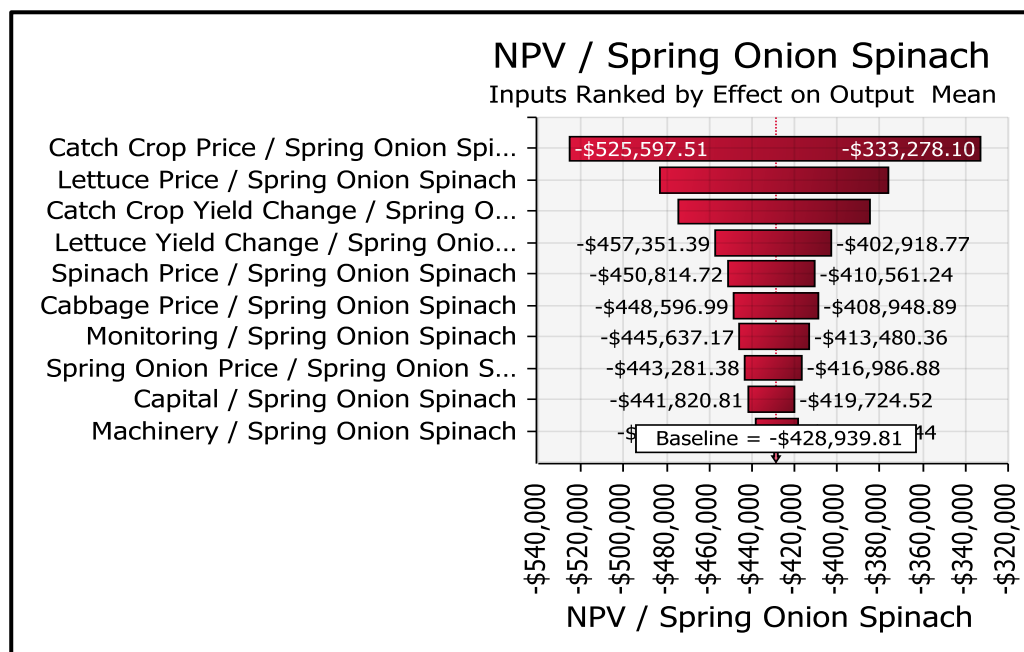
Change in Output Statistic for NPV / Cauliflower Potato			
Rank	Name	Lower	Upper
1	Lettuce Price / Cauliflower Potato	-\$774,012	-\$667,437
2	Lettuce Yield Change / Cauliflower Potato	-\$750,879	-\$694,601
3	Cauliflower Price / Cauliflower Potato (E70)	-\$748,075	-\$694,697
4	Cauliflower Price / Cauliflower Potato (E71)	-\$739,102	-\$705,786
5	Catch Crop Price / Cauliflower Potato	-\$738,926	-\$705,958
6	Monitoring / Cauliflower Potato	-\$737,558	-\$707,066
7	Cauliflower Yield Change / Cauliflower Potato (E56)	-\$735,694	-\$707,409
8	Potato Price / Cauliflower Potato	-\$733,835	-\$711,476
9	Capital / Cauliflower Potato	-\$731,314	-\$710,903
10	Cauliflower Yield Change / Cauliflower Potato (E57)	-\$729,161	-\$713,332

Tornado graph and table highlighting GMP pumpkin, cauliflower, and broccoli rotation.



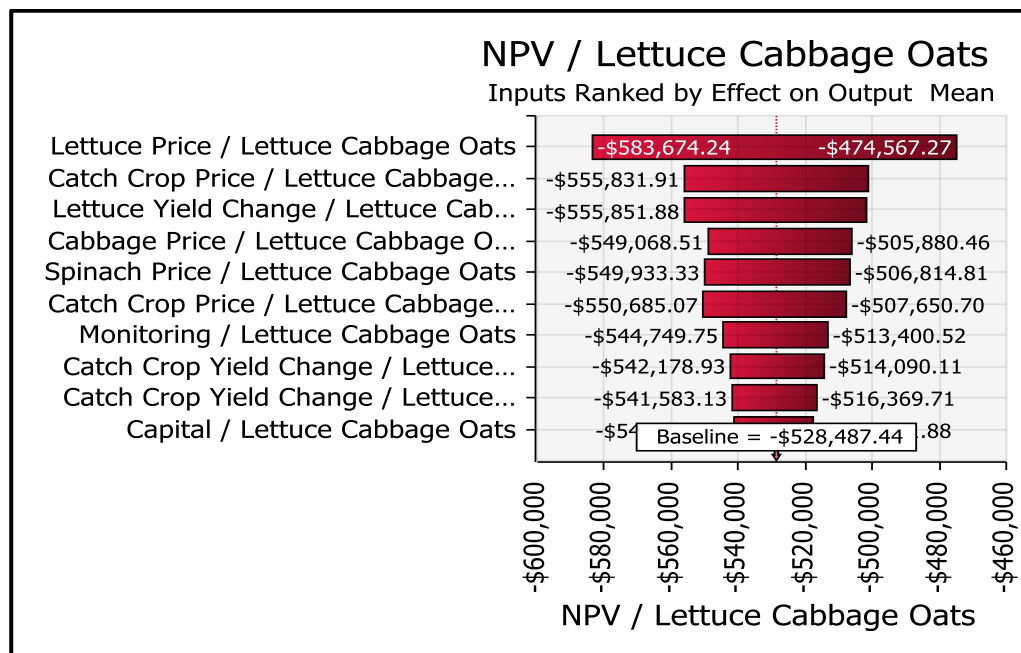
Change in Output Statistic for NPV / Pumpkin Cauliflower			
Rank	Name	Lower	Upper
1	Lettuce Price / Pumpkin Cauliflower	-\$6,493,649	-\$4,281,543
2	Lettuce Yield Change / Pumpkin Cauliflower	-\$5,955,419	-\$4,839,188
3	Capital / Pumpkin Cauliflower	-\$5,431,413	-\$5,331,303
4	Pumpkin Yield Change / Pumpkin Cauliflower	-\$5,439,125	-\$5,342,290
5	Monitoring / Pumpkin Cauliflower	-\$5,421,405	-\$5,329,371
6	Broccoli Price / Pumpkin Cauliflower	-\$5,429,787	-\$5,350,058
7	Cauliflower Price / Pumpkin Cauliflower	-\$5,413,377	-\$5,344,249
8	Pumpkin Price / Pumpkin Cauliflower	-\$5,420,035	-\$5,355,168
9	Machinery / Pumpkin Cauliflower	-\$5,412,655	-\$5,350,351
10	Cauliflower Yield Change / Pumpkin Cauliflower	-\$5,403,443	-\$5,349,186

Tornado graph and table highlighting GMP spring onion, spinach, lettuce, maize, and cabbage rotation.



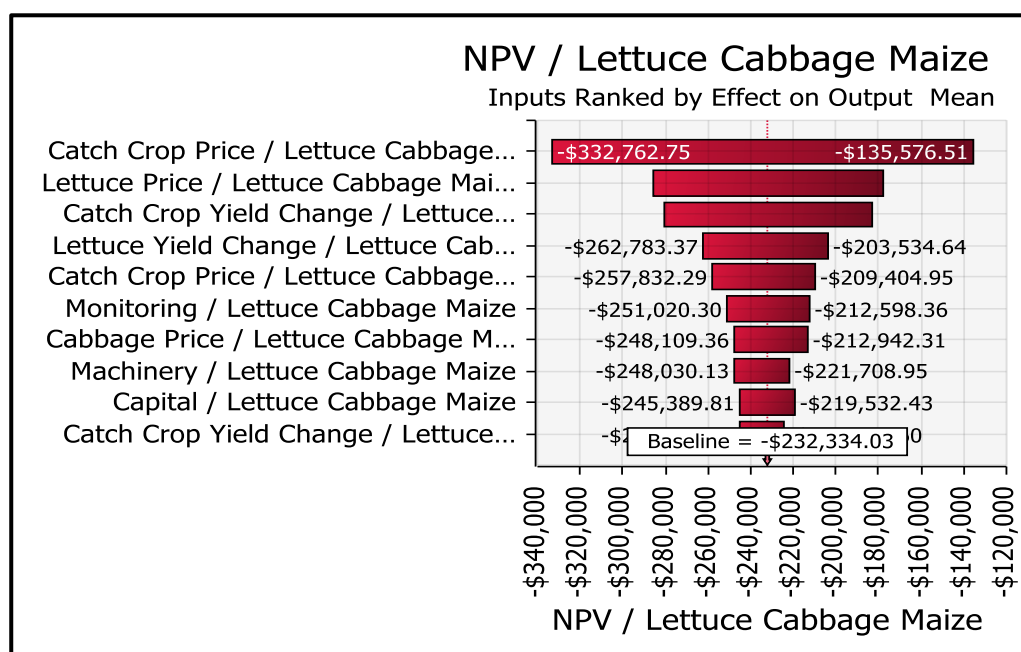
Change in Output Statistic for NPV / Spring Onion Spinach			
Rank	Name	Lower	Upper
1	Catch Crop Price / Spring Onion Spinach	-\$525,598	-\$333,278
2	Lettuce Price / Spring Onion Spinach	-\$483,160	-\$375,871
3	Catch Crop Yield Change / Spring Onion Spinach	-\$474,542	-\$384,916
4	Lettuce Yield Change / Spring Onion Spinach	-\$457,351	-\$402,919
5	Spinach Price / Spring Onion Spinach	-\$450,815	-\$410,561
6	Cabbage Price / Spring Onion Spinach	-\$448,597	-\$408,949
7	Monitoring / Spring Onion Spinach	-\$445,637	-\$413,480
8	Spring Onion Price / Spring Onion Spinach	-\$443,281	-\$416,987
9	Capital / Spring Onion Spinach	-\$441,821	-\$419,725
10	Machinery / Spring Onion Spinach	-\$437,830	-\$418,144

Tornado graph and table highlighting GMP lettuce, cabbage, spinach, and oats rotation.



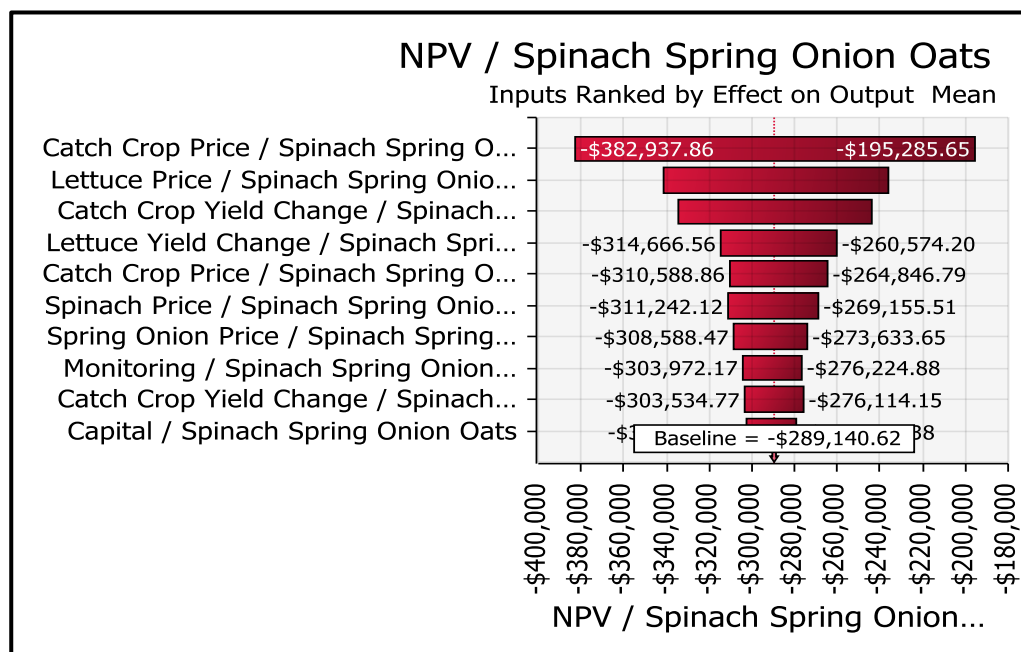
Change in Output Statistic for NPV / Lettuce Cabbage Oats			
Rank	Name	Lower	Upper
1	Lettuce Price / Lettuce Cabbage Oats	-\$583,674	-\$474,567
2	Catch Crop Price / Lettuce Cabbage Oats (I79)	-\$555,832	-\$501,373
3	Lettuce Yield Change / Lettuce Cabbage Oats	-\$555,852	-\$501,553
4	Cabbage Price / Lettuce Cabbage Oats	-\$549,069	-\$505,880
5	Spinach Price / Lettuce Cabbage Oats	-\$549,933	-\$506,815
6	Catch Crop Price / Lettuce Cabbage Oats (I78)	-\$550,685	-\$507,651
7	Monitoring / Lettuce Cabbage Oats	-\$544,750	-\$513,401
8	Catch Crop Yield Change / Lettuce Cabbage Oats (I65)	-\$542,179	-\$514,090
9	Catch Crop Yield Change / Lettuce Cabbage Oats (I64)	-\$541,583	-\$516,370
10	Capital / Lettuce Cabbage Oats	-\$541,303	-\$517,382

Tornado graph and table highlighting GMP oats, lettuce, cabbage, spinach, and maize rotation.



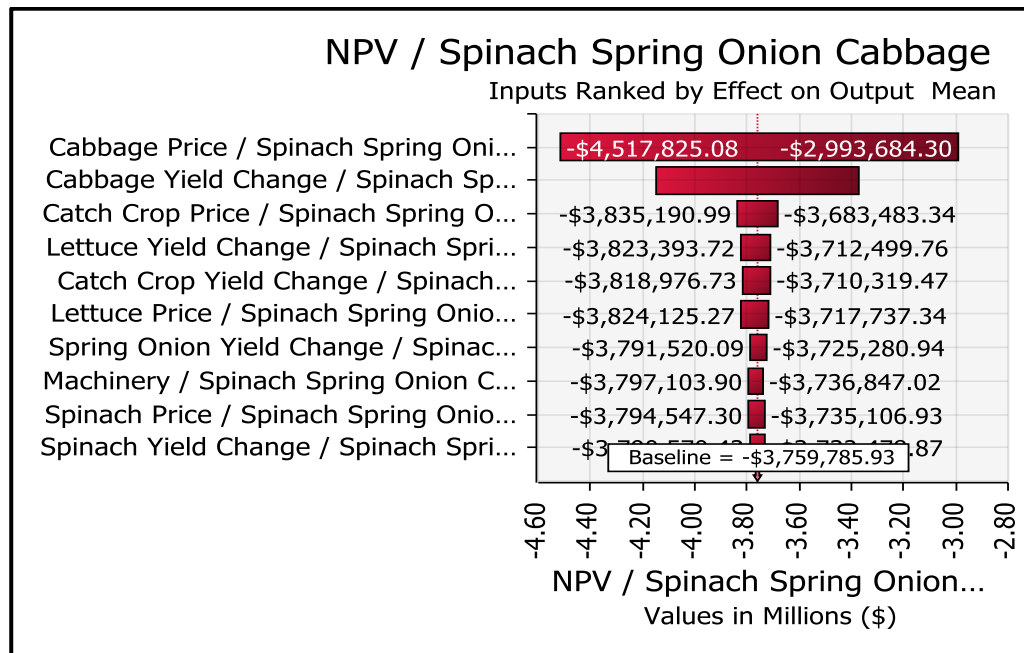
Change in Output Statistic for NPV / Lettuce Cabbage Maize			
Rank	Name	Lower	Upper
1	Catch Crop Price / Lettuce Cabbage Maize (H78)	-\$332,763	-\$135,577
2	Lettuce Price / Lettuce Cabbage Maize	-\$285,921	-\$177,771
3	Catch Crop Yield Change / Lettuce Cabbage Maize (H64)	-\$280,879	-\$182,675
4	Lettuce Yield Change / Lettuce Cabbage Maize	-\$262,783	-\$203,535
5	Catch Crop Price / Lettuce Cabbage Maize (H79)	-\$257,832	-\$209,405
6	Monitoring / Lettuce Cabbage Maize	-\$251,020	-\$212,598
7	Cabbage Price / Lettuce Cabbage Maize	-\$248,109	-\$212,942
8	Machinery / Lettuce Cabbage Maize	-\$248,030	-\$221,709
9	Capital / Lettuce Cabbage Maize	-\$245,390	-\$219,532
10	Catch Crop Yield Change / Lettuce Cabbage Maize (H65)	-\$245,052	-\$224,016

Tornado graph and table highlighting GMP maize, spinach, lettuce, spring onion, and oats rotation.



Change in Output Statistic for NPV / Spinach Spring Onion Oats			
Rank	Name	Lower	Upper
1	Catch Crop Price / Spinach Spring Onion Oats (K78)	-\$382,938	-\$195,286
2	Lettuce Price / Spinach Spring Onion Oats	-\$341,121	-\$236,201
3	Catch Crop Yield Change / Spinach Spring Onion Oats (K64)	-\$334,309	-\$244,120
4	Lettuce Yield Change / Spinach Spring Onion Oats	-\$314,667	-\$260,574
5	Catch Crop Price / Spinach Spring Onion Oats (K79)	-\$310,589	-\$264,847
6	Spinach Price / Spinach Spring Onion Oats	-\$311,242	-\$269,156
7	Spring Onion Price / Spinach Spring Onion Oats	-\$308,588	-\$273,634
8	Monitoring / Spinach Spring Onion Oats	-\$303,972	-\$276,225
9	Catch Crop Yield Change / Spinach Spring Onion Oats (K65)	-\$303,535	-\$276,114
10	Capital / Spinach Spring Onion Oats	-\$302,662	-\$279,283

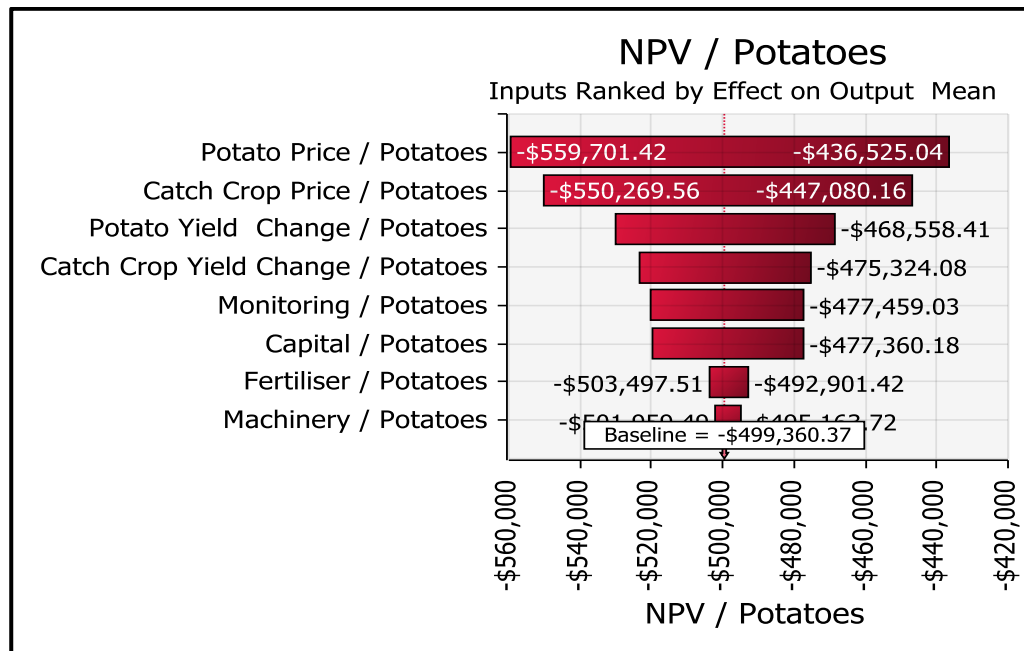
Tornado graph and table highlighting GMP maize, spinach, lettuce, spring onion, and cabbage rotation.



Change in Output Statistic for NPV / Spinach Spring Onion Cabbage			
Rank	Name	Lower	Upper
1	Cabbage Price / Spinach Spring Onion Cabbage	-\$4,517,825	-\$2,993,684
2	Cabbage Yield Change / Spinach Spring Onion Cabbage	-\$4,147,615	-\$3,369,332
3	Catch Crop Price / Spinach Spring Onion Cabbage	-\$3,835,191	-\$3,683,483
4	Lettuce Yield Change / Spinach Spring Onion Cabbage	-\$3,823,394	-\$3,712,500
5	Catch Crop Yield Change / Spinach Spring Onion Cabbage	-\$3,818,977	-\$3,710,319
6	Lettuce Price / Spinach Spring Onion Cabbage	-\$3,824,125	-\$3,717,737
7	Spring Onion Yield Change / Spinach Spring Onion Cabbage	-\$3,791,520	-\$3,725,281
8	Machinery / Spinach Spring Onion Cabbage	-\$3,797,104	-\$3,736,847
9	Spinach Price / Spinach Spring Onion Cabbage	-\$3,794,547	-\$3,735,107
10	Spinach Yield Change / Spinach Spring Onion Cabbage	-\$3,790,570	-\$3,732,479

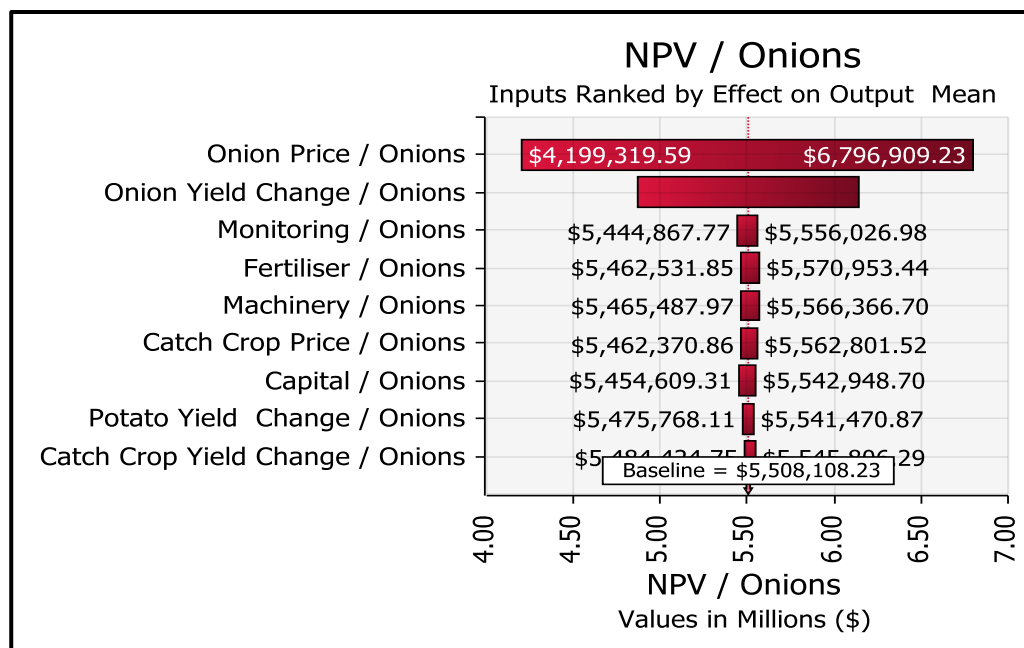
Commercial Vegetables BMP

Tornado graph and table highlighting BMP potato rotation.



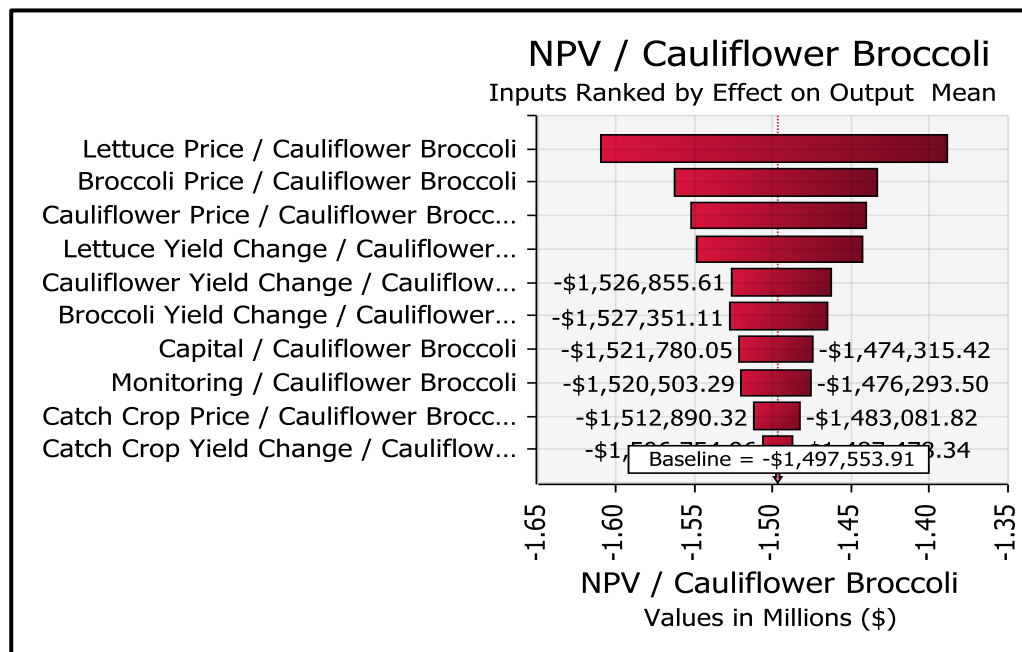
Change in Output Statistic for NPV / Potatoes			
Rank	Name	Lower	Upper
1	Potato Price / Potatoes	-\$559,701	-\$436,525
2	Catch Crop Price / Potatoes	-\$550,270	-\$447,080
3	Potato Yield Change / Potatoes	-\$530,232	-\$468,558
4	Catch Crop Yield Change / Potatoes	-\$523,290	-\$475,324
5	Monitoring / Potatoes	-\$520,434	-\$477,459
6	Capital / Potatoes	-\$519,508	-\$477,360
7	Fertiliser / Potatoes	-\$503,498	-\$492,901
8	Machinery / Potatoes	-\$501,959	-\$495,164

Tornado graph and table highlighting BMP onion rotation.



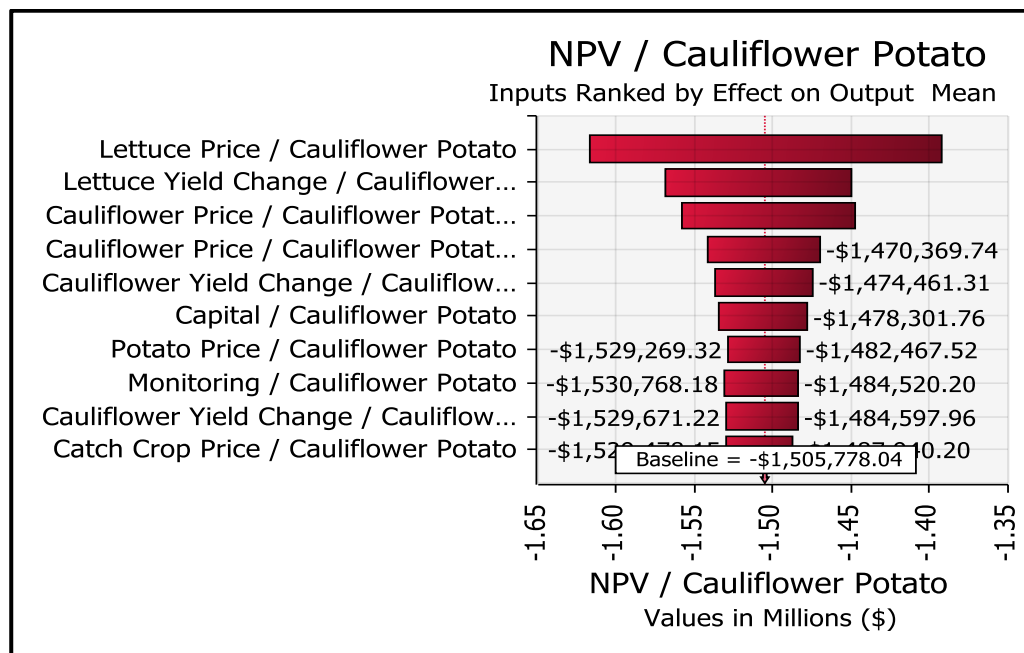
Change in Output Statistic for NPV / Onions			
Rank	Name	Lower	Upper
1	Onion Price / Onions	\$4,199,320	\$6,796,909
2	Onion Yield Change / Onions	\$4,872,911	\$6,144,326
3	Monitoring / Onions	\$5,444,868	\$5,556,027
4	Fertiliser / Onions	\$5,462,532	\$5,570,953
5	Machinery / Onions	\$5,465,488	\$5,566,367
6	Catch Crop Price / Onions	\$5,462,371	\$5,562,802
7	Capital / Onions	\$5,454,609	\$5,542,949
8	Potato Yield Change / Onions	\$5,475,768	\$5,541,471
9	Catch Crop Yield Change / Onions	\$5,484,425	\$5,545,806

Tornado graph and table highlighting BMP cauliflower, broccoli, and broccoli rotation.



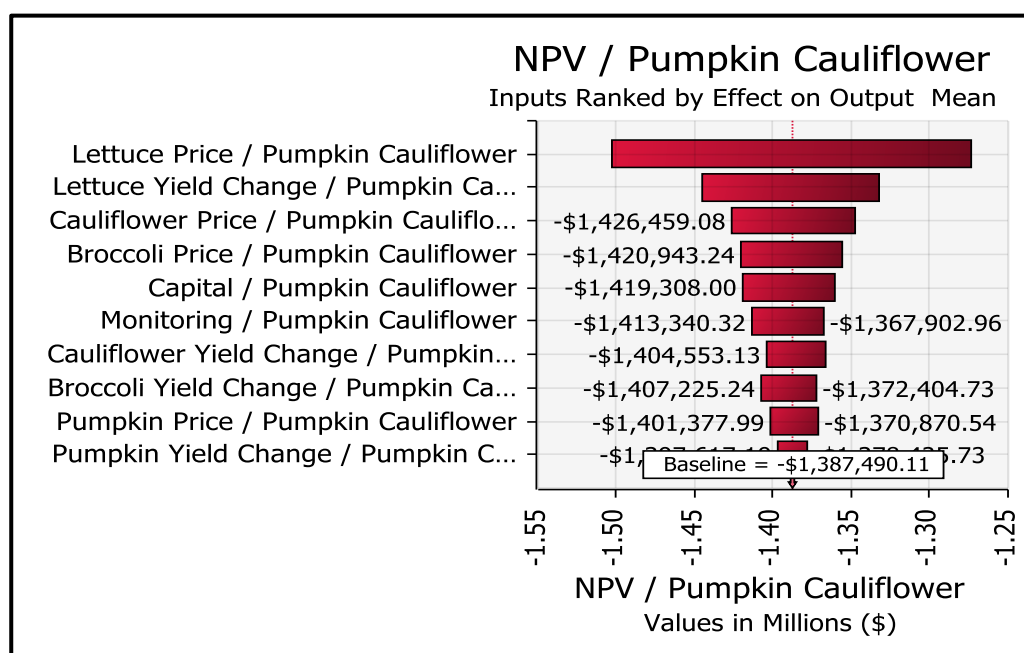
Change in Output Statistic for NPV / Cauliflower and Broccoli			
Rank	Name	Lower	Upper
1	Lettuce Price / Cauliflower Broccoli	-\$1,609,621	-\$1,388,712
2	Broccoli Price / Cauliflower Broccoli	-\$1,562,437	-\$1,432,947
3	Cauliflower Price / Cauliflower Broccoli	-\$1,552,878	-\$1,440,890
4	Lettuce Yield Change / Cauliflower Broccoli	-\$1,549,027	-\$1,443,001
5	Cauliflower Yield Change / Cauliflower Broccoli	-\$1,526,856	-\$1,463,252
6	Broccoli Yield Change / Cauliflower Broccoli	-\$1,527,351	-\$1,465,738
7	Capital / Cauliflower Broccoli	-\$1,521,780	-\$1,474,315
8	Monitoring / Cauliflower Broccoli	-\$1,520,503	-\$1,476,294
9	Catch Crop Price / Cauliflower Broccoli	-\$1,512,890	-\$1,483,082
10	Catch Crop Yield Change / Cauliflower Broccoli	-\$1,506,755	-\$1,487,478

Tornado graph and table highlighting BMP cauliflower, potato, and cauliflower rotation.



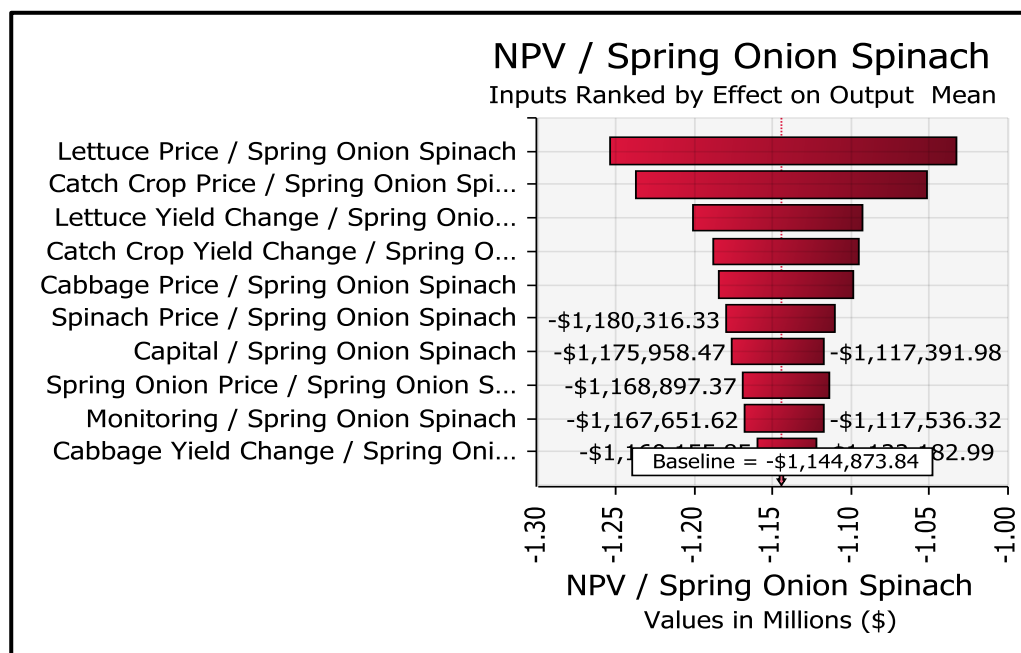
Change in Output Statistic for NPV / Cauliflower and Potato Rotation			
Rank	Name	Lower	Upper
1	Lettuce Price / Cauliflower Potato	-\$1,616,580	-\$1,392,833
2	Lettuce Yield Change / Cauliflower Potato	-\$1,569,391	-\$1,450,129
3	Cauliflower Price / Cauliflower Potato (E70)	-\$1,557,818	-\$1,447,696
4	Cauliflower Price / Cauliflower Potato (E71)	-\$1,541,464	-\$1,470,370
5	Cauliflower Yield Change / Cauliflower Potato (E56)	-\$1,537,536	-\$1,474,461
6	Capital / Cauliflower Potato	-\$1,535,022	-\$1,478,302
7	Potato Price / Cauliflower Potato	-\$1,529,269	-\$1,482,468
8	Monitoring / Cauliflower Potato	-\$1,530,768	-\$1,484,520
9	Cauliflower Yield Change / Cauliflower Potato (E57)	-\$1,529,671	-\$1,484,598
10	Catch Crop Price / Cauliflower Potato	-\$1,529,478	-\$1,487,940

Tornado graph and table highlighting BMP pumpkin, cauliflower, and broccoli rotation.



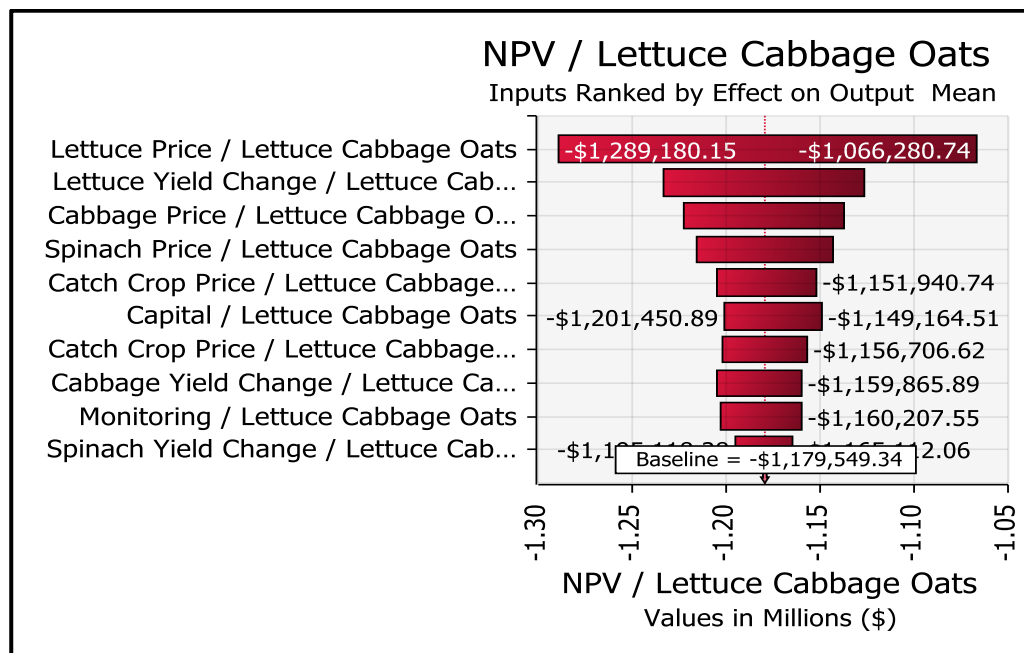
Change in Output Statistic for NPV / Pumpkin Cauliflower			
Rank	Name	Lower	Upper
1	Lettuce Price / Pumpkin Cauliflower	-\$1,503,309	-\$1,273,554
2	Lettuce Yield Change / Pumpkin Cauliflower	-\$1,444,985	-\$1,332,046
3	Cauliflower Price / Pumpkin Cauliflower	-\$1,426,459	-\$1,347,440
4	Broccoli Price / Pumpkin Cauliflower	-\$1,420,943	-\$1,355,299
5	Capital / Pumpkin Cauliflower	-\$1,419,308	-\$1,360,717
6	Monitoring / Pumpkin Cauliflower	-\$1,413,340	-\$1,367,903
7	Cauliflower Yield Change / Pumpkin Cauliflower	-\$1,404,553	-\$1,366,705
8	Broccoli Yield Change / Pumpkin Cauliflower	-\$1,407,225	-\$1,372,405
9	Pumpkin Price / Pumpkin Cauliflower	-\$1,401,378	-\$1,370,871
10	Pumpkin Yield Change / Pumpkin Cauliflower	-\$1,397,617	-\$1,378,426

Tornado graph and table highlighting BMP spring onion, spinach, lettuce, maize, and cabbage rotation.



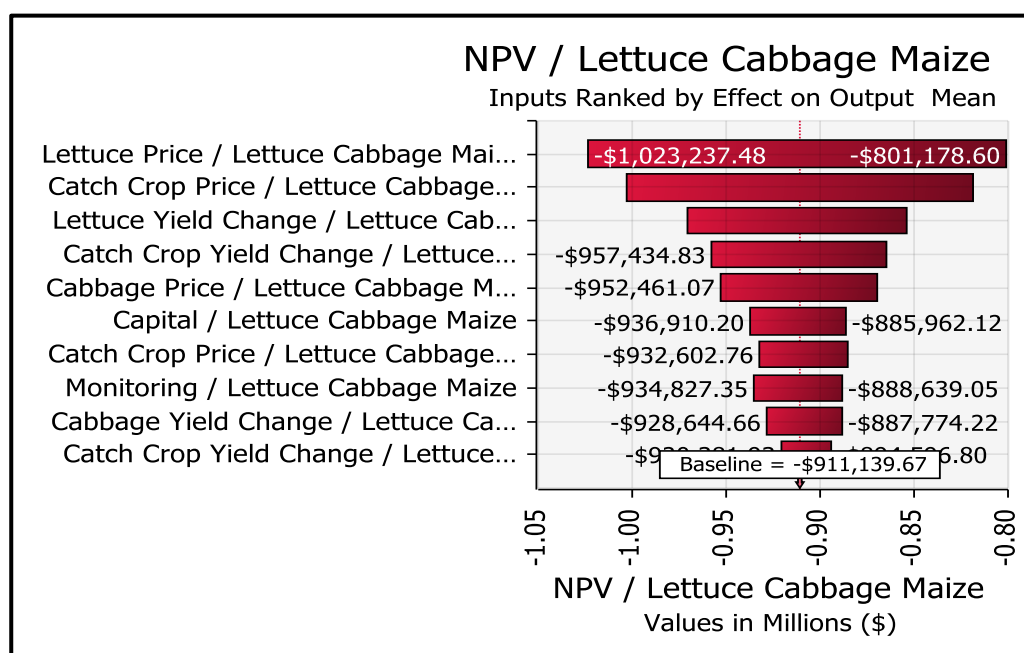
Change in Output Statistic for NPV / Spring Onion Spinach			
Rank	Name	Lower	Upper
1	Lettuce Price / Spring Onion Spinach	-\$1,253,542	-\$1,032,439
2	Catch Crop Price / Spring Onion Spinach	-\$1,237,924	-\$1,051,935
3	Lettuce Yield Change / Spring Onion Spinach	-\$1,201,641	-\$1,092,563
4	Catch Crop Yield Change / Spring Onion Spinach	-\$1,188,346	-\$1,095,631
5	Cabbage Price / Spring Onion Spinach	-\$1,185,196	-\$1,099,145
6	Spinach Price / Spring Onion Spinach	-\$1,180,316	-\$1,110,520
7	Capital / Spring Onion Spinach	-\$1,175,958	-\$1,117,392
8	Spring Onion Price / Spring Onion Spinach	-\$1,168,897	-\$1,114,548
9	Monitoring / Spring Onion Spinach	-\$1,167,652	-\$1,117,536
10	Cabbage Yield Change / Spring Onion Spinach	-\$1,160,156	-\$1,122,183

Tornado graph and table highlighting BMP oats, lettuce, cabbage, spinach, and oats rotation.



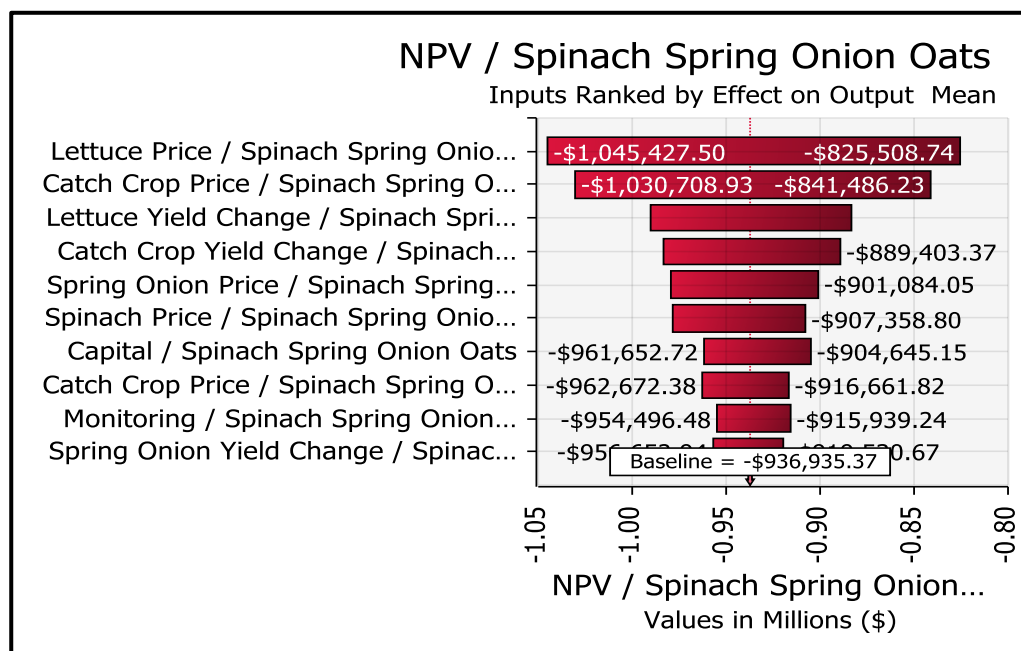
Change in Output Statistic for NPV / Lettuce Cabbage Oats			
Rank	Name	Lower	Upper
1	Lettuce Price / Lettuce Cabbage Oats	-\$1,289,180	-\$1,066,281
2	Lettuce Yield Change / Lettuce Cabbage Oats	-\$1,233,029	-\$1,126,799
3	Cabbage Price / Lettuce Cabbage Oats	-\$1,222,567	-\$1,137,380
4	Spinach Price / Lettuce Cabbage Oats	-\$1,215,830	-\$1,143,221
5	Catch Crop Price / Lettuce Cabbage Oats (I79)	-\$1,204,754	-\$1,151,941
6	Capital / Lettuce Cabbage Oats	-\$1,201,451	-\$1,149,165
7	Catch Crop Price / Lettuce Cabbage Oats (I78)	-\$1,202,419	-\$1,156,707
8	Cabbage Yield Change / Lettuce Cabbage Oats	-\$1,205,358	-\$1,159,866
9	Monitoring / Lettuce Cabbage Oats	-\$1,202,465	-\$1,160,208
10	Spinach Yield Change / Lettuce Cabbage Oats	-\$1,195,118	-\$1,165,112

Tornado graph and table highlighting BMP oats, lettuce, cabbage, spinach, and maize rotation.



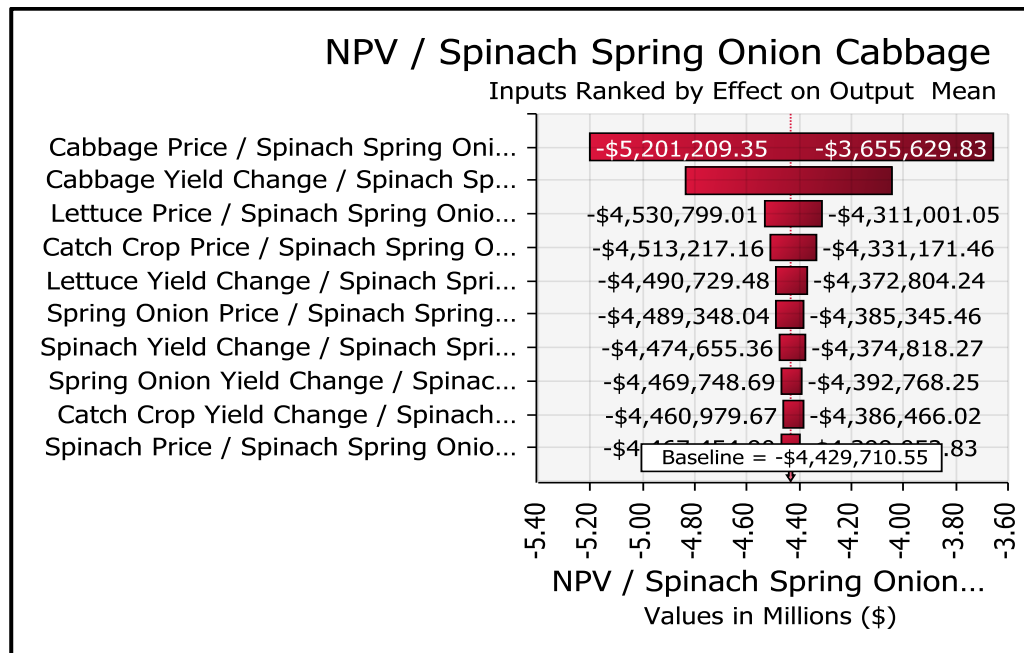
Change in Output Statistic for NPV / Lettuce Cabbage Maize			
Rank	Name	Lower	Upper
1	Lettuce Price / Lettuce Cabbage Maize	-\$1,023,237	-\$801,179
2	Catch Crop Price / Lettuce Cabbage Maize (H78)	-\$1,002,567	-\$818,638
3	Lettuce Yield Change / Lettuce Cabbage Maize	-\$970,259	-\$854,155
4	Catch Crop Yield Change / Lettuce Cabbage Maize (H64)	-\$957,435	-\$864,806
5	Cabbage Price / Lettuce Cabbage Maize	-\$952,461	-\$869,316
6	Capital / Lettuce Cabbage Maize	-\$936,910	-\$885,962
7	Catch Crop Price / Lettuce Cabbage Maize (H79)	-\$932,603	-\$885,689
8	Monitoring / Lettuce Cabbage Maize	-\$934,827	-\$888,639
9	Cabbage Yield Change / Lettuce Cabbage Maize	-\$928,645	-\$887,774
10	Catch Crop Yield Change / Lettuce Cabbage Maize (H65)	-\$920,382	-\$894,597

Tornado graph and table highlighting BMP maize, spinach, lettuce, spring onion, and oats rotation.



Change in Output Statistic for NPV / Spinach Spring Onion Oats			
Rank	Name	Lower	Upper
1	Lettuce Price / Spinach Spring Onion Oats	-\$1,045,427	-\$825,509
2	Catch Crop Price / Spinach Spring Onion Oats (K78)	-\$1,030,709	-\$841,486
3	Lettuce Yield Change / Spinach Spring Onion Oats	-\$990,265	-\$883,460
4	Catch Crop Yield Change / Spinach Spring Onion Oats	-\$982,975	-\$889,403
5	Spring Onion Price / Spinach Spring Onion Oats	-\$978,949	-\$901,084
6	Spinach Price / Spinach Spring Onion Oats	-\$978,729	-\$907,359
7	Capital / Spinach Spring Onion Oats	-\$961,653	-\$904,645
8	Catch Crop Price / Spinach Spring Onion Oats (K79)	-\$962,672	-\$916,662
9	Monitoring / Spinach Spring Onion Oats	-\$954,496	-\$915,939
10	Spring Onion Yield Change / Spinach Spring Onion Oats	-\$956,653	-\$919,531

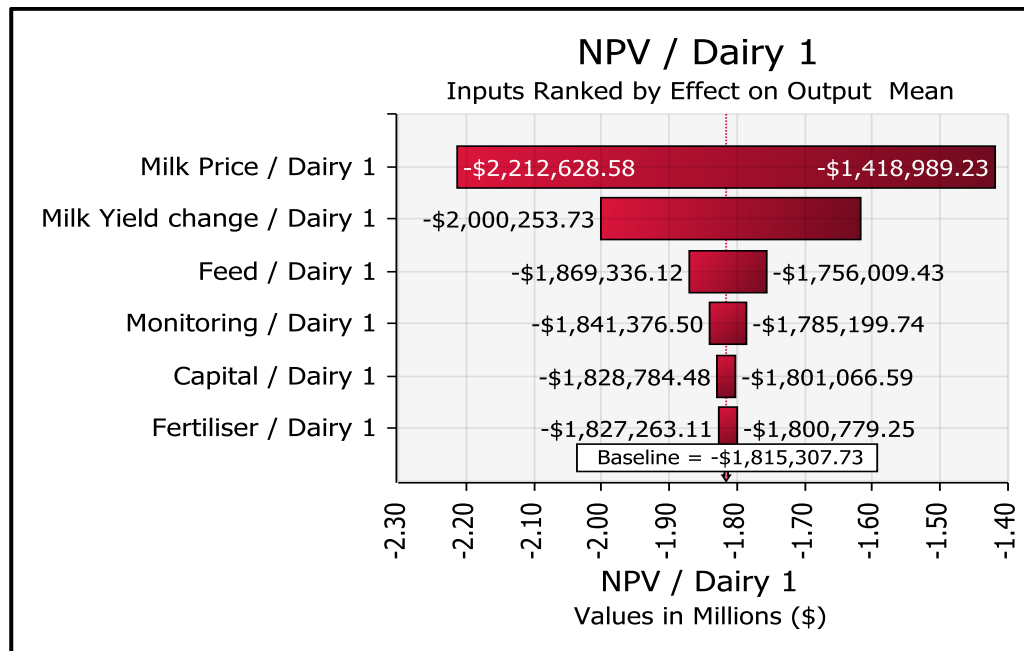
Tornado graph and table highlighting BMP maize, spinach, lettuce, spring onion, and cabbage rotation.



Change in Output Statistic for NPV / Spinach Spring Onion Cabbage			
Rank	Name	Lower	Upper
1	Cabbage Price / Spinach Spring Onion Cabbage	-\$5,201,209	-\$3,655,630
2	Cabbage Yield Change / Spinach Spring Onion Cabbage	-\$4,837,732	-\$4,045,777
3	Lettuce Price / Spinach Spring Onion Cabbage	-\$4,530,799	-\$4,311,001
4	Catch Crop Price / Spinach Spring Onion Cabbage	-\$4,513,217	-\$4,331,171
5	Lettuce Yield Change / Spinach Spring Onion Cabbage	-\$4,490,729	-\$4,372,804
6	Spring Onion Price / Spinach Spring Onion Cabbage	-\$4,489,348	-\$4,385,345
7	Spinach Yield Change / Spinach Spring Onion Cabbage	-\$4,474,655	-\$4,374,818
8	Spring Onion Yield Change / Spinach Spring Onion Cabbage	-\$4,469,749	-\$4,392,768
9	Catch Crop Yield Change / Spinach Spring Onion Cabbage	-\$4,460,980	-\$4,386,466
10	Spinach Price / Spinach Spring Onion Cabbage	-\$4,467,455	-\$4,399,053

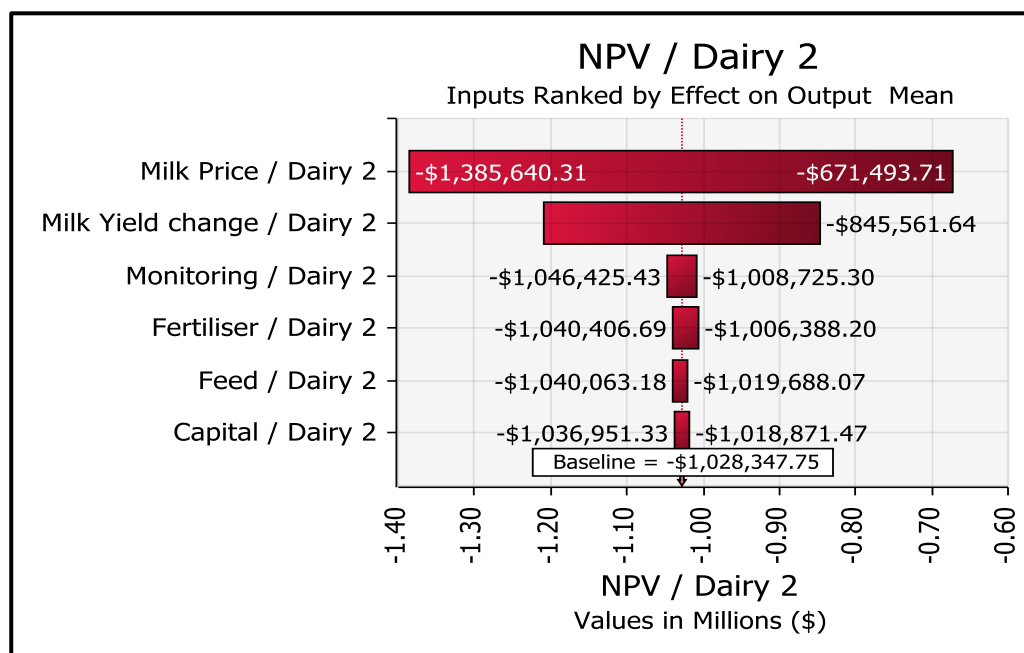
Dairy Farms

Tornado graph and table highlighting dairy cluster 1.



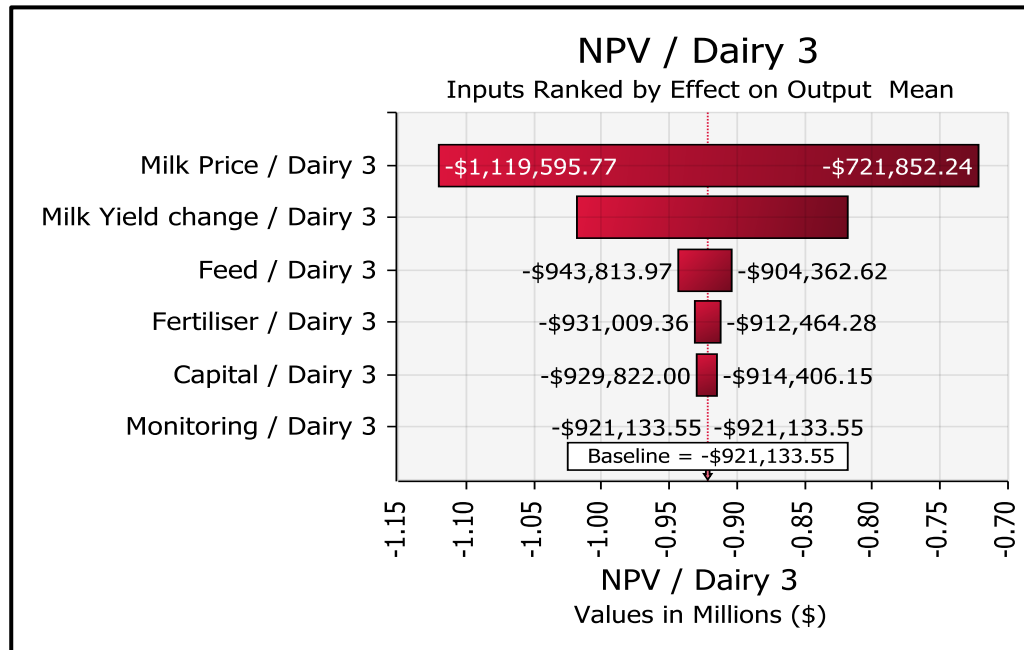
Change in Output Statistic for NPV / Dairy 1			
Rank	Name	Lower	Upper
1	Milk Price / Dairy 1	-\$2,212,629	-\$1,418,989
2	Milk Yield change / Dairy 1	-\$2,000,254	-\$1,616,626
3	Feed / Dairy 1	-\$1,869,336	-\$1,756,009
4	Monitoring / Dairy 1	-\$1,841,376	-\$1,785,200
5	Capital / Dairy 1	-\$1,828,784	-\$1,801,067
6	Fertiliser / Dairy 1	-\$1,827,263	-\$1,800,779

Tornado graph and table highlighting dairy cluster 2.



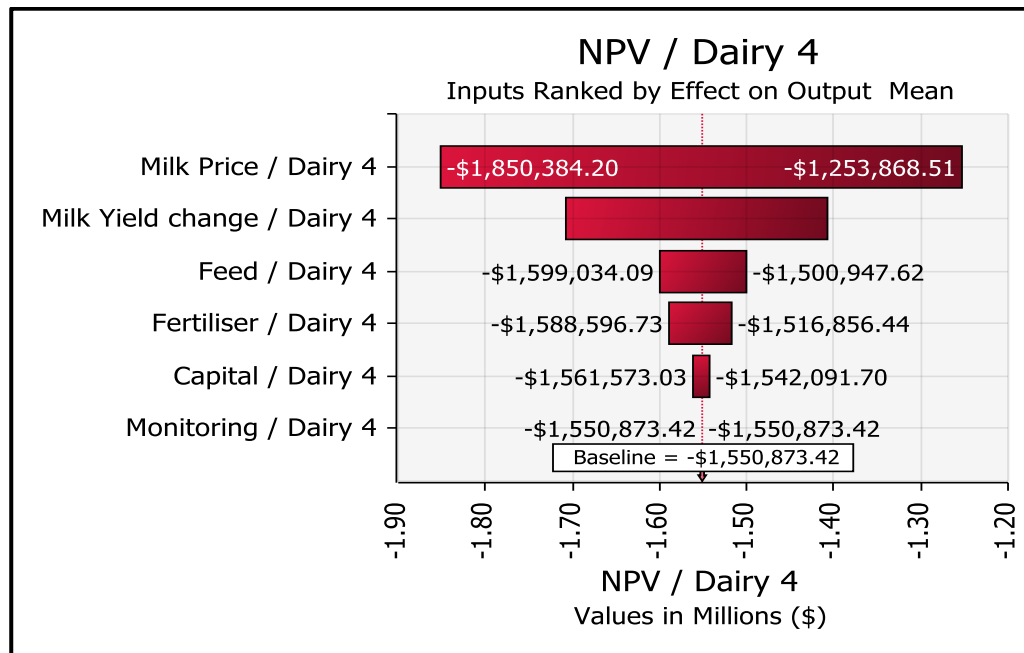
Change in Output Statistic for NPV / Dairy 2			
Rank	Name	Lower	Upper
1	Milk Price / Dairy 2	-\$1,385,640	-\$671,494
2	Milk Yield change / Dairy 2	-\$1,209,240	-\$845,562
3	Monitoring / Dairy 2	-\$1,046,425	-\$1,008,725
4	Fertiliser / Dairy 2	-\$1,040,407	-\$1,006,388
5	Feed / Dairy 2	-\$1,040,063	-\$1,019,688
6	Capital / Dairy 2	-\$1,036,951	-\$1,018,871

Tornado graph and table highlighting dairy cluster 3.



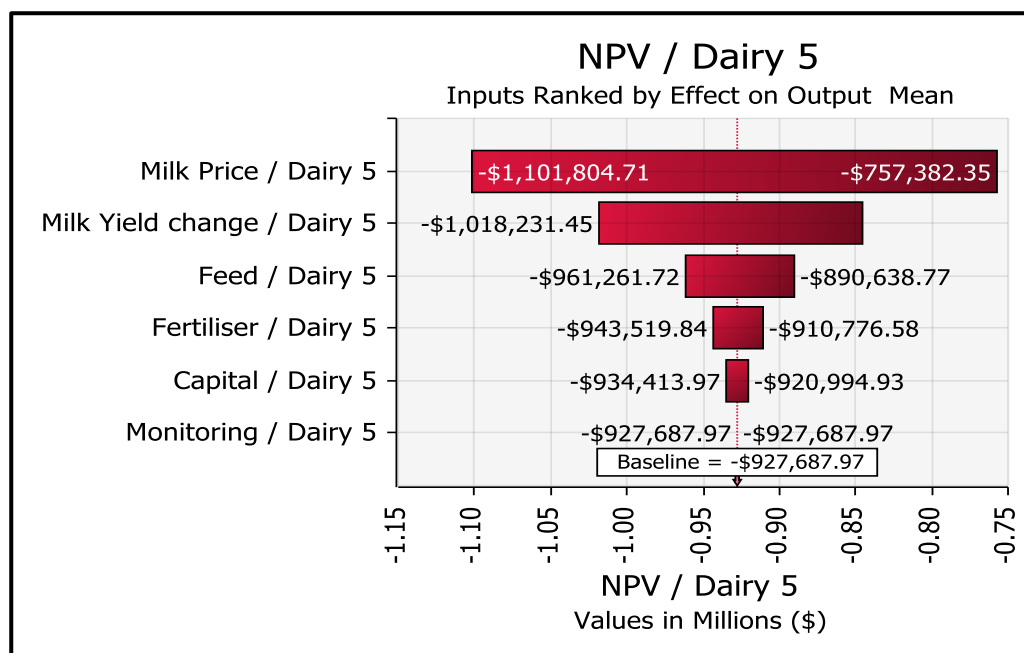
Change in Output Statistic for NPV / Dairy 3			
Rank	Name	Lower	Upper
1	Milk Price / Dairy 3	-\$1,119,596	-\$721,852
2	Milk Yield change / Dairy 3	-\$1,018,014	-\$818,872
3	Feed / Dairy 3	-\$943,814	-\$904,363
4	Fertiliser / Dairy 3	-\$931,009	-\$912,464
5	Capital / Dairy 3	-\$929,822	-\$914,406
6	Monitoring / Dairy 3	-\$921,134	-\$921,134

Tornado graph and table highlighting dairy cluster 4.



Change in Output Statistic for NPV / Dairy 4			
Rank	Name	Lower	Upper
1	Milk Price / Dairy 4	-\$1,850,384	-\$1,253,869
2	Milk Yield change / Dairy 4	-\$1,708,005	-\$1,407,865
3	Feed / Dairy 4	-\$1,599,034	-\$1,500,948
4	Fertiliser / Dairy 4	-\$1,588,597	-\$1,516,856
5	Capital / Dairy 4	-\$1,561,573	-\$1,542,092
6	Monitoring / Dairy 4	-\$1,550,873	-\$1,550,873

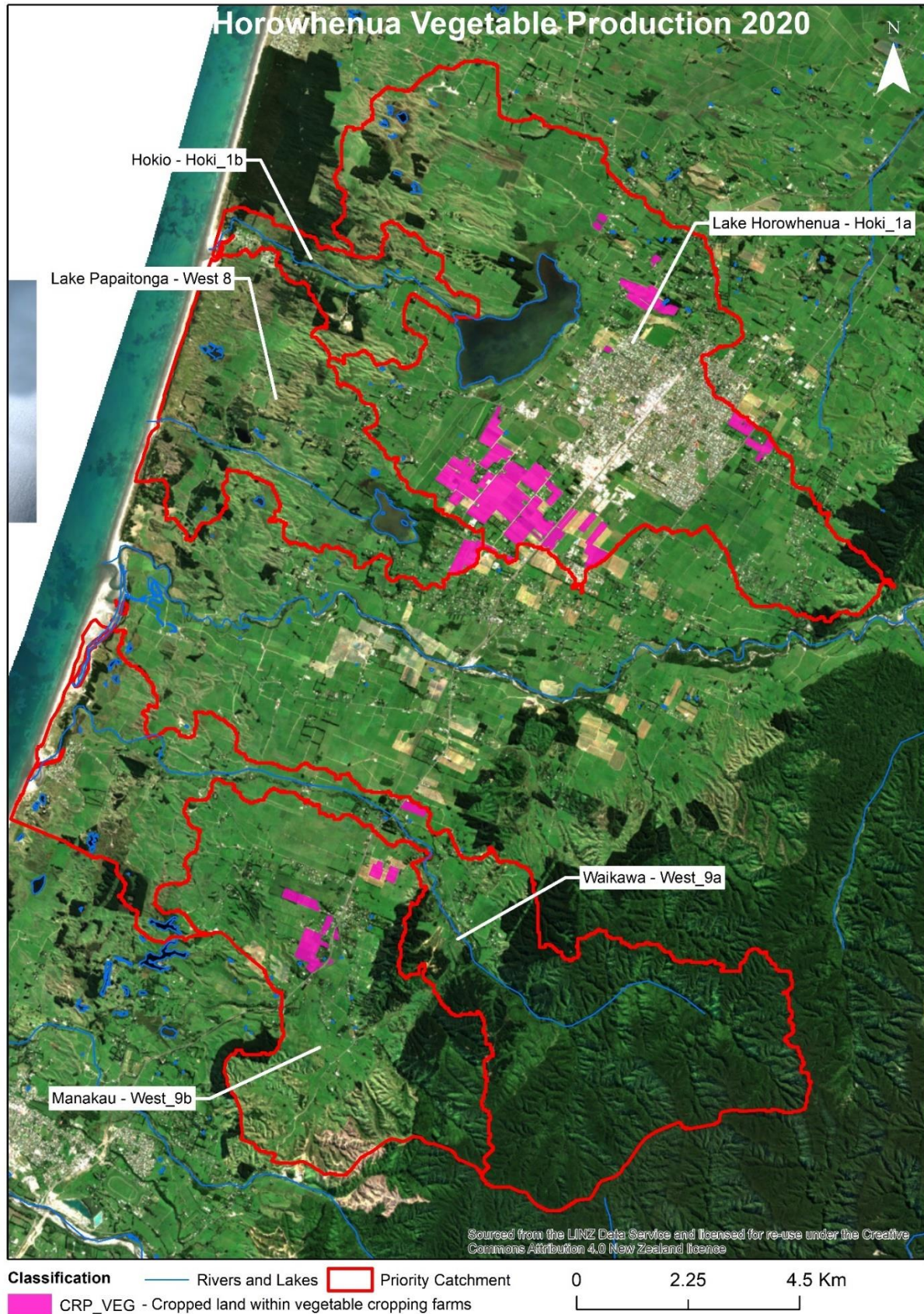
Tornado graph and table highlighting dairy cluster 5.



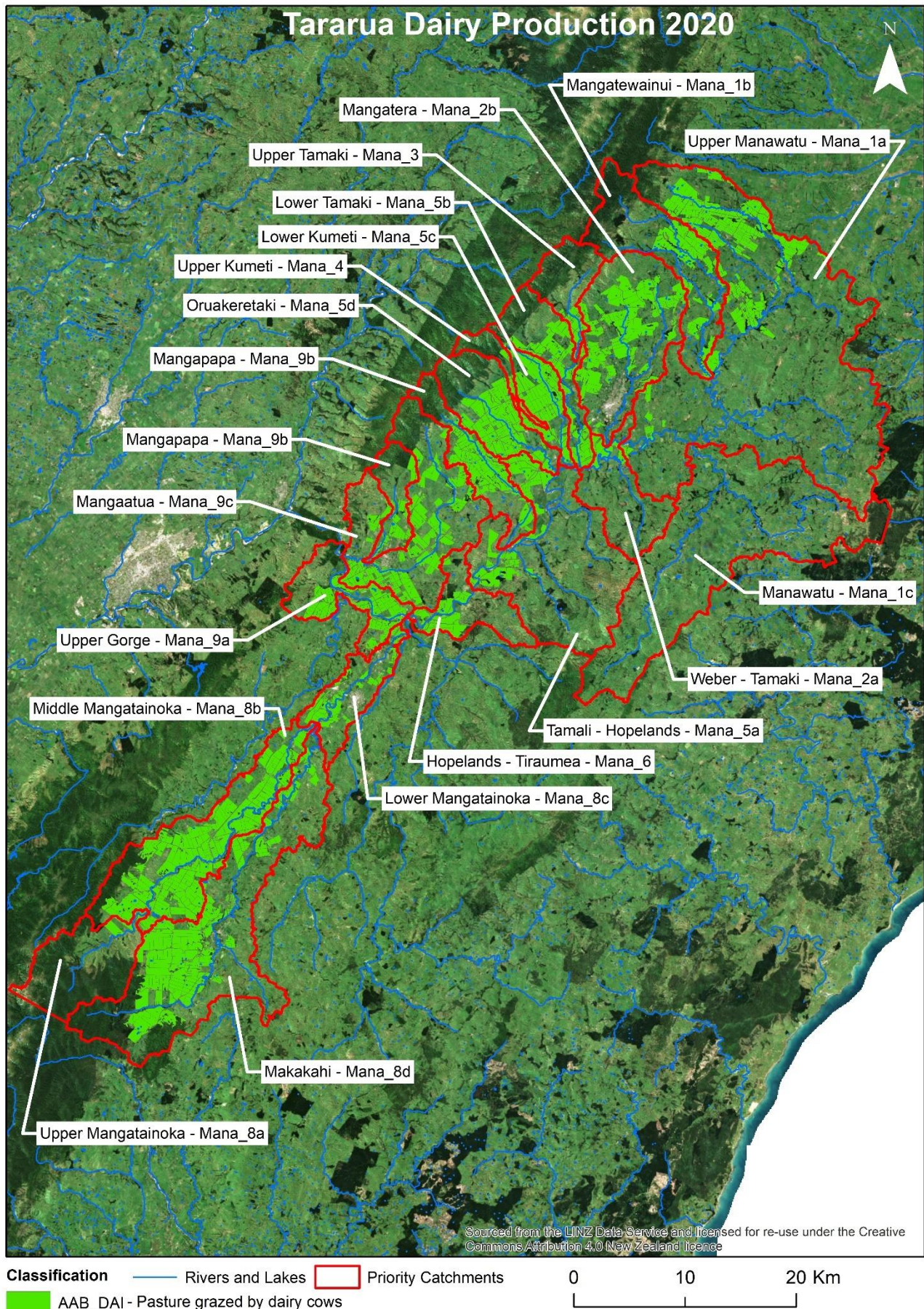
Change in Output Statistic for NPV / Dairy 5			
Rank	Name	Lower	Upper
1	Milk Price / Dairy 5	-\$1,101,805	-\$757,382
2	Milk Yield change / Dairy 5	-\$1,018,231	-\$845,442
3	Feed / Dairy 5	-\$961,262	-\$890,639
4	Fertiliser / Dairy 5	-\$943,520	-\$910,777
5	Capital / Dairy 5	-\$934,414	-\$920,995
6	Monitoring / Dairy 5	-\$927,688	-\$927,688

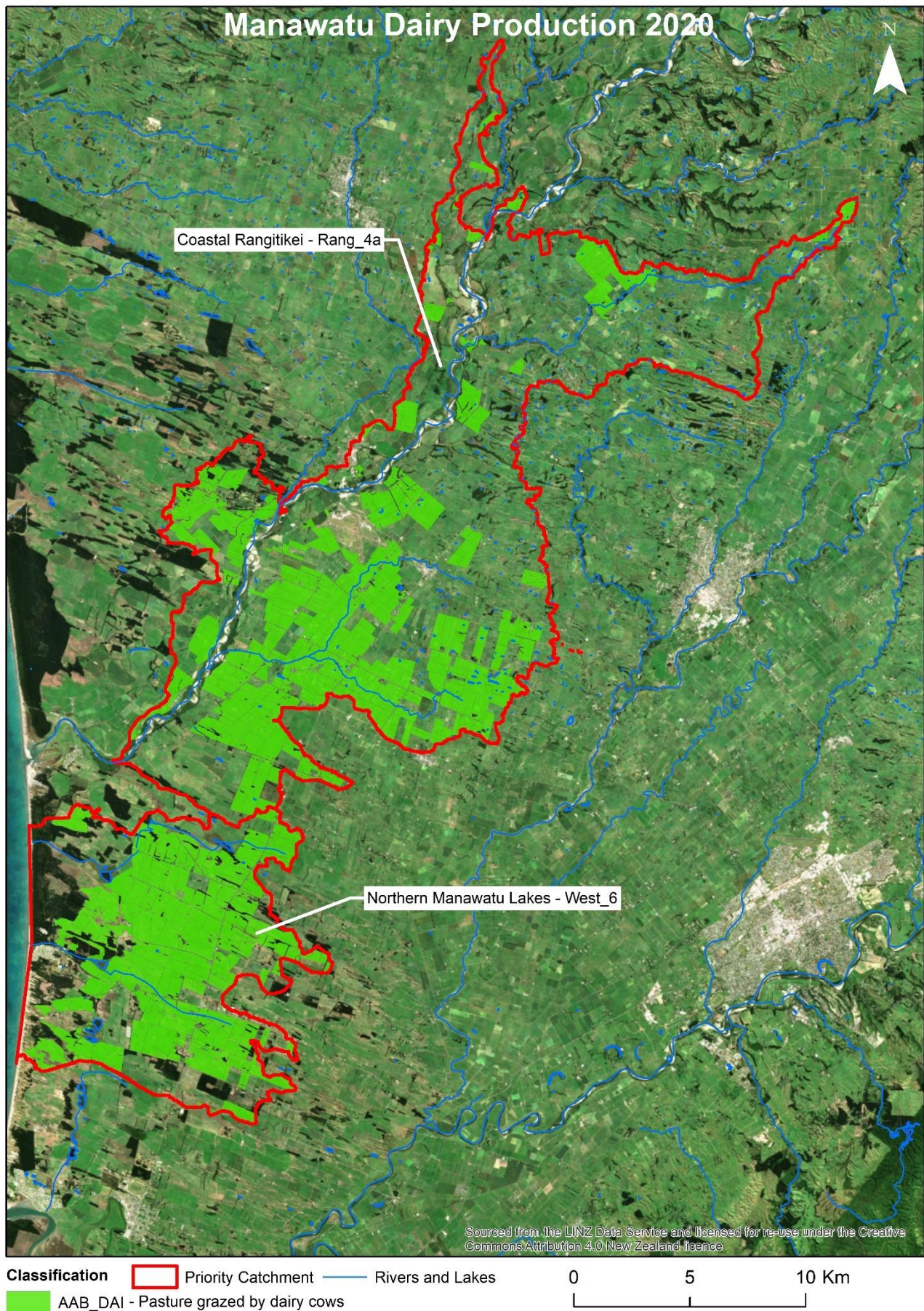
Appendix J Map of CVG Area in Priority Catchment in Horowhenua District

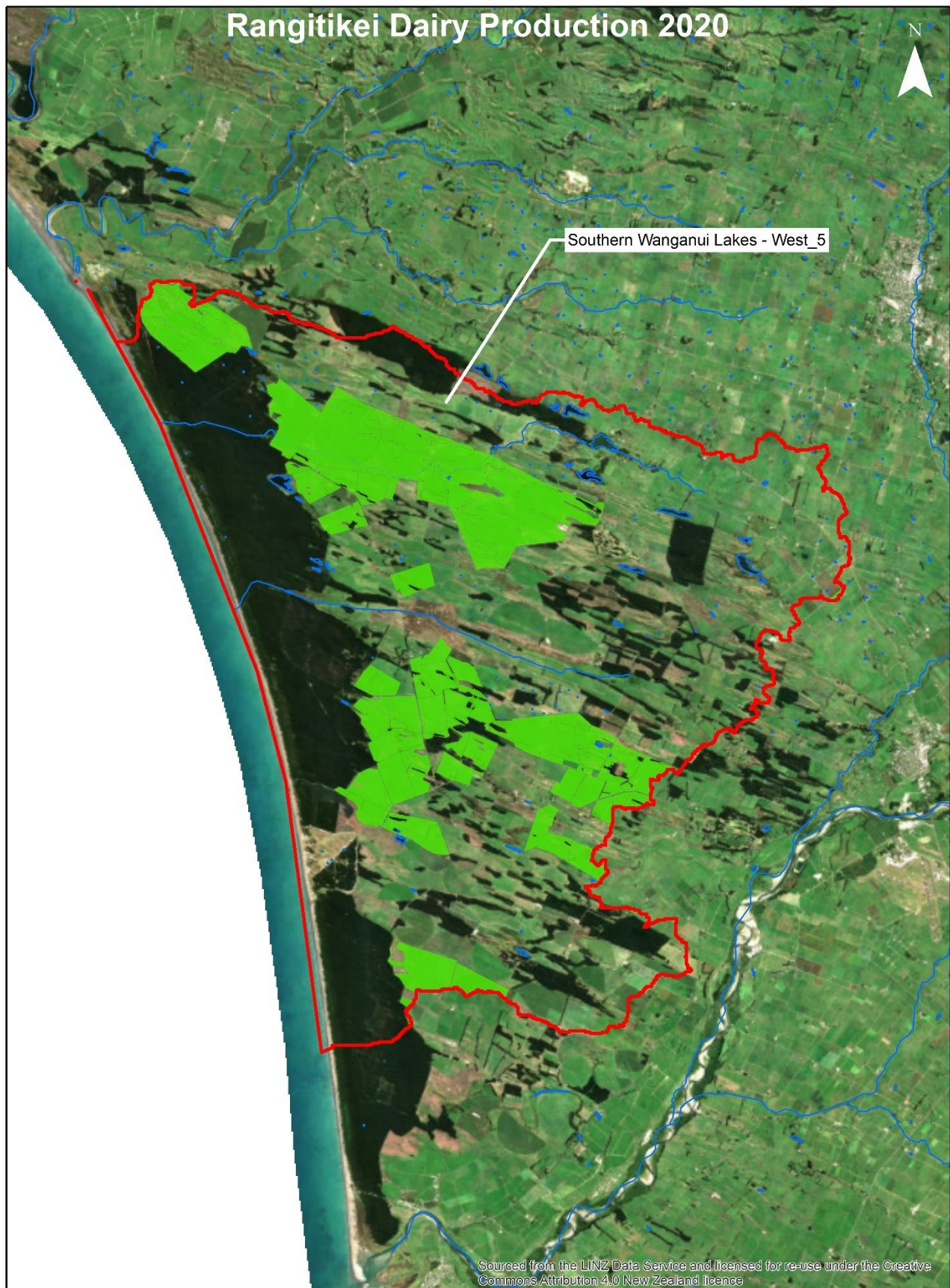
(all CVG farming areas not just over 4 ha)



Appendix K Maps of Dairy Areas in Priority Catchments in Horizons Regions

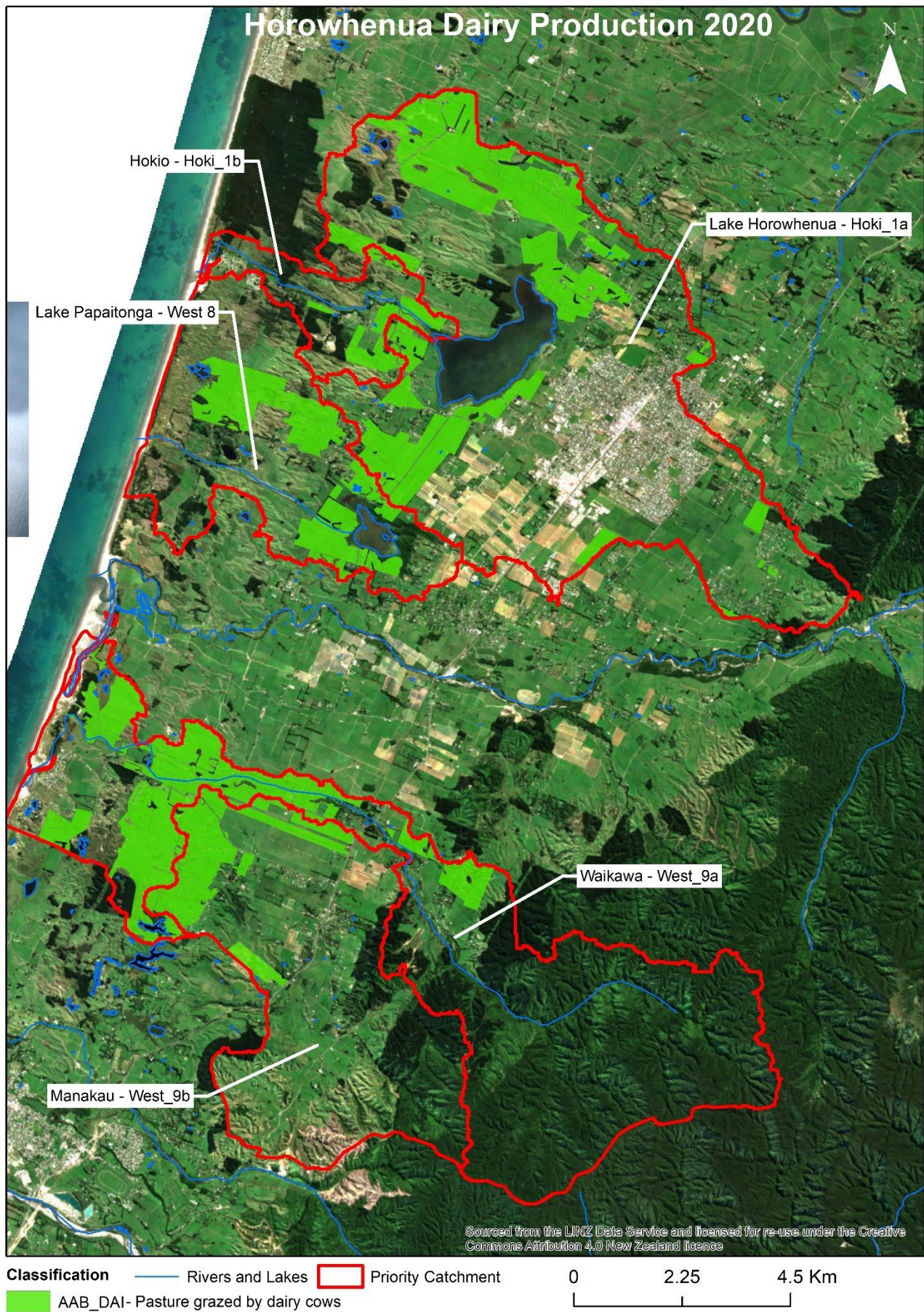






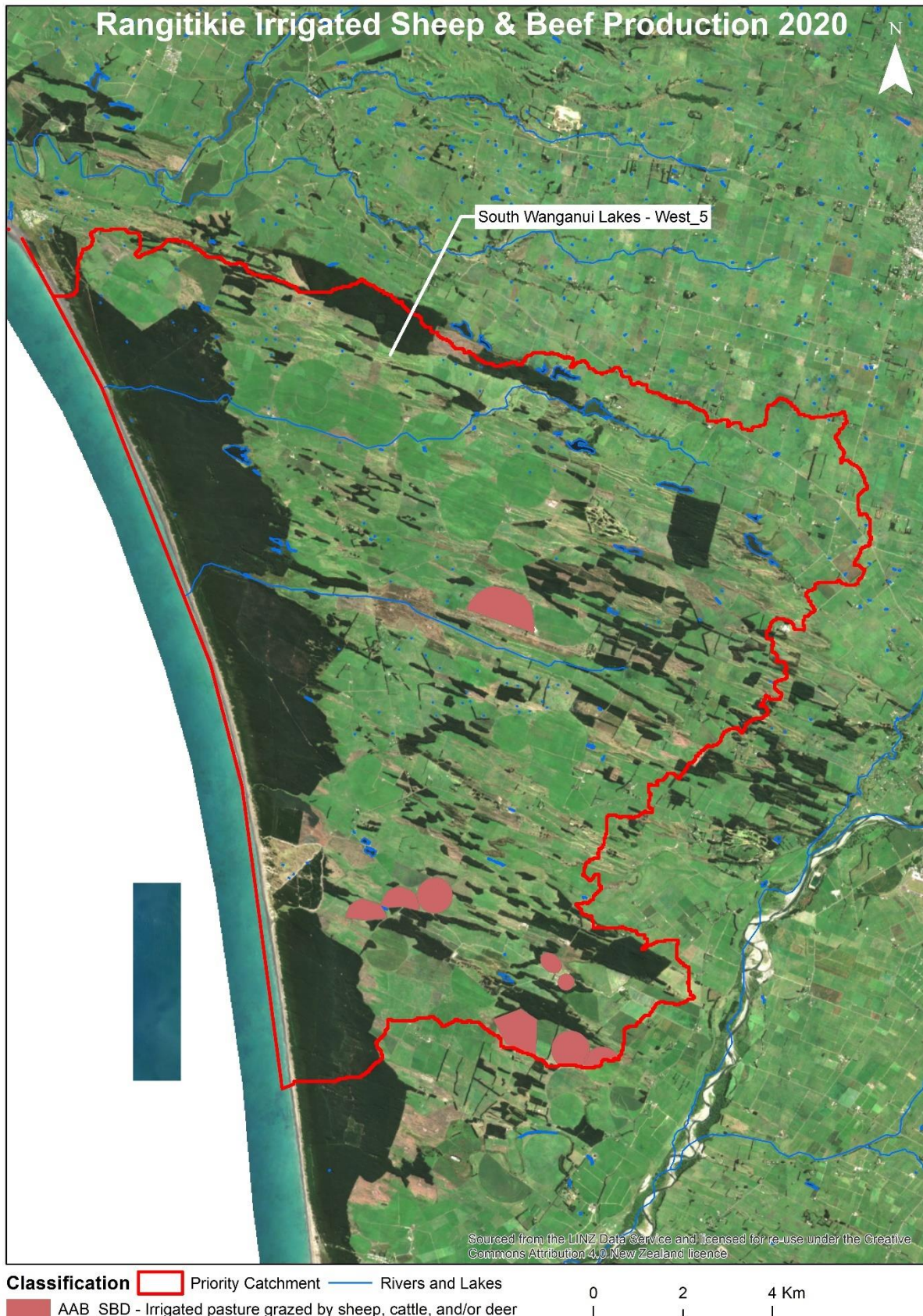
Classification Priority Catchment — Rivers and Lakes
 AAB_DAI - Pasture grazed by dairy cows

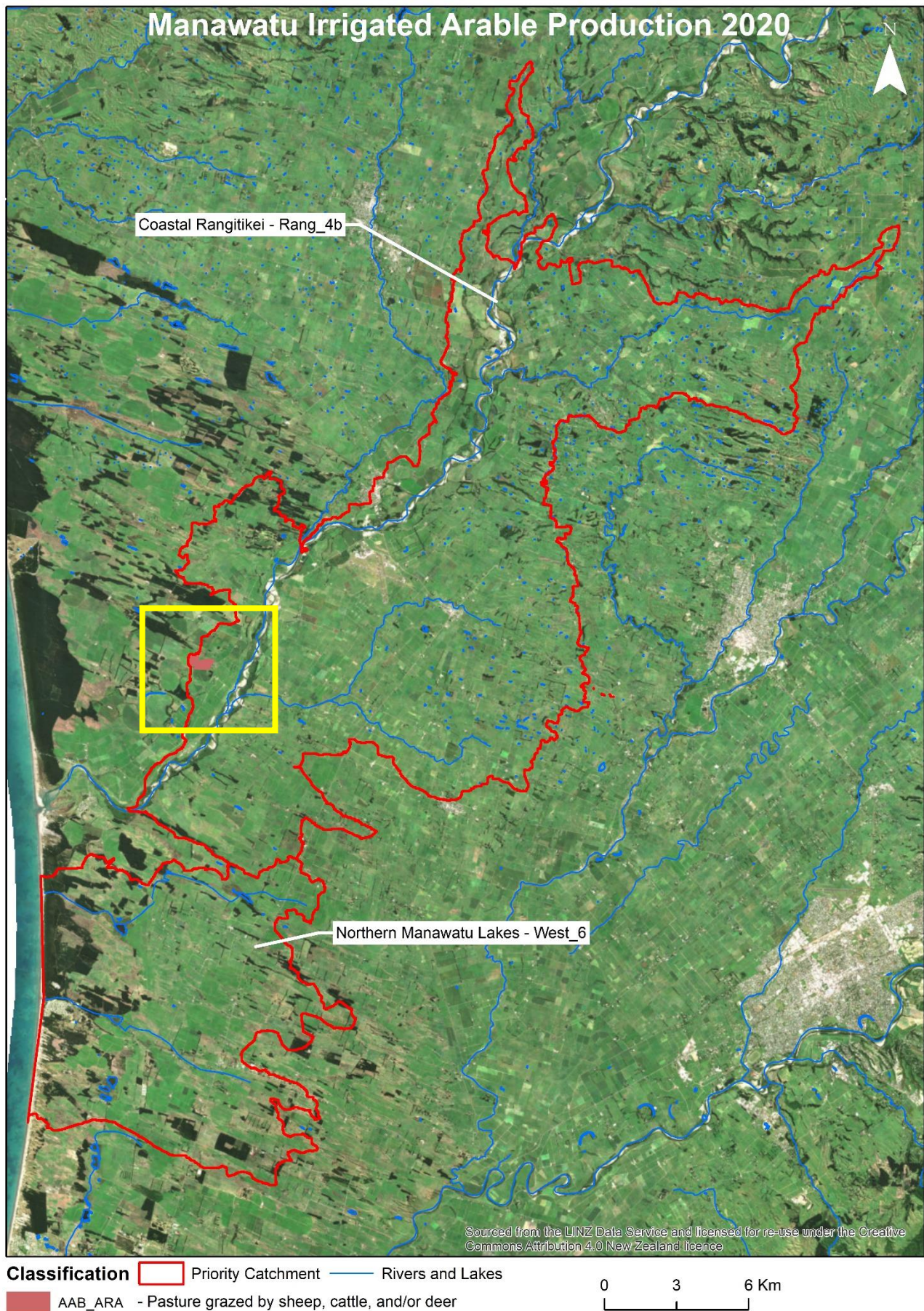
0 3 6 Km
|-----|-----|



Appendix L Maps of Irrigated Sheep and Beef Areas in Priority Catchments in Horizons Regions

(all irrigated sheep and beef farming areas not just over 4 ha also excluding Foxton wastewater application)





Appendix M Maps of Arable Areas in Priority Catchments in Horizons Regions

(all arable farming areas not just over 20 ha)

