BEFORE THE HEARING COMMISSIONERS APPOINTED BY WAIKATO REGIONAL COUNCIL

IN THE MATTER	of the Resource Management Act 1991 ("**the Act**")
AND	
IN THE MATTER	of the hearing of submissions on The Proposed Waikato Regional Plan Change 1 – Waikato and Waipa River Catchments

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INDUSTRY STATEMENT OF MICHELLE KATHLEEN SANDS FOR HORTICULTURE NEW ZEALAND

9 JULY 2019

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SUMMARY

1. This industry statement outlines the position of Horticulture New Zealand (HortNZ) on the Waikato Regional Council's Block 3 Section 42A Report to the submission on the Proposed Waikato Regional Plan Change 1 – Waikato and Waipa River Catchments (PC1).

2. We support the long term and short term objectives to improve the water quality in the Waikato River catchment.

3. The supply of vegetables to feed our domestic population over the life of the PC1 is essential to maintain human health. Vegetables grow in rotations to maintain crop and soil heath.

4. We have designed a CVP policy and rule framework that manages water quality risks, and provides for human and soil health. We are of the view the secondary benefits associated with CVP advance the Vision and Strategy and should be provided for.

5. low intensity horticulture such as fruit production, is modelled is having lesser water quality effects than alternative land uses on similar land. Some times these operations occur over multiple properties.

6. Low intensity horticulture presents a low emissions alternative land use for farmers who will be considering options to reduce methane emissions during the life of the PC1.

7. We have designed a low intensity horticulture policy and rule framework that manages water quality risks, and may help contribute to lesser climate impacts on future generations. We are of the view the secondary benefits associated with low intensity horticulture advance the Vision and Strategy and should be provided for.

Qualifications and experience

8. My name is Michelle Kathleen Sands. I am the Manager Natural Resources and Environment, with Horticulture New Zealand. I manage HortNZ's Natural Resources and Environment team who are involved in national, regional and district planning processes across New Zealand. I have been in this role since May 2018. I have the qualifications and experience set out in my evidence for Block 2.

9. Since beginning my role at HortNZ, I have met with growers across New Zealand to better understand their horticultural operations and how resource management issues impact them.

10. I have represented HortNZ at central government policy discussions on highly productive soils, the essential freshwater review and integrated farm planning.

11. While I am a qualified hydrologist and a water quality scientist, I am not appearing in the capacity of an expert in this hearing. My role in this hearing is as HortNZ's representative and advocate.

Purpose and scope of evidence

12. This statement provides commentary on the Officers' s42A Report for Block 3 and the likely implications for commercial vegetable production.

13. This statement covers:

    a. River Health - and the need to consider the magnitude of potential effects and mitigations at a range of scales

    b. Human Health - and the need to provide for commercial vegetable production to meet population demand over the life of the plan

    c. Soil Health - and need to provide for crop rotation to maintain soil quality and recognise the importance of leased land arrangements to CVP

    d. Climate Change - and the need to provide for opportunities for farmers to transition to lower emissions alternative land uses.

    e. Implementation - for policies and rules to be effective they need to drive better practices and be enforceable

    f. Transitional Plan – to enhance Te Mana o Te Wai beyond the life of the PC1 will require a different allocation system. This should be clearly signalled in the plan.

CVP HORTNZ POLICY AND RULES – ALIGNMENT WITH VISION AND STRATEGY, RPS, AND PC1 OBJECTIVES

14. This section discusses the proposed policy and rules for CVP outlined in the evidence of Vance Hodgson and Chris Keenan and how they align with the Vision and Strategy, the RPS and the PC1 water quality objectives, informed by the technical analysis of Tim Baker and Stuart Easton.

15. The approach we have proposed seeks the same water quality outcome as PC1. We also provide for soil health through crop rotation and human health through provision of vegetables. In my view the approach we have proposed is better aligned with the Vision and Strategy of the Plan.

Healthy Water

16. To inform PC1 NIWA developed a water quality model of the Waikato that enables the link between the unattenuated discharge of nitrogen, phosphorus and *E. Coli* and instream water quality, at the subcatchment, FMU and Waikato River catchment scales.

17. HortNZ worked with NIWA to obtain the calculations supporting the PC1 water quality modelling. The calculations undertaken by the Jacobs team, presented by Tim Baker and Stuart Easton, has been reviewed by NIWA, and found to be consistent with the NIWA PC1 modelling.

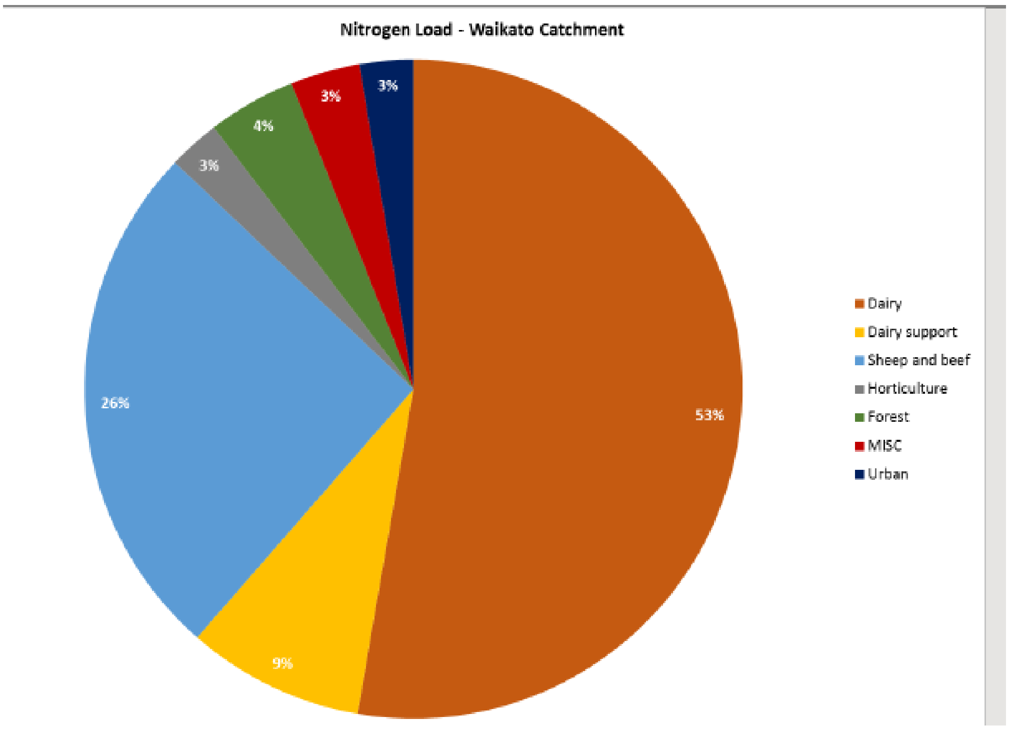
<u>*Nitrogen*</u>

18. The NIWA modelling predicted nitrogen losses from land use activities and accounted for instream attenuation to predict River concentrations.

19. The NIWA modelling can be used to calculate the load at the Waikato Catchment scale. CVP contributes less than 3% of the nitrogen load of the Waikato River, most of this is in the Lower Waikato so for most of the Rivers length, CVP has no impact. The 3% contribution to the load is relevant when considering the effect of CVP on the estuary. At the estuary the impact of CVP is very minor.

20. Figure 1 below, taken from the technical report submitted with the HortNZ submission, compares the Waikato River nitrogen load from sectors that was used in the NIWA modelling underpinning PC1.

Figure 1: Modelled Nitrogen Load – Waikato Catchment (Jacobs, 2017)



21. The NIWA modelling can be used to calculate the load at an FMU scale, The contribution of CVP to the FMU load is: 7% in the Lower Waikato, 1% in the Waipa, 4% in the Central Waikato, and 1% in the Upper Waikato.

22. The FMU scale is relevant, because this is the scale that the NPSFM envisages water quality is managed at. The NPSFM Objectives A2: The overall quality of fresh water within a freshwater management unit is maintained or improved. In the preamable, the following stated: "*This national policy statement allows some variability in terms of freshwater quality, as long as the overall freshwater quality is maintained within a freshwater management unit*".

23. The NIWA modelling shows that of the 30 subcatchments, where CVP is present, the CVP nitrogen load is more than 20% of the total subcatchment nitrogen load in three catchments, these are at Tuakau Bridge, Ohaeroa and Whakapipi. This scale is useful for assessing impacts at a subcatchment scale, for example Waikato River tributaries.

24. The NIWA modelling assumed that CVP had the highest leaching rate of all land uses. The leaching rates assumed in the NIWA modelling were based on three proxy rotations and based on modelling undertaken by Stuart Ford[1]. This assessment of discharge loads at the property scale considers localised impacts, for example headwater streams.

25. The planning framework in PC1 used the property scale leaching estimates as a proxy for effects across all scales. This method probably worked reasonably well for dairy, which had relatively high leaching at a property scale and therefore contributed the highest load. However, it does not work for CVP, and has resulted in a rule framework that treats the activity that contributes the least to the Waikato River nitrogen load with the strictest rule framework.

26. The assessment described in Stuart Easton's and Tim Baker's evidence indicates that CVP could expand to provide for the projected Waikato population growth and CVP land lost to urban in the Waikato (11%), and only result in increases in nitrogen load of 0.2% at the catchment scale, less than 0.5% at the FMU scale and less than 1% at the subcatchment scale.

27. When the improvements associated with PC1 are accounted for, this small increase in nitrogen load can be accommodated within the required PC1 reductions. Improvements in nitrogen load associated

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[1] Ford, S. (2014). Nutrient Performance and Financial Analysis of Lower Waikato Horticulture Growers.

with all CVP moving to GMP, is predicted to reduce the nitrogen increase to 0.09% of the Waikato River nitrogen load. When the improvements associated with reducing dairy above the 75th percentile are accounted for, the reduction in the Waikato River nitrogen load is -2.5%.

Phosphorus

28. The NIWA modelling predicted phosphorus losses from land use activities and at a subcatchment scale, calculated phosphorus bound to subcatchment sediment loads.

29. The methodology means that it is not possible to use this modelling to determine a change in phosphorus with an increase in CVP.

30. The average phosphorus loss rates assumed in the NIWA modelling was the same for CVP and dairy.

31. The phosphorus bound sediment would be removed with sediment treatment.

32. The analysis described in the evidence of Stuart Easton predicts no or very little change in phosphorus with an increase in CVP.

E. coli

33. The NIWA modelling predicted *E. coli* losses from land use activities and accounted for instream attenuation to predict River concentrations.

34. Vegetable growing has very little *E. coli* associated with it. In the NIWA modelling the contribution of CVP to the Waikato River *E. coli* load is less than 3.5% in all subcatchments, and less than 2% at FMU and Waikato River catchment scale. Therefore, increases in CVP could be expected to result in reduced *E. coli* loads when activities that generate E. coli are replaced with CVP.

Sediment

35. It was not possible to use the NIWA sediment modelling to assess the impact of CVP relative to other activities because the NIWA sediment modelling was based on the NZEEM model and did not differentiate bare earth from pasture. Therefore, it could not demonstrate a change in erosion from a change in the area of cultivated land.

36. In the Jacobs technical report[2] submitted as part of the HortNZ submission, a bare earth analysis was undertaken of the Mangaone catchment. In that catchment, the landuse and bare soil analysis

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[2] Jacobs. (2017). Healthy Rivers Plan Change Technical Support for Horticulture New Zealand's Submission.

indicates that horticultural land, while likely to have a higher proportion of bare earth compared with other land uses, is likely to make up only small fraction of the bare earth on farm land within the Waikato Region, due to its small footprint. In the Mangaone catchment, horticulture makes up 2% of the landuse, bare earth makes up 5% of the land within the catchment. The Jacobs estimate was that the horticultural landuse makes up approximately 30% of the bare earth within the catchment, which means that 70% of the bare earth is part of other land uses. This analysis highlights that sediment generation from cultivated land is not just an issue that is associated to the horticulture sector.

37. To assess the impact of an increase in CVP land on sediment loads discharges at different spatial scales, Stuart Easton relied on the 'Don't Muddy the Water' research described in Andrew Barber's evidence. This research has found that with BMP (sediment ponds), the sediment losses from CVP land are less than sediment loads discharged from pasture.

38. Therefore, increases in CVP, provided they are treated with sediment ponds, can be expected to result in reduced sediment loads.

Water Quality Summary

39. The assessment undertaken, has shown the increase in CVP could result in improvements in water quality for all contaminants above that assumed in PC1, except for nitrogen. Improvements consistent with PC1 objectives for nitrogen are still expected.

40. To manage the potential effects of nitrogen we have proposed methods, to cap the increase in nitrogen at the sub catchment and FMU scale, so the increases are negligible and exceeded by the decreases in nitrogen proposed in the other rules.

41. In addition, Tim Baker has assessed the sub catchments with soils that are suitable for CVP and identified nine sub-catchments where due to current water quality issues additional CVP is not recommended to be included within the proposed restricted discretionary cap.

42. The approach is consistent with Objectives 1 and 3 of PC1, because it seeks to achieve long-term a restoration and protection as well as short-term improvement of water quality for each sub-catchment and FMU to achieve the water quality states across all contaminants. It is also consistent with Objective 6, because it directs new CVP away from Whangamarino.

Healthy Soil

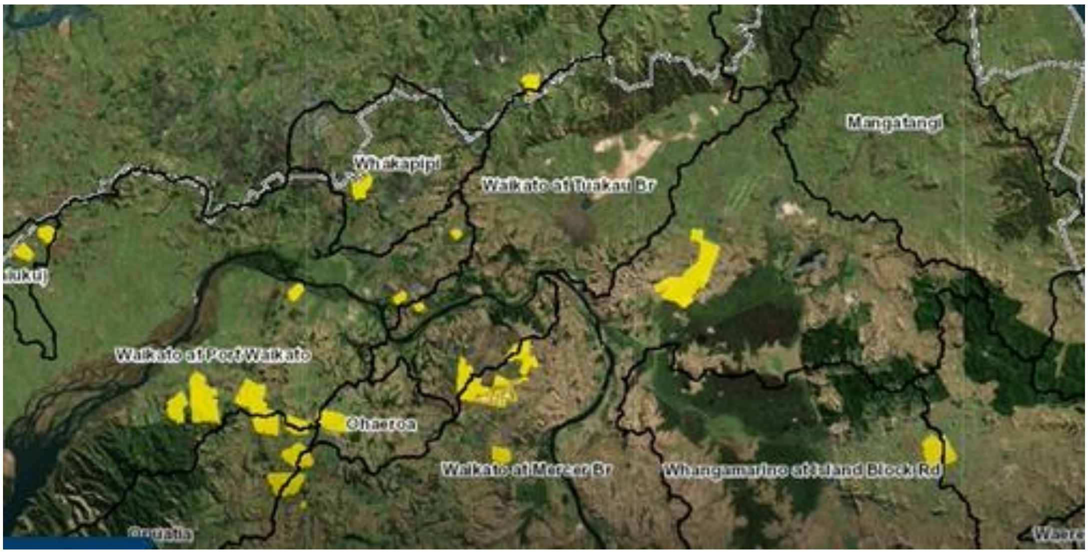
43. Growing the same crop in the same location, results in poor crop performance. This is because depletion of the soil nutrients will occur over time. The growth of some crops is suppressed by self-emitted

metabolites if they are not grown in rotations with other crops. Some rotations include legumes, which fix atmospheric nitrogen to be used by following crops in the rotation. Some crops with deep strong roots are useful for opening channels deeper in the subsoil than the harvested crop might penetrate. A pasture phase can improve soil structure by adding organic matter to the soil.

44. Rotating crops breaks pest and disease cycles by removing host material for a period and reducing pest populations. Some crops and their residues can act as soil bio-fumigants. In NZ there are certain sorghum and brassica species used in this way.

45. Below is an image of a single growers blocks within the lower Waikato. This grower has blocks in 7 sub-catchments within the FMU, and some blocks straddle the sub catchment boundaries.

Figure 2 North Waikato - a CVP Operation.



46. A large proportion of CVP land is leased, for example for the grower above 27% of the land is leased. As leases expire, under the Block 3 approach in the Section 42A report, growers will be forced to seek an equal or smaller piece of land to lease within the sub-catchments that they currently occupy, or seek a non-complying consent.

47. In my view, the approach proposed in the Section 42A, would likely result in a reduced area in CVP in the Waikato over the life of the plan, and will drive growers into more constrained crop rotations where lease arrangements change. This is likely to result in measurable decline in soil health.

48. The RPS Policy 14.1 maintain or enhance the life supporting capacity of the soil resource, and includes managing the soil resource to: maintain or enhance biological, chemical and physical soil properties; and retain soil versatility to protect the existing and foreseeable range of uses of the soil resource.

49. We have proposed a pathway for existing crop area to rotate across subcatchments within an FMU. This provision is essential to provide for many of the existing growers who grow crops across sub catchments, and grow in this way to manage pests and maintain soil health.

50. In my view, providing for growers to operate their rotations across FMU's is consistent with the RPS because crop rotations maintain and enhance the biological, chemical and physical soil properties. Some soil diseases can leave soils with reduced uses for many years, for example Potato Mop Top Virus (currently in Canterbury), can live in the soil for up to 18 years. Supporting CVP rotations is essential to retain soil versatility.

Estimation of Land where Vegetable growing can occur

51. Land suitable for vegetable growing requires a number of factors, suitable climate and soils and access to clean water, labour and infrastructure.

52. The types and timing of crops grown will depend on the climate, so in the north of the Waikato Region, where it is frost free vegetables can be grown year around, further south the growing season will be more constrained and the crops that can be grown will differ.

53. In the work undertaken by Stuart Easton he has used LUC I and LUC II. The land actually suitable for growing would be much less than all of the LUC I and II identified.

54. The main purpose of identifying the potential vegetable growing footprint is to enable the calculation of the NRP for land that was leased to CVP during the baseline period and then moves out of CVP during the life of the plan. The method used to estimate this NRP is discussed in the evidence of Mr Easton.

55. In my view this approach is consistent with RPS Policy 14.1 because it provides a mechanism for land that was leased to CVP during the baseline period to retain its versatility by providing a mechanism to allocate nitrogen to that land without increasing the overall sub catchment nitrogen load.

Healthy People

56. The evidence of Stuart Ford indicates that to meet the proposed offsetting requirements in Block 3, the price of vegetables would need to increase by between 16 % – 50%.

57. Affordability is a key factor in why people eat less than the recommended intake of vegetables. The provisions proposed in the Section 42A would likely result in a reduction in existing vegetable growing and very limited new vegetable growing. This will be

insufficient to meet growing demand with an increased population. The reduced availability of vegetables and an increased price would impact on the health of the most vulnerable people.

58. The Waikato Region has a higher Maori population than the national average (22.9% compared to 15.8%) and has more people in the most deprived population (25% in Quintile 5 – most deprived and 24% in Quintile 4) compared to the national average (20% respectively)[3]. In 2013/2014, Waikato had the highest proportion of obese adults in New Zealand (34.4%).[4]

59. A 2019 Ministry of Health study, has analysed household food insecurity among children in New Zealand, many of these children live in the Waikato.[5]

60. 174,000 (19%) children in NZ are estimated to live in food insecure households. When considering just the children in food insecure households, almost two-thirds lived in the two most deprived quintiles of neighbourhoods (Quintiles 4 and 5: 63.3%).

61. There were marked differences in the prevalence of household food insecurity by ethnicity. Pacific and Māori children had the highest prevalence of household food insecurity.

62. Of Māori children, over one in four (28.6%) lived in food-insecure households. Conversely, of children in food-insecure households, over one in three (38.8%) children were Māori. As Māori children made up 25.7 percent of the total child population based on the New Zealand Health Survey estimates, this means Māori children were overrepresented in the food-insecure group.

63. There is an extensive body of research indicating that children experiencing household food insecurity have lower fruit and vegetable intake, diets higher in fat, and are at an increased risk of obesity.

64. The health benefits of fruit and vegetables are well documented but include protection against heart disease, strokes, high blood pressure, obesity and diabetes[6]. Low fruit and vegetable intake is identified as a leading risk factor in loss of health. In New Zealand, having a high body

[3] https://www.health.govt.nz/new-zealand-health-system/my-dhb/waikato-dhb/population-waikato-dhb

[4] http://socialreport.msd.govt.nz/health/obesity.html#regional-differences

[5] https://www.health.govt.nz/system/files/documents/publications/household-food-insecurity-among-children-new-zealand-health-survey-jun19.pdf

[6] Vegetables.co.nz. https://www.vegetables.co.nz/health/the-cost-of-low-consumption/

mass index (i.e. being overweight or obese) has overtaken tobacco as a leading cause in health loss.[7]

65. Stuart Easton estimates that 15% more CVP area would be required to meet the growing population of Auckland and Waikato, and an increase of 11% to just meet the Waikato population demand and CVP land lost earmarked to be lost to urban in the Waikato.

66. The evidence of Vance Hodgson proposes a restricted discretionary activity for new commercial vegetable growing capped at a level to provide for the predicted population growth in the Waikato and to replace vegetable growing land earmarked for urbanisation in the Waikato.

67. The Vision and Strategy envisages a future where a healthy Waikato River sustains abundant life and prosperous communities who, in turn, are all responsible for restoring and protecting the health and wellbeing of the Waikato River, and all it embraces, for generations to come.

68. Te Mana o Te Wai, recognises the values of Mana Atua and Mana Tangata in the past, present and future. The mauri of water is part of its intrinsic value. The physical health of people is an intrinsic value. The health and the mana of people and the health and mana of the River are intertwined.

69. The health and mauri of water, recognises the value of clean fresh water for human activities and needs, the value recognises humans as part of the Waikato ecosystem.

70. The cultivation and primary production value recognises the value of food production, and this would include vegetables for domestic supply.

71. The CVP policy framework proposed by HortNZ seeks to maintain peoples' access to healthy vegetables through the life of the plan, while achieving improvements in water quality through the life of the plan. The health benefits of providing vegetables for a growing Waikato Population, can be considered a secondary benefit in the context of Policy 17 (which is concerned with the wider context of the Vision and Strategy), because it advances the Vision, Strategy and values.

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[7] Health Loss in NZ 1990 – 2013. https://www.health.govt.nz/publication/health-loss-new-zealand-1990-2013

LOW INTENSITY HORTICULTURE HORTNZ POLICY AND RULES – ALIGNMENT WITH VISION AND STRATEGY, RPS, AND PC1 OBJECTIVES

72. This section discusses the proposed policy and rules for CVP outlined in the evidence of Vance Hodgson and Chris Keenan and how they align with the Vision and Strategy, the RPS and the PC1 water quality objectives, informed by research undertaken by Plant and Food Research.

Healthy Water

73. As outlined in the Block 2 evidence of Andrew Barber, we consider a range of horticultural crops can be considered low intensity for water quality. These crops contribute little or no *E. coli*, are not subject to frequent cultivation so have lesser sediment risks, and have relatively low leaching risks.

74. The risk of leaching is also more easily managed for perennial crops such as fruit trees and asparagus, where the fertiliser needs of the crop, (the available nitrogen in soils and the fertiliser need) can be more readily matched.

75. Attached to my evidence is a recently published Plant and Food report[8]. This report calculated nitrogen balances from a survey of asparagus growers in the Waikato, and found, using a simple N surplus, the average surplus was 11.4kg/ha. In my view asparagus would better meet the definition of low intensity horticulture than the definition of the CVP.

76. The Section 42A also discusses glasshouse crops. These should be excluded from the definition of CVP.

77. The current definition includes legume crops such as peas and beans. In New Zealand these crops are usually grown for processing in arable rotations, and given they fix nitrogen are associated with low fertiliser use. There is currently no processor based in the Waikato and process vegetables are unlikely to be grown in the Region during the life of the Plan. However, if there were, these crops would be low intensity.

78. In the evidence of Chris Keenan, he discusses recent work undertaken by Zespri to measure and model leaching from Kiwifruit.

79. It is the view of HortNZ that enabling new low intensity horticulture as a permitted activity is consistent with the Vision and Strategy and the

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[8] Hunt, A, Dellow, S. 2019 Evaluation of nitrogen mass balances for Waikato asparagus growers.

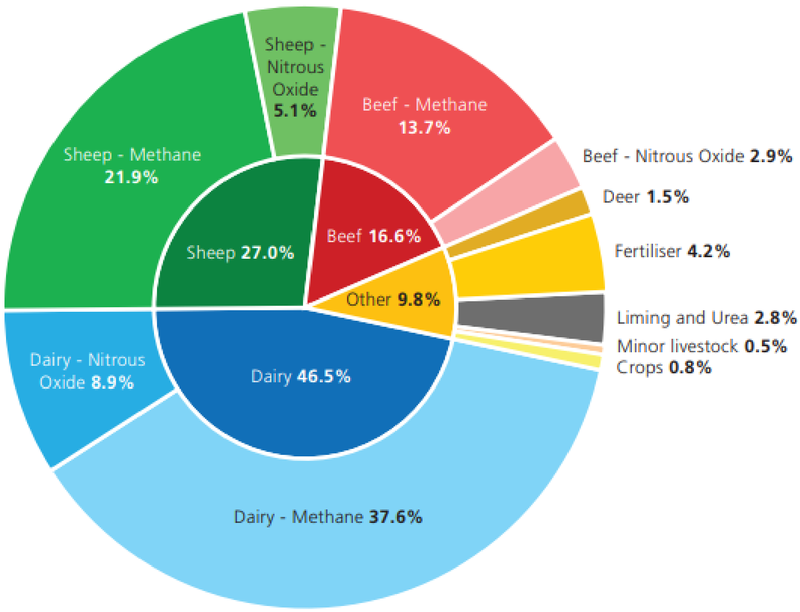
objectives of PC1, because it is likely to result in improvements in water quality at a sub catchment, FMU and catchment scale.

Healthy Climate

80. Nearly half of New Zealand's greenhouse gas emissions come from agriculture.

81. The main source of agriculture emissions is methane from livestock digestive systems. It makes up almost three quarters of our agriculture emissions. The third largest source is manure management, the various agricultural sectors contribution to agricultural greenhouse gas emissions are illustrated in Figure 3 below.

Figure 3 Profile of domestic biological emissions showing relative contributions of industry and gas (2016)[9]



82. Dairy is the sector with the largest contribution, followed by Sheep and then Beef.

83. The Climate Change Amendment (Zero Carbon) Bill, has identified the purpose to:

    provide a framework by which New Zealand can develop and implement clear and stable climate change policies that contribute to the global effort under the Paris Agreement to limit the global average temperature increase to 1.5° Celsius above pre-industrial levels;

[9] https://www.mpi.govt.nz/dmsdocument/32125-berg-report-final-for-release-6-dec

84. The targets proposed in the Bill to give effect to that purpose include a proposed reduction in methane of 10% by 2030, which is within the life of the PC1.

85. The reductions required to achieve this level of reduction would likely require increased efficiency and given this efficiency could not be replaced by increased productivity without increasing emissions, the reduction in methane is likely to facilitate some shifts in land use.

86. On suitable land, horticulture presents an opportunity for farmers to reduce their emissions with diversification.

87. The RPS identifies the effects of Climate Change (Issue I1.2) and states:

The effects of climate change (including climate variability) may impact our ability to provide for our wellbeing, including health and safety.

88. While determining actions to reduce climate change may be a central government role, when these actions include land use diversification, that action needs to be supported by local government, with action to both reduce and adapt to the threat of climate change.

89. The Vision and Strategy recognises the Waikato River as a treasure to all generations. Climate Change threatens serious and irreversible damage to the Waikato River, the whole world and all future generations.

90. In my view, an exception to provide a permitted activity pathway for low intensity horticultural activities achieves the water quality objectives in PC1 and achieves the secondary benefit, consistent with Policy 17, by providing opportunities to reduce greenhouse gas emissions and therefore contributes to efforts to reduce the impacts of climate change on the future generations.

Healthy People

91. The Eat-Lancet[10] found food is the single strongest lever to optimise human health and environmental sustainability and without action, the world risks failing to meet the UN Sustainable Development Goals (SDGs) and the Paris Agreement. The report recommended a transformation to healthy diets by 2050 requiring substantial dietary shifts, with global consumption of fruits, vegetables, nuts and legumes having to double, and consumption of foods such as red meat and sugar being reduced by more than 50%.

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[10] https://eatforum.org/eat-lancet-commission/eat-lancet-commission-summary-report/

92. The low intensity horticulture policy framework proposed by HortNZ seeks to achieve the secondary benefit of increasing the proportion of healthy food grown in the catchment, while achieving improvements in water quality through the life of the plan.

IMPLEMENTATION - RULES THAT DRIVE BETTER OUTCOMES

93. This section discusses the analysis of rules for CVP and low intensity Horticulture outlined in the evidence Chris Keenan, Stuart Ford, Andrew Barber and Damien Farrelly.

94. Developing regulations that provide for commercial vegetables has proven difficult for regional councils in recent years. It is important that PC1 does not perpetuate the problems that have occurred in other regions, for example in Manawatu and Canterbury where most new and many existing vegetable growing operations cannot be consented.

CVP baseline and benchmarks

95. The Section 42A acknowledges the difficulty of representing crop rotations within Overseer. The reasons, for this are described in the evidence of Stuart Ford.

96. The Officers proposed N surplus. In the evidence of Stuart Ford he discusses N Surplus calculated using Overseer. Vegetable growing is an efficient user of nitrogen compared with other farming systems because it produces so much more food on a per ha basis. It would be possible to provide a proxy N surplus from proxy rotations, but Mr Ford questions the practical purpose these surplus scores would serve.

97. In Mr Keenan’s evidence he discusses what might be required to develop a property scale N surplus that accounted for crop rotations. This is extremely complex and in my view unworkable.

98. As outlined in the evidence of Andrew Barber, matching fertiliser requirements to crop demand is a key principle in the HortNZ nutrient management guidelines. However, N surplus used in this way is crop specific and block specific and is most valuable as a decision support for growers.

99. In addition, there is not a way of calculating N surplus for many crops. The recently published report, Nutrient Management for Vegetable Crops has 15 crops, Overseer includes the same crops and an additional 4 crops. However, there are scores of crops grown in NZ that are not included, for example, of the vegetables listed in the CVP definition in the Section 42A report 44 of these are not included in either the Nutrient Management for Crops in New Zealand or Overseer, (more when the definition above from the 2019 Commodity Levy is used). Furthermore, the nutrient requirements of different varieties vary. The

Nutrient Management for Crops in New Zealand Manual[11] includes 3 varieties of Potatoes. There are 10 to 12 varieties that are commonly grown in NZ, and more than 30 varieties that are grown.

100. As outlined in the evidence of Stuart Ford and Chris Keenan, in our view the best way to define CVP is with the area of a representative proxy crop rotation, and an associated nitrogen load as a nitrogen reference point and to provide meaningful metrics that can be easily measured at the property scale both in the baseline period and going forward.

101. The recommend changes to Schedule B provide a framework for calculating a NRP for CVP, and for measuring the NRP limit for new CVP against the subcatchments limits proposed in Tim Baker's evidence. This is provided in Appendix A to my evidence.

Farm Environment Plans

102. The recommend changes to Schedule 1 in Damien Farrelly's evidence provide a framework for achieving high quality farm environment plans and provides a pathway for independent auditing for FEP's

Certified Farm Planners

103. We support the concept of certified farm planners for the development of FEPS. I have been provided HortNZ input into the national project looking at certification for people developing FEP's. HortNZ raised concerns about the proposed minimum qualifications requiring the Certificate of Completion in Advanced Sustainable Nutrient Management in New Zealand Agriculture from Massey University. The Course prescriptions is defined as follows:

> *An advanced knowledge of sustainable nutrient management is developed for common New Zealand pastoral and arable farming systems. A study guide and the Overseer® Nutrient Budgets software will assist participants to develop nutrient management plans for actual pastoral and arable farming enterprises. The aim is for each participant to produce sustainable nutrient management plans that meet production goals whilst minimising the negative effects of nutrient losses on the wider environment*[i]

104. The course is for *pastoral and arable farming systems. The* limitations of Overseer as a farm level decision support tool for CVP is well understood. Our view is this course should not be a prerequisite to develop a FEP for CVP, and therefore we support the alternative, assuming that course can include tertiary qualifications that horticultural agronomist hold.

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[11] Reid, J.B, Morton, J,D, 2019 Nutrient Management for vegetable Crops in New Zealand

105. Our proposal is that the certified criteria be altered as described in the evidence of Andrew Barber. Our view is that experienced people should develop FEPs, and the quality of FEPs is assured through independent auditing.

106. Given the development of a certified FEP is a condition of consent for growers, its essential that these plans can be developed.

Good management practice and minimum standards

107. The horticulture industry has developed codes of practice that outline good management practices and best management practices for:

- erosion and sediment control,
- nutrient management, and
- vegetable wash water

108. The codes of practice are underpinned by research that has been jointly funded by the government and the horticulture industry.

109. The minimum standards that were included in the notified version of PC1 are consistent with minimum practices that would be required to achieve GMP according to the HortNZ codes or practices, and would be required to be demonstrated to pass the NZGAP EMS audit.

Auditing

110. As outlined in the evidence of Damien Farrelly, the Global GAP and NZ GAP operate under the Joint Accreditation System of Australia and New Zealand auditing and assurance framework, which is accountable to the Minister of Commerce and Consumer Affairs.

111. The horticulture industry has recently developed an Environmental Management System (EMS) module for NZ GAP, to meet both market and regulatory environmental requirement.

112. Growers support the NZGAP process, because they are already operating under this process and it creates national consistency in environmental standards.

113. The EMS audit, would not require council to delegate its compliance function to EMS. The EMS audit would occur, the audit outcome could be passed to Council for both consented and permitted activities and this could be used by Council to inform the prioritisation of the audits and compliance check they undertake. We would anticipate they might seek to prioritise growers that don't meet the EMS audit standard, but we would also anticipate they would seek to audit a sample of growers that do pass the EMS audit process to calibrate expectations.

TRANSITIONAL PLAN

114. The Section 42A suggests deleting Policy 7. As outlined in the evidence of Chris Keenan, we see that PC1 should clearly state the allocation within the PC1 is transitional.

115. The CVP proposals we have put forward, will only meet the population demand until 2030, after that time a new plan with an allocation system that provides a pathway for achieving Te mana o Te Wai for future generations will be required.

Michelle Sands

9 July 2019

PFR SPTS No. 17767

Evaluation of nitrogen mass balances for Waikato asparagus growers

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Plant & Food Research: [1]Hawke's Bay, [2]Lincoln

April 2019















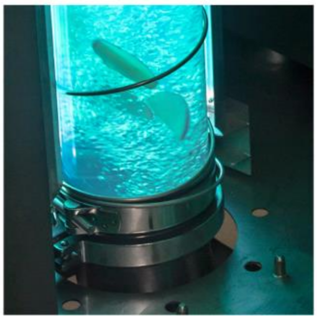


Report for:
Horticulture New Zealand

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LIMITED PROTECTION

PUBLICATION DATA

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1 INTRODUCTION

This report has been prepared at the request of Horticulture New Zealand (HortNZ) to better understand typical nitrogen (N) mass balances of asparagus crops in Waikato grown under current management. This information is pertinent to the New Zealand Asparagus Council (NZAC) who are looking to understand the potential impacts of current practices on water quality outcomes.

To undertake this mass balance assessment, The New Zealand Institute for Plant and Food Research Limited (PFR) designed a survey to define current N management practices of growers Waikato region of New Zealand. The data were gathered by HortNZ and returned to PFR for evaluation.

Previous research on asparagus production in New Zealand has principally focused on agronomic management practices such as crop establishment and harvest management, resulting in a decision support tool ‘Aspire’ developed by PFR. (Aspire Lite for Android smartphones). Investigations into the N response of asparagus within the New Zealand cropping context were undertaken by Wilson and Sinton (2005) as part of the Sustainable Farming Fund project ‘Improved profitability and sustainability in asparagus production’. They were unable to find consistent productivity responses to applied N and concluded that there was no benefit to applying high rates of N and in some cases rates of 200 kg N/ha may have suppressed yields.

2 APPROACH

2.1 Survey of current grower practices

A basic survey was designed by PFR to capture current grower practices relevant to N management of asparagus crops in the major production regions across New Zealand (Table 1). HortNZ contacted growers to gather responses and anonymised the data. This was carried out to protect the privacy of the cooperating growers. The data were taken as received for the purpose of this report."

Table 1. Survey questions used by HortNZ to gather data on current grower management practice for Asparagus production in the Waikato region.

Question	Example response
Name/Grower ID	Frank Smith (Name to be retained by HortNZ and substituted for an anonymised grower id e.g. "Grower A")
Region	Hamilton
Dominant soil type	Soil texture as a minimum (sandy loam) but ideally New Zealand soil classification from Smap
Area under production (establishing < 3 years old, established >3 years old)?	2 ha establishing 5.5 ha established
Oldest established crop	10 years old
How often do you soil test for N, what analysis and to what depth?	Mineral nitrogen (N), in spring, to a depth of 15 cm
Last 3 years' soil tests	Attached reports from Hill Laboratories Limited
How much irrigation is applied and when?	15 mm per week during summer
Gross yield harvested (removed from the field)	7 t/ha
Fertiliser practice on establishing crops	50 kg of urea in November
Fertiliser practice on established crops	100 kg of urea in January
Any additional inputs containing N?	2 t/ha compost, 4%N
How do you manage fern trash?	Mulch in April

2.2 Balance evaluation

The N balance (Nb) in kg N/ha was defined for each individual grower using the following equation:

$$Nb = Ni - Y * DM * Nc$$

Where:

Ni: N fertiliser Inputs (N kg/ha/year). (The amount of N applied each year by the grower to the crop)

Y: Fresh gross yield (t FW/ha)

DM: Dry matter content of spears (assumed to be 10%, Drost 2013)

Nc: N concentration in the harvested DM spears (assumed to be 5%, Drost 2013)

Therefore, a crop yielding 5 t/ha gross yield with a fertiliser input of 25 kg N/ha would have a net balance of 0 kg N/ha

$$0 \text{ kg N/ha} = 25 \text{ kg N/ha} - 5000 \text{ kg/ha} * 0.1 * 0.05$$

The following components are considered to have the potential to influence the N balance, but in the absence of sufficient data we have chosen to provide hypothetical contributions only, which are discussed in the results section of this report.

- Soil mineral N (the amount of immediately plant available N in the soil from previous management, residue decomposition or mineralisation of soil organic matter)
- Anaerobically minaralisable N (AMN) (the amount of future plant available N that could be mineralised from the soil organic matter)
- Seasonal change in plant biomass (both within season fern growth and below ground root growth).

3 RESULTS

3.1 Responses

There were a total of 11 grower survey responses (one grower broke their reporting into three parts, represented as Grower Aa, Ab and Ac) and a total of 303 ha under cultivation in the Waikato region. 75.5 ha of this was classified by growers as 'still establishing' (i.e. <3 years old) and 227 ha as 'mature plantings' (>3 years old). Fresh Facts (2017) has reported that the industry has 39 growers with plantings totalling 521 ha. This indicates that the survey has captured a substantial proportion of asparagus production in New Zealand. The responses have been coded as Letters A to N Note that the original survey extended outside the Waikato region, but these responses have been removed. In some cases growers chose not respond to some questions in the survey or provided responses which could not readily be incorporated in to the mass balance calculations. We have noted this when it has some potential bearing on the results.

3.2 Yield

Yield is a key component to be considered in the evaluation of the N mass balance as it has an important bearing on both grower profitability and the removal of N from the soil. Asparagus spear yields varied substantially among survey respondents from 0.1 to 10.0 t/ha (Figure 1). This is likely the consequence of variability in crop age and management. Fresh facts (2017) indicated that 1500 t were produced off 521 ha, which would equate to a mean yield of 2.9 t/ha.

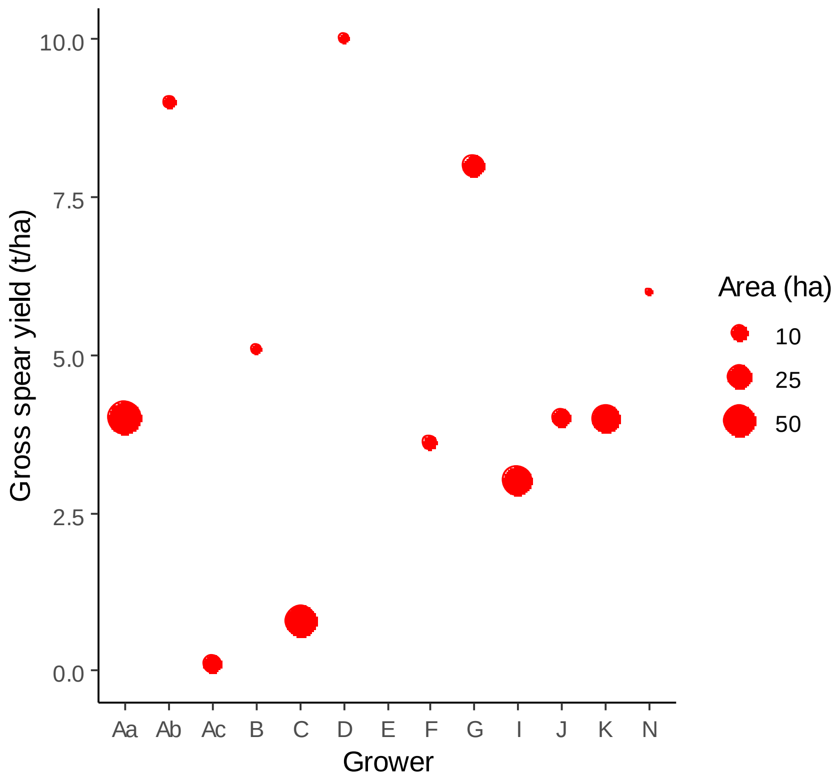

Figure 1. Gross spear yield (t/ha) for each survey response. The size of the point is scaled to the total production area of each grower.

The survey gathered responses from a wide range of crop ages. The intent was to look primarily at normal yielding crops, so responses indicating a yield of less than 1 t/ha have been removed from this point onwards in the analysis (growers Ac and C). After removing these extreme values, the area-weighted average gross yield is 4.4 t/ha.

3.3 Soil characterisation

All respondents characterised the predominant soil type of their production as light textured (sandy through to sandy loam). The soil analysis results provided by growers support this with lab bulk density less than 1 and as low as 0.6 g/mL (Figure 2). These soils are clearly preferred for asparagus production. From an N management perspective these soils are free draining and therefore susceptible to N leaching when rain exceeds evapotranspiration and nitrate is present. Average rainfall in the Waikato region is approximately 1250 mm per year and it is unlikely that evapotranspiration in asparagus crops will ever exceed this amount.

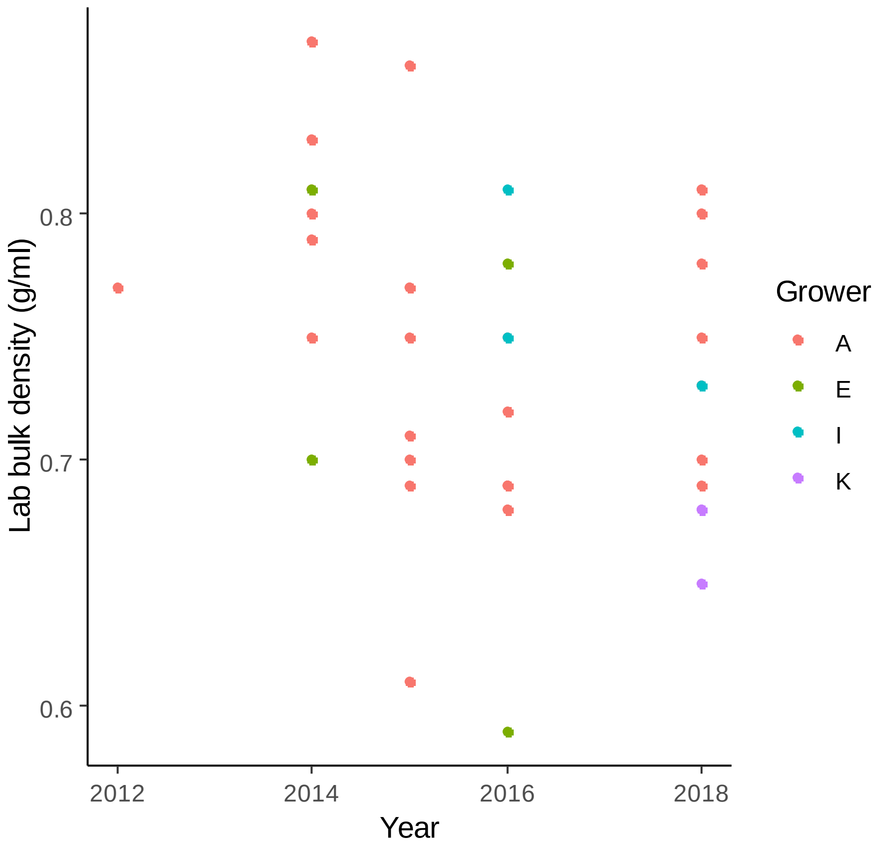

Figure 2. Lab bulk density (g/ml) results for all soil tests supplied by surveyed Waikato growers. Some growers did not provide soil tests.

Some of the surveyed growers provided soil tests which included measures of AMN. This gives an indication of the amount of N that could be mineralised from the organic N pool in the soil during a year. AMN values ranged from 23 to 144 kg N/ha (0–15 cm depth) (Figure 3).

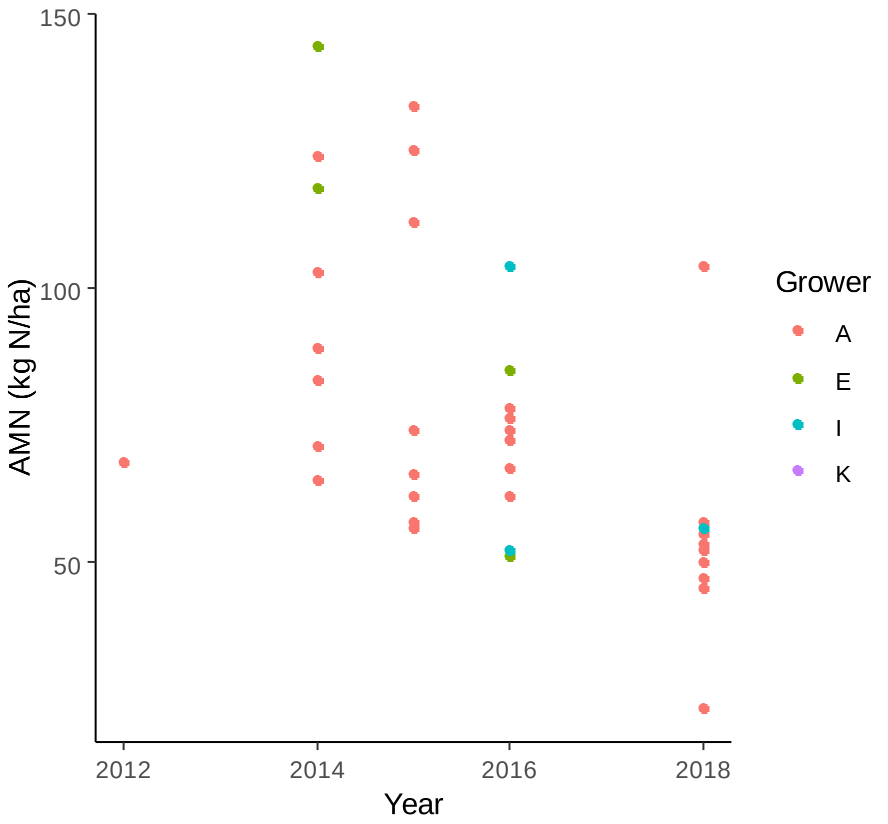

Figure 3. Anaerobically mineralisable N (AMN) (kg/ha, 0–15 cm) for all of the grower-supplied soil tests in the Waikato region. The colour of each point denotes the grower.

It is also worth noting that growers generally only soil tested the top 15 cm of the soil though much of the root mass and nutrient uptake of an asparagus crop will be well below this depth, with roots previously found below 80 cm of depth in New Zealand soils (Drost & Wilson 2003). Also, grower soil tests were generally carried out in winter and in most cases did not include analysis for mineral N (nitrate and ammonium), which is immediately available to plants and is the most susceptible to leaching. In combination, these factors could lead to an underestimation of the N available for crop growth thought the growing season.

3.4 N Inputs

The self-reported average fertiliser N applications described by the growers varied considerably from 0 to 137 kg N/ha/year (Figure 4). One grower reported applying as much as 209 kg N/ha in a single year, however this analysis has only used average application rates. Grower F did not indicate the N content of fertiliser inputs and has therefore been excluded.

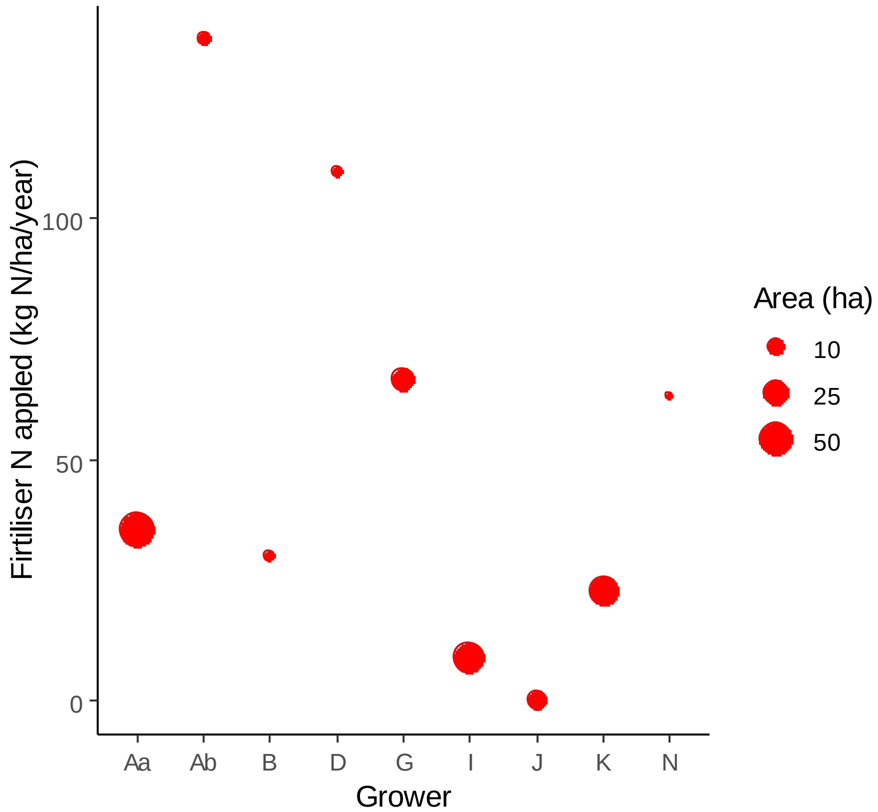

Figure 4. Fertiliser nitrogen (N) applied (kg N/ha/year) for each of the grower responses. The size of the point in scaled to the total production area of each grower. Most growers did not indicate the fertiliser inputs for establishing crops and therefore N input rates have been considered as uniform for each grower.

3.5 N mass balance

The diversity in N management practices has a strong influence on the estimated mass balance of each grower. This was calculated using a basic balance equation (see Section 2.2) using indicated yield and fertiliser application rates. Growers Ac and C were excluded due to their low yields, grower E because they did not indicate yield and grower F because they did not indicate N fertiliser inputs. The N mass balance of the growers varied from -20 kg N/ha/year (implying a net removal of N from the system) to 92 kg N/ha/year (implying that N is being applied to the system in excess of the N removed in spears harvested each year) (Figure 5). The weighted mean (for total area) across all growers was 11.4 kg N/ha/year. This estimate is highly dependent on the exclusion of some growers and increases substantially when growers yielding less than 1 t/ha are included. For instance, the inclusion of Grower C with an individual mass balance of 66 kg N/ha for 51 ha of production would double the weighted mean to 23 kg N/ha.

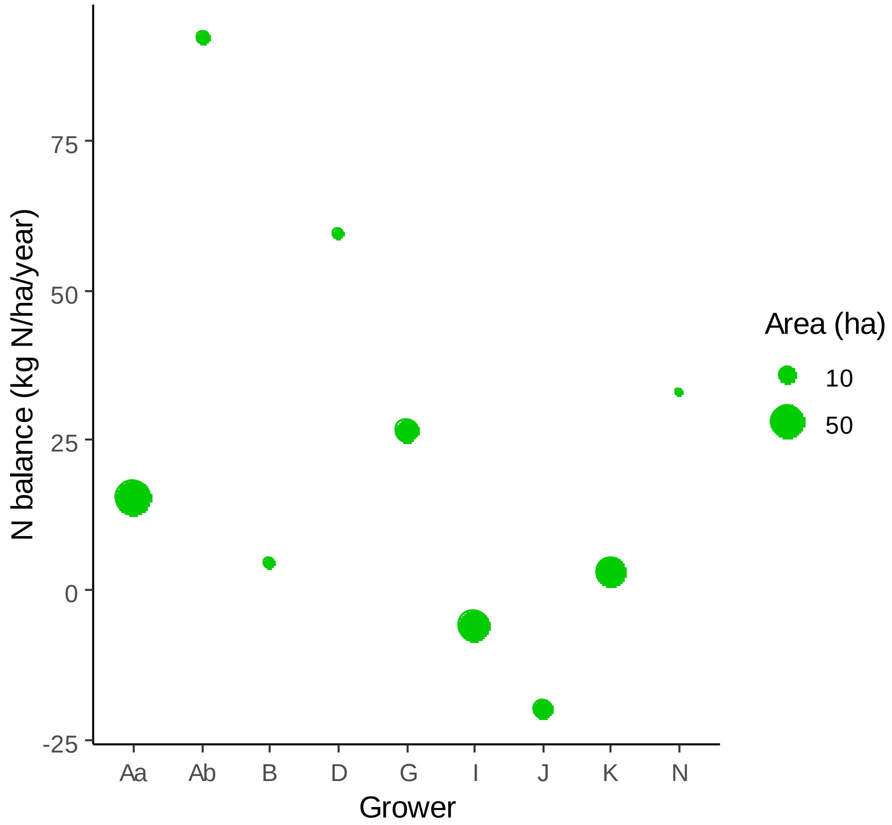

Figure 5. The nitrogen (N) balance for each grower in kg N/ha. The size of the point in scaled to the production area of each grower. The total area after exclusions is 187 ha.

Unmeasured components

The balance calculated above does not include all of the components of N in the production system but covers the extent to which the limited available data offers insight in to the full complexity of the N balance of an asparagus planting. We have included a discussion of other components of the balance not covered in the simple assessment below.

Soil N supply

The median AMN value from the grower-supplied soil tests was **69 kg N/ha** in the top 15 cm of soil**.** AMN provides an estimate of the N released though mineralisation during the growing season and is therefore available to the plant (and subsequently, at risk of leaching if not used by the plant).

Mineral N values were not reported by any growers. In spring these values are difficult to estimate without direct measurement and could vary substantially with depth through the soil profile. For the sake of this analysis we will use the value of **30 kg N/ha**. The actual value could be greater or less than this and would need to be sampled regularly in each field (ideally to 120 cm) to clarify.

Therefore, it is feasible that 100 kg N/ha could be added to the balance of the typical asparagus production system. These estimates would require further validation.

Plant N demand

In a fully established asparagus crop, substantial amounts of N are carried over between seasons in the below ground proportion of the plant and most of the N in fern growth is remobilised back into the below ground biomass during senescence, with the remainder returned to the soil. There is little data available in New Zealand to describe this process.

Hypothetically, during the establishment phase, when substantial plant biomass (root tissue) is accumulated each season, the addition of 3000 kg/ha of below ground DM would indicate a plant demand of **63 kg N/ha** in order to reach a tissue dry weight N concentration of 2%. This could vary substantially amongst crops and biomass accumulation expected to be at its highest during the 3ed and 4th year after planting.

Therefore, it is feasible that 63 kg N/ha could be subtracted from the balance of the typical asparagus production system during the most rapid growth phase (years 3 and 4), but this would decrease to 0 kg N/ha once the below ground biomass has stabilised.

4 DISCUSSION

The survey revealed a wide range of grower practices and yields among asparagus growers in the Waikato region of New Zealand.

In many cases, more N is being applied as fertiliser than is being exported from the field in asparagus spears each year. The fate of this extra N is difficult to assess without direct measurement of losses from beneath the root zone of the crop. In any one year a proportion of the N could be leached below the root zone, taken up by plants, bound up in organic forms, denitrified, volatilised or remain as mineral N within the soil.

The establishing crowns provide a potential sink for substantial quantities of N. As discussed in Section 3.5, vigorous high yielding crop (accumulating 3000 kg/ha/ year of dry matter) could reasonably take up 63 kg N/ha/year contained in the total below ground crop biomass (Drost 2013). Hence, during establishment, additional N applications may be required to satisfy N demand. However, this sink can be assumed to stop accumulating additional N inputs once the total biomass of the crop stops increasing and some of the N demand could be met by mineralisation of soil organic matter. Also of note is that when the asparagus crop reaches the end of its productive life, this N will be returned to the soil and is available to the following cropping rotation for uptake or leaching.

Asparagus growers face a number of challenges when managing N within their production systems. They must ensure there is sufficient N available to grow the crop in order to remain profitable as it is key to the growth of ferns, spears and below ground biomass.

It is clear from this analysis that the gross amount of N removed from the field is relatively low. The 10 t/ha crop could have removed only 50 kg N/ha (10 t containing 5 kg N/t). Many growers have adopted conservative N fertiliser practices to help reduce N leaching risk. However, there is substantial variability in N fertiliser practice amongst asparagus growers in New Zealand, with some practices contributing to N leaching.

5 OPPORTUNITES FOR IMPROVED N MANAGEMENT

There are opportunities for the asparagus industry to minimise their N leaching risk:

- Apply N fertiliser shortly before the most rapid growth phase
- Only apply N to support the coming years growth (large applications are at high risk of leaching during the winter)
- Soil test close to fertiliser application time (including mineral N)
- Maintain a nutrient balance for each field and adjust inputs accordingly
- Match fertiliser N release pattern to crop uptake pattern, i.e. slow release N

Direct research to understand N flow in the soil and plant would help validate these estimates. Losses can be measured directly through a variety of means.

6 REFERENCES

Drost D 2013. Asparagus nutrient management. Horticultural Development Company, https://horticulture.ahdb.org.uk/download/5982/file , Kenilworth, Warwickshire UK.

Drost D, Wilson D 2003. Monitoring root length density and root biomass in asparagus (Asparagus officinalis) with soil cores. New Zealand Journal of Crop and Horticultural Science 31(2):125–137.

Wilson D, Sinton S 2005. Improved profitability and sustainability in asparagus production, SFF Project Number: 02/108, Crop & Food Research Confidential Report No. 1450.

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Schedule B - Nitrogen Reference Point/Te Āpitihanga B – Te tohu ā-hauota

A property or enterprise with a cumulative area greater than 20 hectares (or any property or enterprise used for commercial vegetable production) must have a Nitrogen Reference Point calculated as follows:

a. The Nitrogen Reference Point must be calculated by a Certified Farm Nutrient Advisor to determineby modelling the amount of nitrogen being leached from the property or enterprise during the relevant reference period specified in clause f), except for any land use change approved under Rules 3.11.5.6 or 3.11.5.7 where the Nitrogen Reference Point shall be determined through the Rule 3.11.5.6 or 3.11.5.7 consent process, or

ab. For CVP the Nitrogen Reference Point may be calculated by matching the crop rotation during the relevant reference period specified in clause f), with a proxy nitrogen leaching rate for the relevant location provided in Table 1.

b. The Nitrogen Reference Point shall be the highest modelled annual nitrogen leaching loss that occurred during a single year (being 12 consecutive months) within the reference period specified in clause f), except for an NRP calculated using a the proxy rotations for commercial vegetable production, in which case the Nitrogen Reference Point shall be the average annual nitrogen leaching loss during the reference period

.

c. The Nitrogen Reference Point under a) must be calculated using the current most recent version of the OVERSEER® Model as the default model (or any other models may be approved for use by the Chief Executive of the Waikato Regional Council, if justified on a case by case basis). The Nitrogen Reference Point must be updated using the initial reference data whenever a new version of the OVERSEER® Model, or any other approved model used to prepare the Nitrogen Reference Point, is released, or
For the Nitrogen Reference Point under b) must adopt the nitrogen reference point for the appropriate proxy rotation provided in Table X, .

d. The Nitrogen Reference Point under a) data shall comprise the data used by electronic output file from the OVERSEER® or other approved model to calculate the Nitrogen Reference Point, and where the OVERSEER® Model is used, it must be calculated using the OVERSEER® Best Practice Data Input Standards 2016 or replacement technical guidance that relate to the version of the OVERSEER® model being used, with the exceptions and inclusions set out in Schedule B Table 1 a Waikato Regional Council Nitrogen Reference Point Guide. Where another approved model is used, it will conform to the data input standards as approved by the Chief Executive of the Waikato Regional Council.

e. The Nitrogen Reference Point under a) Analysis (inputs and outputs) and the Nitrogen Reference Point data must be provided published to Waikato Regional Council within the period 1 September 2018 1 May 2020 to 31 March 2019 30 November 2020.

f. The Nitrogen Reference Period reference period is the two financial years covering 1 July 2014/2015 and 2015/ to 30 June 2016, except for commercial vegetable production in which case the reference period is 1 July 2006 2011 to 30 June 2016.

g. The following records (where relevant to the land use undertaken on the property or enterprise calculation and compliance auditing of the Nitrogen Reference Point) must be retained for the life of the plan and/or relevant consent, whichever is longer, and provided to Waikato Regional Council at its request:

   i. Stock numbers as recorded in annual accounts together with stock sale and purchase invoicesRecords of stock numbers and stock classes, births and deaths, stock movements on and off the property, grazing records and transport records;
   ii. Dairy production dataTotal annual milk solids as stated in the milk supply statement;
   iii. Invoices for fertiliser applied to the landRecords of fertiliser type and amount, including annual accounts, and any records of fertiliser application rates and placement;
   iv. Quantity and type of Invoices for feed supplements sold or purchased and used on the property;
   v. Water use records for irrigation (to be averaged over 3 years or longer) in order to determine irrigation application rates (mm/ha/month per irrigated block) and areas irrigated;
   vi. Crops grown on the land property (area and yield), quantities of each crop consumed on the property, and quantities sold off farm; and
   vii. Horticulture crop diaries and NZGAP records; and
   viii. The Nitrogen Reference Point Data as defined in Schedule B clause d; and
   ix. Soil test data – including anion storage capacity; and
   x. A map which shows property boundaries, block management areas, retired/non-productive areas and areas used for effluent irrigation.

h. For new CVP calculated under rule 3.11.5.X, the NRP for the new area must be calculated with using method a) or b), and must not exceed The total area of land for which consent is sought for commercial vegetable production must not exceed the maximum land area calculated as additional sub-catchment Nitrogen load not exceeding 1%, using proxy rotations on land suitable for additional CVP, as defined in Policy 3 ci, cii., as described in Table 2.

Table 1 CVP proxy limits
*the default for all rotations used in the PC1 NIWA modelling, (based on Ford 2014), relate to the additional yields and areas presented in table 2. Table 1 will be updated with proxy yields for representative rotations calculated in APSIM.

**The table provides a proxy leaching yield for each subcatchment, the APSIM modelling undertaken to develop the proxy may develop more than one yield per subcatchment to account for soils and climate, and may develop more than three representative rotations.

	NIWA Modelling for PC1*			To be developed to replace NIWA data as better information becomes available**				
Subcatchment	N load per catchment	CVP Proxy N load	CVP N Loss	N load per catchment	CVP Proxy N load	Market Garden Rotation N loss	Leafy Greens Rotation N loss	Root Veg Rotation N loss
	t N/y	(kg/N/yr)	(kg N/ha)	t N /y	N load (kg/N/yr)	(kg N/ha)	(kg N/ha)	(kg N/ha)
Pueto	148	754	66					
Waikato at Ohaaki	301	8626	66					
Waikato at Ohakuri	821	0	0					
Torepatutahi	246	0	0					
Mangakara	24	0	0					
Waiotapu at Homestead	236	0	0					
Kawaunui	32	0	0					
Waiotapu at Campbell	48	0	0					
Otamakokore	76	0	0					
Whirinaki	13	0	0					
Waikato at Whakamaru	487	0	0					
Waipapa	154	1658	67					
Tahunaatara	293	0	0					
Mangaharakeke	46	0	0					
Waikato at Waipapa	719	0	0					
Mangakino	222	0	0					
Mangamingi	116	0	0					
Whakauru	100	0	0					
Pokaiwhenua	571	0	0					
Little Waipa	299	0	0					
Waikato at Karapiro	1013	21221	66					
Karapiro	94	2358	66					
Waikato at Narrows	206	8135	66					
Mangawhero	99	3024	66					
Waikato at Bridge St Br	92	13154	66					
Mangaonua	130	5963	66					
Mangakotukutuku	55	65	65					
Mangaone	106	7482	66					
Waikato at Horotiu Br	79	133	67					
Waitawhiriwhiri	36	0	0					
Kirikiriroa	18	0	0					
Waipa at Mangaokewa Rd	17	0	0					
Waipa at Otewa	224	0	0					
Mangaokewa	165	0	0					
Mangarapa	75	0	0					
Mangapu	236	0	0					
Mangarama	76	0	0					

Waipa at Otorohanga	301	0	0	_	_	_	_	_	
Waipa at Pirongia-Ngutunui Rd Br	977	10258	66	_	_	_	_	_	
Waitomo at Tumutumu Rd	33	0	0	_	_	_	_	_	
Waitomo at SH31 Otorohanga	45	0	0	_	_	_	_	_	
Moakurarua	210	0	0	_	_	_	_	_	
Puniu at Bartons Corner Rd Br	544	19938	66	_	_	_	_	_	
Puniu at Wharepapa	220	0	0	_	_	_	_	_	
Mangatutu	152	0	0	_	_	_	_	_	
Mangapiko	611	2210	66	_	_	_	_	_	
Mangaohoi	2	0	0	_	_	_	_	_	
Waipa at SH23 Br Whatawhata	612	8035	66	_	_	_	_	_	
Mangauika	4	0	0	_	_	_	_	_	
Kaniwhaniwha	116	0	0	_	_	_	_	_	
Waipa at Waingaro Rd Br	191	7005	66	_	_	_	_	_	
Ohote	57	794	65	_	_	_	_	_	
Firewood	27	0	0	_	_	_	_	_	
Waikato at Huntly-Tainui Br	316	5108	66	_	_	_	_	_	
Komakorau	424	1507	66	_	_	_	_	_	
Mangawara	695	0	0	_	_	_	_	_	
Waikato at Rangiriri	77	0	0	_	_	_	_	_	
Awaroa (Rotowaro) at Harris	51	0	0	_	_	_	_	_	
Awaroa (Rotowaro) at Sansons Br	35	0	0	_	_	_	_	_	
Waikato at Mercer Br	528	64292	66	_	_	_	_	_	
Whangape	338	0	0	_	_	_	_	_	
Whangamarino at Island Block Rd	134	13414	66	_	_	_	_	_	
Whangamarino at Jefferies Rd Br	117	1969	66	_	_	_	_	_	
Waerenga	17	0	0	_	_	_	_	_	
Matahuru	113	0	0	_	_	_	_	_	
Waikare	88	0	_	_	_	_	_	_	
Opuatia	71	6264	67	_	_	_	_	_	
Mangatangi	173	398	66	_	_	_	_	_	
Waikato at Tuakau Br	158	45034	66	_	_	_	_	_	
Ohaeroa	30	8094	66	_	_	_	_	_	
Mangatawhiri	21	0	0	_	_	_	_	_	
Whakapipi	102	65758	66	_	_	_	_	_	
Awaroa (Waiuku)	33	1766	66	_	_	_	_	_	
Waikato at Port Waikato	362	62522	66	_	_	_	_	_	

Table 2 Additional CVP sub catchment area limits

*The yields and areas calculated in table 2 rely on the leaching assumptions in the NIWA modelling for PC1. The CVP yield will be updated with appropriate yield for a proxy rotation. As improved information on leaching yield from other land uses becomes available this will be used to calculate the maximum subcatchment area corresponding to an increase in nitrogen load no greater than 1% of the subcatchment background load, the information for table 2 relies on table 1.

Sub-catchments with suitable CVP growth areas	NIWA Modelling for PC1*		To be developed to replace NIWA data as better information becomes available*	
	Additional N yield* from CVP (Baseline Yield,) (kg/N/ha)	**Additional CVP area for 1 % total sub-catchment N load increase * (ha)**	**Additional N yield* from CVP (Baseline Yield,) (kg/N/ha)**	**Additional CVP area for 1 % total sub-catchment N load increase * (ha)**
Awaroa (Rotowaro) at Harris/Te Ohaki Br	54	9		
Awaroa (Waiuku)	56	6		
Firewood	47	6		
Kirikiriroa	43	4		
Mangaonua	51	25		
Mangatangi	53	33		
Mangatawhiri	56	4		
Mangawara	42	167		
Matahuru	53	21		
Ohaeroa	53	6		
Ohote	50	12		
Opuatia	50	14		
Waerenga	51	3		
Waikare	51	17		
Waikato at Bridge St Br	48	19		
Waikato at Horotiu Br	42	19		
Waikato at Huntly-Tainui Br	40	78		
Waikato at Mercer Br	52	101		
Waikato at Narrows	50	41		
Waikato at Port Waikato	52	70		
Waikato at Rangiriri	50	15		
Waikato at Tuakau Br	56	28		
Waipa at SH23 Br Whatawhata	46	134		
Waipa at Wainaro Rd Br	48	40		

Advice note: For the avoidance of doubt, financial information contained within the above records may be redacted (blacked out) prior to it being provided to Waikato Regional Council.

Table 1: Data input methodology for ensuring consistency of Nitrogen Reference Point data using the OVERSEER®Model[24]

OVERSEER®Parameter	Setting that must be used	Explanatory note
Farm model Pastoral and horticulture	To cover the entire enterprise including riparian, retired, forestry, and yards and races. The model is to include non-contiguous properties that are part of the enterprise that are in the same	To capture the "whole farm" in one Overseer® file, where possible, to truly represent nitrogen losses from farm in the catchment area.

[24] Ballance PC1-6570, FANZ PC1-10642, Beef and Lamb PC1-11506, Fonterra PC1-10517

	~~sub-catchment.~~ ~~If the farm (for example where dairy animals are grazed or wintered) is part of another farming business such as a drystock farm, the losses from those animals will be represented in the drystock farm's Overseer model.~~	
~~Location~~ ~~Pastoral and horticulture~~	~~Select Waikato Region~~	~~This setting has an effect on climate settings and some animal characteristics and is required to ensure consistency.~~
~~Animal distribution – relative productivity pastoral only~~	~~Use "no differences between blocks" with the following exceptions:~~ • ~~Grazed pines or other woody vegetation. In this case use "Relative yield" and set the grazed pine blocks to 0.4 (40%).~~ • ~~Where the farm has a mixture of irrigated and non-irrigated areas. In this case use "Relative yield" and set the irrigated area to 1 (100%), and the non-irrigated areas to 0.75 (75%).~~	
~~Wetlands~~	~~Entered as Riparian Blocks~~	~~As per the 2016 OVERSEER® Best Practice Data Input Standards.~~
~~Stock number entry~~	~~Based on specific stock numbers only~~	~~To ensure consistency and accuracy of stock number inputs.~~
~~Animal weights~~	~~Only use OVERSEER® defaults – do not enter in weights and use the age at start setting where available (national averages).~~	~~Accurate animal weights are difficult to obtain and prove.~~
~~Block climate data~~	~~Only use the Climate Station tool~~ ~~For contiguous blocks use the coordinates from the location of the dairy shed or the middle of the farm area (for non-dairy).~~ ~~For non-contiguous blocks use individual blocks' climate station coordinates.~~	
~~Soil description~~	~~Use Soil Order – obtained from S-Map or where S-Map is unavailable from LRI 1:50,000 data or a soil map of the farm.~~	~~To ensure consistency between areas of the region that have S-Map data and those that don't.~~
~~Missing data~~	~~In the absence of Nitrogen Referencing information being provided the Waikato Regional Council will use appropriate default numbers for any necessary inputs to the OVERSEER® model (such default numbers will generally be around 75% of normal Freshwater Management Unit^ average values for those inputs).~~	~~Some farms will not be able to supply data, therefore a default must be established.~~