BEFORE THE INDEPENDENT HEARING PANEL APPOINTED BY WAIKATO REGIONAL COUNCIL

IN THE MATTER	of the Resource Management Act 1991 (the Act)
AND	
IN THE MATTER	Submissions made on Proposed Waikato Regional Plan Change 1 – Waikato and Waipa River Catchments

---

STATEMENT OF EVIDENCE OF STUART GRAHAM EASTON FOR HORTICULTURE NEW ZEALAND (WATER QUALITY)

9 July 2019

CONTENTS

SUMMARY AND CONCLUSIONS

1. This evidence estimates the 'Provisional CVP growth area' in the Waikato; the additional land area required for Commercial Vegetable Production (CVP) to account for population growth and current CVP land lost to urban expansion. The resulting change in Nitrogen, Sediment, Phosphorus, and *E. coli* loading is estimated for the Healthy Rivers catchments.

2. Nitrogen and *E. coli* load estimates rely on NIWA provided Healthy Rivers modelling information. Sediment loads are based on Don't Muddy the Water research, as the NIWA NZEEM modelling does not allow for comparison between cultivated land and pasture. Phosphorus is addressed briefly; available data precludes P loss comparison between CVP and pastoral land uses.

3. Two scenarios are provided:

    (a) a) Waikato, which represents an increase of CVP land of 715.5 ha to account for population growth and CVP land lost to urban expansion in the Waikato region only, and

    (b) b) Auckland and Waikato, which represents an increase of CVP land of 1,473 ha to account for population growth and CVP land lost to urban expansion in the combined Auckland and Waikato regions.

4. An initial estimate of 82,379 ha suitable for CVP has been identified. This land is LUC 1 or 2; currently used for Dairy, Forestry, Miscellaneous, or Sheep & Beef (i.e. not Urban or Horticulture); and is zoned as 'Rural' in the proposed Waikato District Plan.

5. CVP growth produces a minimal net increase in N load, and a net decrease in *E. coli* load and a net decrease in sediment load when Best Management Practice (BMP) is implemented.

6. A 0.09% increase in total catchment Nitrogen load is predicted for the Waikato scenario, and a 0.49% increase in N load for the Auckland & Waikato scenario with CVP Good Management Practice. Under both scenarios, an overall decrease in total N load is predicted following mitigations on the highest N leaching Dairy land to the 75th percentile as Required by Policy 1 b1 (BLOCK 2), but not accounting for other reductions that would be achieved through the real and enduring reductions for others farms at GMP required in the same policy.

7. An increase in CVP area of 716 ha to provide for population growth and lost to urban development in the Waikato region only decreases total catchment sediment load by 143.2 – 501.2 tonnes when BMPs are implemented and decreases total catchment *E. coli* load by 0.06%. Negligible change in P load is expected with CVP growth.

INTRODUCTION

Qualifications and experience

8. My full name is Stuart Graham Easton.

9. I am employed by Jacobs New Zealand Ltd (Jacobs), an engineering and environmental consulting firm. I am contracted to provide water quality expertise on the Proposed Waikato Regional Plan Change 1 – Waikato and Waipa River Catchments (PC1) to Horticulture New Zealand (HortNZ).

10. I hold a Bachelor of Science (BSc) in Environmental Science (2009) and a Master of Geographic Information Systems Degree (2015) from Victoria University of Wellington.

11. I have 4 years' experience in the field of water resource science. I started my career at Victoria University following the

completion of my Master's degree before joining Jacobs in 2016.

12. I have a background in Horticulture, specifically Apple growing, having worked in multiple roles for Easton Apples Ltd between 2004 and 2012 and am familiar with horticultural systems and processes.

13. My evidence is prepared on behalf of HortNZ. I have contributed to Jacobs' technical work in support of HortNZ through the PC1 process, including undertaking some of the technical assessments outlined in Jacobs (2017) and (2018), submitted with HortNZ's submissions on PC1.

Code of Conduct

14. While this is not a hearing before the Environment Court, I can confirm that I have read and agree to comply with the Code of Conduct for Expert Witnesses produced by the Environment Court and have prepared my evidence in accordance with those rules. My qualifications are set out above.

15. I confirm that the issues addressed in this brief of evidence are within my area of expertise.

16. I have not omitted to consider material facts known to me that might alter or detract from the opinions expressed.

Background and Role

17. My colleague, Ms Gillian Holmes, has been previously engaged by HortNZ as their water quality expert and has presented evidence at both Block 1 and 2 hearings, as well as attending the Expert Conferencing on Table 3-11-1 and contributing to the Joint Witness Statement.

18. I conducted technical work to support Ms Holmes' research and am familiar with the data and processing that underpins Jacobs' technical submissions on PC1.

19. Ms Holmes is now on maternity leave and as such, Tim Baker will provide evidence based on Ms. Holmes' research. I have also been engaged by Hort NZ to provide technical evidence to support their key submission points on PC1 in Block 3.

20. HortNZ is concerned that PC1 does not give enough consideration to the fact that horticulture farming systems and operations are unique from other farming sectors. Due to this uniqueness, HortNZ believe that horticulture requires an additional separate consenting pathway to ensure the continued provision of vegetables to domestic communities.

21. I have read the Joint Witness Statement for the Expert Conferencing for Table 3-11-1 and concur with the recommendations made by Ms Holmes.

Purpose and Scope of Evidence

22. This evidence provides technical support to the assessment of those provisions within the scope of Block 3 hearings on which HortNZ submitted and addresses the Section 42A Report for Block 3 prepared by WRC.

23. Specifically, this evidence provides:

    (a) An estimate of the Commercial Vegetable Production (CVP) area required to provide for population growth and land development in the Waikato, and for Auckland and the Waikato combined.

    (b) The resulting changes in catchment loads of Nitrogen (N), *E. coli*, Phosphorus (P) and Sediment using the NIWA Healthy Rivers modelling and other available information for the area estimated in (a).

    (c) A worked example of a proposed methodology to establish a Nitrogen Reference Point (NRP) following CVP rotation.

(d) Identification of potentially suitable sub-catchments for CVP growth.

PROVISIONAL CVP GROWTH AREA

24. The total provisional CVP growth area is estimated as the sum of the additional CVP area required to provide for increased demand for vegetables through population growth and the current CVP land lost to urban development.

25. The provisional CVP growth area is estimated for two scenarios: Waikato only, and Auckland and Waikato combined.

26. Consideration for the Auckland region is given as the Pukekohe CVP hub lies across both regions. 46% of NZ's population resides in Auckland and Waikato[1], supplied by the Pukekohe hub which produces 26% of NZ vegetable production by value[2]. There is limited opportunity for new CVP in the Auckland region, and CVP expansion to provide for population growth and land lost to urban development in both regions is expected to extend southwards from the Pukekohe hub into the Waikato.

27. It is assumed that to meet increased produce demand from population growth, an equivalent growth in CVP is required. This is likely a conservative estimate; at a global scale the demand for fruit and vegetables will increase by 90%, and significantly exceed estimated global population growth of 30% from 2010 to 2050[3].

28. The total CVP area in the Waikato is approximately 6,250 ha[4]. Stats NZ[5] predicts a 9.9% increase in population to 2030 under a medium growth scenario (**Table 1**). An equivalent increase in CVP land is therefore 619 ha.

[1] Statistics New Zealand, Subnational Population Projections
[2] Deloitte, 2018. New Zealand's food story: The Pukekohe hub. Prepared for Horticulture New Zealand
[3] Ibid
[4] NIWA Healthy Rivers modelling GIS data
[5] Statistics New Zealand, Subnational Population Projections

Table 1 Population growth projection - Waikato region

Growth Scenario	2018	2030*	Change	% Change
High	546,000	637,700	91,700	14.4%
Medium	535,130	593,990	58,860	**9.9%**
Low	524,230	549,840	25,610	4.7%

* Calculated as average of 2028 and 2033

29. Stats NZ predicts a 15.5% increase in population for the combined Auckland and Waikato regions (**Table 2**) to 2030.

Table 2 Population growth projection - Auckland and Waikato regions

Growth Scenario	2018	2030*	Change	% Change
High	2,282,200	2,836,700	554,500	19.5%
Medium	2,235,030	2,645,040	410,010	**15.5%**
Low	2,187,530	2,452,390	264,860	10.8%

* Calculated as average of 2028 and 2033

30. The total CVP area estimated in the Waikato is approximately 6,250 ha[6]. Of this area, approximately 3,250 ha is within the Pukekohe hub[7], which has a total estimated area of 6,500 ha[8]. The combined total CVP area in Pukekohe and the rest of the Healthy Rivers catchments is therefore 9,500 ha [(6,250-3,250) +6,500]. An 15.5% increase from 9,500 ha is an additional 1,473 ha.

31. A desktop GIS exercise was conducted to estimate the current CVP land in the Pukekohe hub and surrounds that has been zoned for future urban growth in the Auckland Unitary Plan and Waikato District proposed plan. Property parcels within future development zones were classified as CVP land based on visual assessment of aerial imagery. A total of 565 ha of current CVP land zoned for urban development was identified (**Figure**

[6] NIWA Healthy Rivers modelling GIS data
[7] Ibid
[8] Ford estimates between 6-7000 ha in Agribusiness Group, 2014. Nutrient Performance and Financial Analysis of Lower Waikato Horticulture Growers. Prepared for: Waikato Regional Council, Ministry of Primary Industries and HortNZ.

1). Of the 565 ha, 96.5 ha is within the Waikato Region and 468.5 ha is in the Auckland region.

Figure 1 CVP land lost to future urban development

32. When considering the Waikato region only, 619 ha is required for population growth and 96.5 ha of current CVP is lost to urban development, giving 715.5 ha total provisional CVP growth. 715.5 ha represents an 11% increase in area from the current 6,250 ha in CVP in the Healthy Rivers catchments.

33. For the combined Auckland and Waikato regions, 1,473 ha is required for population growth and 565 ha of current CVP lost

to future urban development, giving 2,038 ha total provisional CVP growth. 2,038 ha represents a 33% increase in area from the current 6,250 ha in CVP in the Healthy Rivers catchments.

POTENTIAL CVP GROWTH CATCHMENTS

34. An initial estimate of potential CVP growth land has been made based on the following criteria:

(a) LUC 1 or 2; and

(b) Existing land use is Dairy, Forestry, Miscellaneous, or Sheep & Beef (i.e. not Urban or Horticulture); and

(c) is zoned as 'Rural' in the proposed Waikato District Plan.

35. There are 82,379 ha that meet these criteria (**Figure 2**). Potential CVP growth area per sub-catchment is summarised in **Table 10** in the Appendix. There is opportunity to add additional criteria to further define the potential CVP growth area, for example utilising the MfE identified high class land for food production GIS data[9], or allowing for practical constraints such as access to transport corridors.

[9] http://archive.stats.govt.nz/browse_for_stats/environment/environmental-reporting-series/environmental-indicators/Home/Land/high-class-land-food-production.aspx

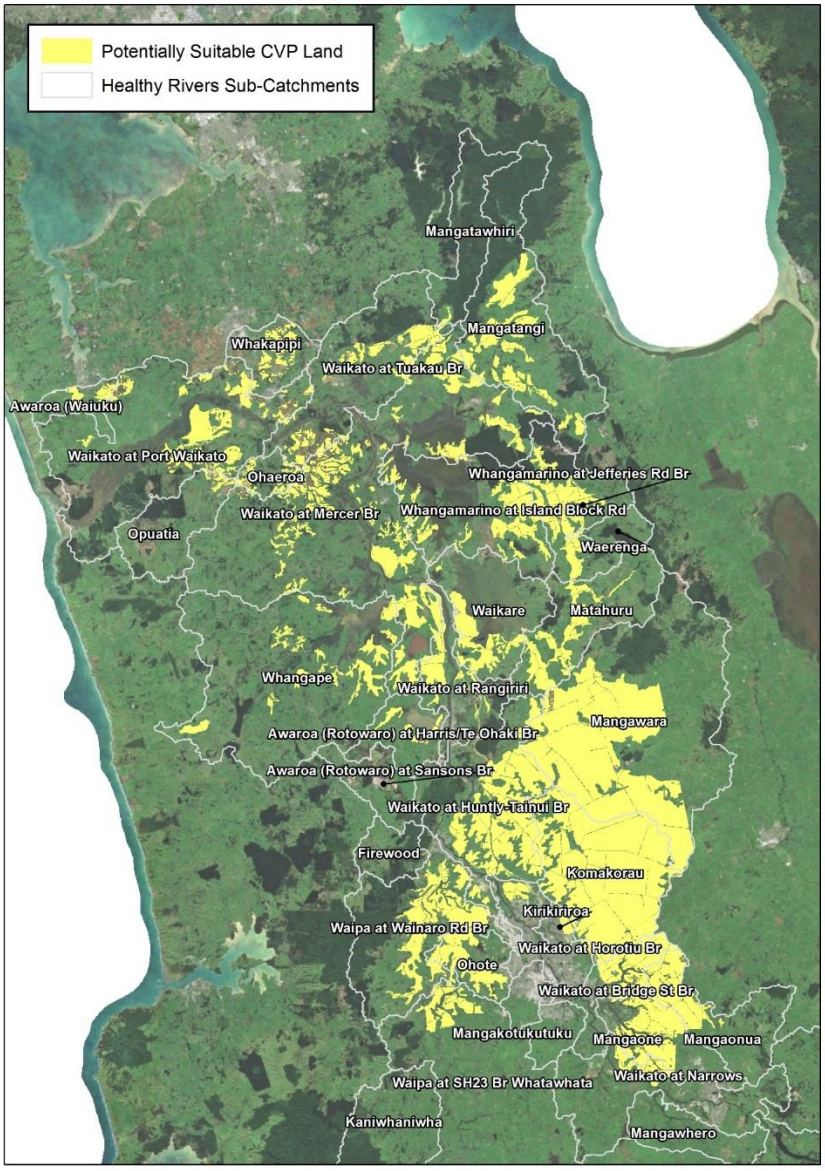

Figure 2 Potential CVP growth areas

NITROGEN LOADING FROM CVP GROWTH

36. The N load associated with new CVP areas can be estimated as the difference between the existing land use load and CVP load.

Using the NIWA modelled Healthy Rivers data, the additional N load associated with new CVP averages 50 kg/N/ha across the CVP suitable sub-catchments.

37. **Table 3** estimates the additional N load associated with the provisional CVP areas.

Table 3 N load for provisional CVP growth

Scenario	Provisional CVP growth area (ha)	Additional N load associated with provisional CVP growth (kg)	Additional N load as percentage of total Healthy Rivers N load
Waikato	716	35,775	0.23%
Auckland and Waikato	2038	101,880	0.65%

38. **Table 4** estimates the additional CVP land that could be developed under incremental FMU N-load increases from 0.5 to 5% for FMUs containing suitable CVP land. The additional load is calculated per FMU using the NIWA modelled Healthy Rivers data, based on the FMU average additional CVP N load for suitable land. An equivalent per sub-catchment table is provided in the Appendix (**Table 11**).

Table 4 Estimated additional CVP land under 1-5% FMU N load increase scenarios

FMU	Additional N loading rate for CVP (kg/ha)	Potential CVP growth (ha)	Additional CVP area for 0.5 – 5% total FMU N load increase (ha)					
			0.5%	1%	2%	3%	4%	5%
Lower Waikato	46.2	66941	421	841	1683	2524	3365	4207
Waipa	47.9	6542	511	1022	2044	3066	4088	5110
Central Waikato	49.9	8896	92	184	367	551	734	918
Total		82379	**1024**	**2047**	4094	6141	8188	10235

39. **Table 4** shows that the 2,038 ha of provisional CVP growth area required for Auckland and Waikato can be provided for with a 1% increase in N load from the Lower Waikato, Waipa, and Central Waikato FMUs. The 716 ha of provisional CVP growth area required for the Waikato only can be provided for with a less than 0.5% increase in N load from the Lower Waikato, Waipa, and Central Waikato FMUs.

40. The implementation of Good Management Practice (GMP) is estimated to reduce N load by an average of 5% for Horticulture[10], equivalent to 19,847 kg/N/year across the current total Healthy Rivers horticultural area, or 418 ha of additional CVP area at an average marginal N rate of 47.5 kg/ha/year (assuming 5% GMP from 50 kg/ha/year).

41. Mitigation strategies to reduce the N-loss from the highest leaching Dairy land to meet the 75th percentile (36.8 kg/ha[11]) reduce N load by 397,770 kg, equivalent to 2.5% of the total Healthy Rivers catchment N load, and 8,792 ha additional CVP area at an average marginal N loading rate of 47.5 kg/ha/year.

42. The total catchment Healthy Rivers load is estimated at 15,661 t/year. **Table 5** estimates the total change in N load following CVP growth and mitigation implementation.

43. Provision for CVP growth for the Waikato only, with the implementation of Horticultural GMP, increases the overall N load by 0.09%.

44. Provision for CVP growth for the Waikato and Auckland, and Waikato only, with the implementation of Horticultural GMP and Dairy Mitigations (Paragraph 41) reduce catchment N load by 2.45% and 2.05%, respectively.

Table 5 N load change under CVP growth and mitigation scenarios

Scenario	Provisional CVP growth area (ha)	Additional N load for CVP growth with GMP (kg/year)	Mitigation	Mitigated N load (kg/year)	Overall change in catchment N load (kg)	Overall change in catchment N load
Waikato	716	33,986	Horticultural GMP	-19,847	+14,139	+0.09%
Auckland and Waikato	2038	96,786			+76,939	+0.49%
Waikato	716	33,986	Dairy '75th percentile clawback'	-397,770	-363,784	-2.32%
Auckland and Waikato	2038	96,786			-300,984	-1.92%
Waikato	716	33,986		-417,617	-383,631	-2.45%

[10] HortNZ PC1 submission
[11] Jacobs 2017, Healthy Rivers Plan Change Technical Support for Horticulture New Zealand's Submission. Values and Current Allocation of Responsibility for Contaminant Discharges.

Scenario	Provisional CVP growth area (ha)	Additional N load for CVP growth with GMP (kg/year)	Mitigation	Mitigated N load (kg/year)	Overall change in catchment N load (kg)	Overall change in catchment N load
Auckland and Waikato	2038	96,786	Horticultural GMP and Dairy '75th percentile clawback'		-320,831	-2.05%

SEDIMENT LOADING FROM CVP GROWTH

45. The NIWA NZEEM modelling considers there is no erosion rate difference between bare earth (i.e. cultivated land) and pasture, therefore does not allow for comparison.

46. Erosion rates for cultivated and pastoral land have been modelled using the Revised Universal Soil Loss Equation (RUSLE) calibrated to Pukekohe sites as part of the Don't Muddy the Water SFF research project, undertaken by Agrilink, NIWA and Landcare and discussed in the Evidence of Mr Andrew Barber.

47. The RUSLE modelling shows that for CVP under Best Management Practice (BMP), i.e. cultivation with sediment retention ponds, the rate of erosion is less than that for pasture for all slope angles.

Table 6 RUSLE modelled erosion rates for Hamilton

Slope (°)	Rate of erosion (t/ha/yr)			
	Pasture	Unmitigated cultivation	Cultivation with buffer strips	Cultivation with Sediment Retention Ponds
0	0.00	0.5	0.1	0.0
0.6	0.2	3.3	0.6	0.0
1.2	0.7	11.7	2.2	0.0
2.9	1.4	22.3	4.3	0.1
5.7	3.5	57.3	11.0	0.2
8.5	6.6	108.8	20.9	0.4

48. The sediment load associated with CVP growth has been estimated for the identified potential CVP growth area using the

RUSLE erosion rates and GIS slope information derived from a national 8 m resolution Digital Elevation Model (DEM)[12].

49. As no comparable erosion rate information is available for Forest and Urban land uses, the analysis here is constrained to Dairy, Sheep & Beef, and Miscellaneous (i.e. pastoral) land uses within the identified potential CVP growth areas.

50. **Table 7** estimates the sediment reduction achieved for the Healthy Rivers catchments under the two CVP growth scenarios. The estimates are based on an average slope of 0.9° and assume the replacement of pasture with BMP CVP. **Table 7** shows that an increase in CVP of 716 ha has a net benefit on sediment load between 143 and 501 tonnes, depending on slope class assignment.

Table 7 Sediment load reduction following CVP growth, under BMP

Scenario	Provisional CVP growth area (ha)	Average Slope of potential CVP growth area	Sediment Loading rate – BMP Horticulture* (t/ha/yr)	Sediment Loading rate – Pasture* (t/ha/yr)	Total sediment load reduction (t)
Waikato	716	0.9°	0.0	0.2 – 0.7	143.2 – 501.2
Auckland and Waikato	2038				407.6 – 1426.6
* Based on nearest slope class in **Table 6**.					

51. **Table 12** in the Appendix estimates sediment load reductions at the sub-catchment scale for the potential CVP area currently in pastoral land uses. The right-most columns estimate the reduction in sediment load for the increased CVP area associated with 1 and 2% increase in N loads from **Table 11**. This sub-catchment scale analysis supports **Table 7**, estimating total sediment load reductions of 226 and 451 tons for CVP

[12] https://data.linz.govt.nz/layer/51768-nz-8m-digital-elevation-model-2012/

growth scenarios of 1,024 ha (1% N load increase) and 2,047 ha (2% N load increase), respectively.

E. COLI LOADING FROM CVP GROWTH

52. The *E. coli* load associated with new CVP areas can be estimated as the difference between the *E. coli* loss rate from the existing land use and the CVP *E. coli* loss rate.

53. Using the NIWA modelled Healthy Rivers data at the sub-catchment scale, CVP is estimated at reducing *E. coli* by an average of 0.00007 peta organisms/ha, equivalent to a 78% decrease from the average existing land use, for the identified potential CVP areas.

54. For the two CVP growth scenarios of 716 ha and 2,038 ha, the total catchment load is estimated to decrease by -0.06% and -0.16%, respectively.

55. Table 13 in the Appendix estimates sub-catchment *E. coli* load reductions under the CVP growth scenarios associated with N load increase given in **Table 11**. **Table 13** shows that for the sub-catchments identified as suitable for CVP growth, a -0.2% and -0.4% decrease in *E. coli* load is provided by CVP growth of 1,160 and 2,260 ha, respectively.

Table 8 *E. coli* load for provisional CVP growth

Scenario	Provisional CVP growth area (ha)	Total Catchment *E. coli* load (peta/organisms)	Average *Horticulture* *E. coli* loading rate (peta organisms/ha)	Average suitable land *E. coli* loading rate (peta organisms/ha)	Total *E. coli* load reduction (peta/organisms)	Catchment total *E. coli* load reduction (peta/organisms)
Waikato	716	89.4	0.00002	0.00009	-0.05	-0.06%
Auckland and Waikato	2038				-0.143	-0.16%

PHOSPHORUS LOADING FROM CVP GROWTH

56. The NIWA modelled P loss is based on Overseer, which (at the time) is unvalidated for CVP and does not account for P bound to sediment[13]. The NIWA modelling addressed this by estimating sediment bound-P at the sub-catchment scale using the NZEEM modelled erosion rates[14]. However, NZEEM does not differentiate between pasture and cultivated land covers[15] which does not allow for comparison between CVP and pastoral land uses.

57. NIWA recognise that it is inherently more difficult to model P than N, and that source yields of P are not as representative of P losses from pastoral land uses as those for N[16].

58. The NIWA modelling estimates TP loss at 1.2 kg/ha from CVP, and an average of 1.2 kg/ha from Dairy (average of sub-catchments). Dairy P loss rates range from 0.6 kg/ha to 2.7 kg/ha. Dairy Support P loss rates range from 0.2 to 1.1 kg/ha with a sub-catchment average of 0.4 kg/ha. The ratio of particulate to dissolved P has not been modelled.

59. Particulate P can be assumed to be lost with sediments. The **Sediment loading from CVP growth** section shows that for CVP under BMP, i.e. Cultivation with Sediment Retention Ponds, the rate of erosion is less than that for Pasture for all slope angles. It can therefore be expected that Particulate P loss from CVP with BMP is less than Pasture. This is corroborated in the evidence of Mr. Andrew Barber who concludes that P discharge levels are significantly less for CVO with BMP than on an equivalent pasture paddock.

[13] Gray,Wheeler, McDowell. 2016. Review of the phosphorus loss submodel in OVERSEER
[14] Semadeni-Davies, Elliott, Yalden. 2015. Modelling nutrient loads in the Waikato and Waipa River Catchments
[15] Dymond, Betts, Schierlitz, 2010. An erosion model for evaluating regional land-use scenarios,
[16] Semadeni-Davies, Elliott, Yalden. 2015

60. Available data does not allow for a comparison of dissolved P loss between CVP and pastoral systems.

CVP GROWTH AND WATER QUALITY

61. Those sub-catchments that contain a large enough area of suitable CVP land and have the capacity to assimilate an increase in N load are best suited to CVP growth.

62. The Waikare, Whangamarino at Island Block Rd, Whangamarino at Jefferies Rd Br, and Whangape sub-catchments contain particularly sensitive environments where significant reductions in N load are desirable. Objective 6 of PC1 relates specifically to reducing N, P, sediment and microbial pathogen loads in the catchment of Whangamarino Wetland due to the significance of this wetland. Lake Whangape is hypertrophic, with turbidity and total nitrogen concentrations increasing between 1993 and 2017[17].

63. Similarly, the Whakapipi sub-catchment has limited capacity for any increase in N load; the baseline (2010 – 2014) median in-stream TN concentration is 3.88 mg/l, with horticulture contributing an estimated 65% of the total N load.

64. HortNZ also propose that those sub-catchments within or below the C NOF band for nitrate (based on the baseline 2010 – 2014 nitrate concentrations) are excluded from an increase in CVP area; the Mangaone (Central Waikato), Whakapipi (Lower Waikato), and Komakorau (Lower Waikato) within the identified CVP growth sub-catchments, and the Mangamingi (Upper Waikato), and Kawanui (Upper Waikato).

65. Table 11 shows that between the 10 sub-catchments of Mangatangi, Mangawara, Matahuru, Waikato at Huntly-Tainui Br, Waikato at Mercer Br, Waikato at Narrows, Waikato at Port Waikato, Waikato at Tuakau Br, Waipa at SH23 Br Whatawhata, and Waipa at Wainaro Rd Br, 715 ha of additional CVP can be

[17] Vant 2018, Trends in river water quality in the Waikato region, 1993-2017.

provided for with a 1% increase in individual sub-catchment N load (i.e. equivalent to Waikato only scenario). Within these identified sub-catchments, there is a total of 43,408 ha of identified suitable land.

POST CVP NITROGEN REFERENCE POINT

66. The post CVP Nitrogen reference point (NRP) is the N load per hectare per year associated with a land parcel after the completion of CVP rotation(s), where that parcel does not have an assigned NRP based on land use in the baseline period. The post CVP NRP can be estimated as the area weighted average sub-catchment N loading rate for suitable CVP land, for non-CVP land uses.

Worked example

67. The Waikato at Mercer Bridge sub-catchment is 44,917 ha.

1. 7,577 ha is suitable for CVP following the potential CVP growth area criteria, distributed by land use following the first row of **Table 9**. This does not include current CVP land.

2. The total N load of the suitable CVP area is 98,727 kg.

3. 98,727 kg divided by 7,577 ha gives an NRP of 13.0 kg/N/ha.

Table 9 Nitrogen reference point worked example for Waikato at Mercer Bridge

Waikato at Mercer Bridge	Dairy	Forestry	MISC	S&B	Total
Suitable Land for CVP (ha)	2856	60	978	3472	**7,577 ha**
N loading rate (kg/ha/yr)	21.3*	4	3	10	
N load (kg)	60833	240	2934	34720	**98727 kg**
Nitrogen Reference Point					**13.0 kg/ha**
* Calculated as 75% Dairy and 25% Dairy Support following NIWA assumptions					

68. An NRP calculated in this way means that the total catchment NRP derived load will not increase when CVP rotates to new land, assuming that post-CVP land use proportionality is equivalent to the current configuration of CVP suitable land.

Stuart Easton for Horticulture New Zealand

9 July 2019

APPENDIX

Table 10 Potential CVP growth

Catchments with potential CVP growth areas	Total catchment area (ha)	Existing CVP area (ha)	Potential CVP growth area (ha)	Potential CVP growth area (% of total sub-catchment area)
Awaroa (Rotowaro) at Harris/Te Ohaki Br	4730	0	335	7%
Awaroa (Waiuku)	2506	27	372	15%
Firewood	3372	0	5	0%
Kirikiriroa	1233	0	214	17%
Komakorau	16399	23	14264	87%
Mangaone	6760	113	2837	42%
Mangaonua	8096	90	2382	29%
Mangatangi	19452	6	3229	17%
Mangatawhiri	6795	0	78	1%
Mangawara	35884	0	15305	43%
Matahuru	10637	0	2146	20%
Ohaeroa	2033	123	499	25%
Ohote	4041	12	1704	42%
Opuatia	7319	94	202	3%
Waerenga	1959	0	67	3%
Waikare	10418	72	1722	17%
Waikato at Bridge St Br	5072	200	2237	44%
Waikato at Horotiu Br	5405	2	447	8%
Waikato at Huntly-Tainui Br	17322	77	6678	39%
Waikato at Mercer Br	44917	977	7367	16%
Waikato at Narrows	12987	124	778	6%
Waikato at Port Waikato	28185	950	3072	11%
Waikato at Rangiriri	6853	0	1240	18%
Waikato at Tuakau Br	15135	684	1815	12%
Waipa at SH23 Br Whatawhata	31506	122	1127	4%
Waipa at Wainaro Rd Br	15484	106	3706	24%
Whakapipi	4663	1000	820	18%
Whangamarino at Island Block Rd	14364	204	2638	18%
Whangamarino at Jefferies Rd Br	9701	30	2946	30%
Whangape	31767	0	2144	7%
Total	402038	5038	82379	20%

Table 11 Additional CVP land per sub-catchment under 1-5% N load increase scenarios

Sub-catchments with suitable CVP growth areas	Additional N load from CVP (no GMP assumed) (kg/N/ha)	Additional CVP area for 1 – 5% total sub-catchment N load increase (ha)				
		1%	2%	3%	4%	5%
Awaroa (Rotowaro) at Harris/Te Ohaki Br	53.5	9	18	27	36	45
Awaroa (Waiuku)	55.7	6	12	18	24	30
Firewood	46.7	6	12	18	23	29
Kirikiriroa	43.0	4	9	13	17	21
Komakorau	40.1	106	211	317	423	529
Mangaone	51.9	20	41	61	82	102
Mangaonua	51.2	25	51	76	102	127
Mangatangi	52.6	33	66	99	132	164
Mangatawhiri	56.0	4	7	11	15	18
Mangawara	41.7	167	334	500	667	834
Matahuru	52.9	21	43	64	86	107
Ohaeroa	53.1	6	11	17	22	28
Ohote	49.8	12	23	35	46	58
Opuatia	50.3	14	28	43	57	71
Waerenga	51.3	3	7	10	14	17
Waikare	51.1	17	35	52	69	86
Waikato at Bridge St Br	48.0	19	38	57	77	96
Waikato at Horotiu Br	41.7	19	38	57	75	94
Waikato at Huntly-Tainui Br	40.4	78	156	235	313	391
Waikato at Mercer Br	52.3	101	202	303	404	505
Waikato at Narrows	50.2	41	82	123	164	205
Waikato at Port Waikato	52.1	70	139	209	278	348
Waikato at Rangiriri	50.4	15	31	46	62	77
Waikato at Tuakau Br	55.5	28	57	85	114	142
Waipa at SH23 Br Whatawhata	45.8	134	267	401	535	668
Waipa at Wainaro Rd Br	47.7	40	80	120	160	201
Whakapipi	57.0	18	36	54	71	89
Whangamarino at Island Block Rd	52.9	25	51	76	101	127
Whangamarino at Jefferies Rd Br	49.8	24	47	71	94	118
Whangape	53.0	64	128	191	255	319
Total	49.9 (sub catchment average)	1129	2259	3388	4517	5646

Table 12 Sub-catchment average erosion rate and sediment load estimate

Sub-catchments with suitable CVP growth areas	Area (ha)*	Area – weighted average slope	Average slope class (Table 6)	Pasture Erosion rate (t/ha/yr)	CVP with BMP Erosion rate (t/ha/yr)	CVP with BMP vs. Pasture erosion rate difference (t/ha/yr)	Sediment reduction from additional CVP area for 1 – 2% total sub-catchment N load increase in Table 11 (t/yr)	
							1%	2%
Awaroa (Rotowaro) at Harris/Te Ohaki Br	295.3	0.8	0.6	0.2	0.0	0.2	1.9	3.8
Awaroa (Waiuku)	368.8	1.0	1.2	0.7	0.0	0.7	4.2	8.4
Firewood	145.3	8.6	8.5	6.6	0.4	6.2	36.4	72.7
Kirikiriroa	897.8	0.1	0	0.0	0.0	0.0	0.0	0.0
Komakorau	13917.0	0.3	0	0.0	0.0	0.0	0.0	0.0
Mangaone	2577.8	0.5	0.6	0.2	0.0	0.2	4.1	8.2
Mangaonua	3692.5	0.4	0.6	0.2	0.0	0.2	5.1	10.2
Mangatangi	1608.1	1.5	1.2	0.7	0.0	0.7	23.0	46.0
Mangatawhiri	11581.4	1.7	1.2	0.7	0.0	0.7	2.6	5.2
Mangawara	4692.8	0.3	0.6	0.2	0.0	0.2	33.4	66.7
Matahuru	1365.4	1.2	1.2	0.7	0.0	0.7	15.0	30.0
Ohaeroa	407.3	4.0	2.9	1.4	0.1	1.3	7.3	14.5
Ohote	1729.5	0.8	0.6	0.2	0.0	0.2	2.3	4.6
Opuatia	153.7	4.1	2.9	1.4	0.1	1.3	18.4	36.9
Waerenga	1021.1	1.0	1.2	0.7	0.0	0.7	2.4	4.7
Waikare	894.7	0.7	0.6	0.2	0.0	0.2	3.5	6.9
Waikato at Bridge St Br	2090.9	0.2	0	0.0	0.0	0.0	0.0	0.0
Waikato at Horotiu Br	807.2	0.5	0.6	0.2	0.0	0.2	3.8	7.5
Waikato at Huntly-Tainui Br	6372.5	0.6	0.6	0.2	0.0	0.2	15.6	31.3
Waikato at Mercer Br	7546.8	1.7	1.2	0.7	0.0	0.7	70.6	141.3
Waikato at Narrows	554.7	1.3	1.2	0.7	0.0	0.7	28.7	57.5
Waikato at Port Waikato	3563.2	2.5	2.9	1.4	0.1	1.3	90.4	180.7
Waikato at Rangiriri	638.4	0.6	0.6	0.2	0.0	0.2	3.1	6.2
Waikato at Tuakau Br	1909.2	2.3	2.9	1.4	0.1	1.3	36.9	73.9
Waipa at SH23 Br Whatawhata	1166.4	1.1	1.2	0.7	0.0	0.7	93.5	187.1
Waipa at Wainaro Rd Br	3530.7	1.0	1.2	0.7	0.0	0.7	28.1	56.1
Whakapipi	1734.3	2.4	2.9	1.4	0.1	1.3	23.2	46.5
Whangamarino at Island Block Rd	3721.4	1.2	1.2	0.7	0.0	0.7	17.7	35.5

Sub-catchments with suitable CVP growth areas	Area (ha)*	Area – weighted average slope	Average slope class (Table 6)	Pasture Erosion rate (t/ha/yr)	CVP with BMP Erosion rate (t/ha/yr)	CVP with BMP vs. Pasture erosion rate difference (t/ha/yr)	Sediment reduction from additional CVP area for 1 – 2% total sub-catchment N load increase in Table 11 (t/yr)	
							1%	2%
Whangamarino at Jefferies Rd Br	1415.2	0.8	0.6	0.2	0.0	0.2	4.7	9.4
Whangape	1626.1	1.5	1.2	0.7	0.0	0.7	44.6	89.3
Total	2.5%	0.9	0.6	0.2	0.0	0.2	226.0	451.9
* Dairy, S&B, Misc land uses within potential CVP growth areas								

Table 13 Sub-catchment *E. coli* load under CVP growth scenarios

Sub-catchments with suitable CVP growth areas	E. coli loading rate (peta organisms/ha)		*E. coli* reduction from additional CVP area for 1 – 5% total sub-catchment N load increase in Table 11 (t/yr)				
	Horticulture*	Area-weighted sub-catchment average for suitable CVP land	1%	2%	3%	4%	5%
Awaroa (Rotowaro) at Harris/Te Ohaki Br	0.00002	0.00005	-0.1%	-0.2%	-0.3%	-0.4%	-0.4%
Awaroa (Waiuku)	0.00001	0.00005	-0.1%	-0.2%	-0.4%	-0.5%	-0.6%
Firewood	0.00002	0.00006	-0.1%	-0.1%	-0.2%	-0.3%	-0.3%
Kirikiriroa	0.00001	0.00013	-0.3%	-0.6%	-0.9%	-1.3%	-1.6%
Komakorau	0.00002	0.00015	-0.6%	-1.1%	-1.7%	-2.2%	-2.8%
Mangaone	0.00001	0.00004	-0.2%	-0.4%	-0.6%	-0.7%	-0.9%
Mangaonua	0.00002	0.00008	-0.2%	-0.4%	-0.5%	-0.7%	-0.9%
Mangatangi	0.00002	0.00010	-0.2%	-0.4%	-0.6%	-0.9%	-1.1%
Mangatawhiri	0.00004	0.00009	-0.1%	-0.3%	-0.4%	-0.6%	-0.7%
Mangawara	0.00003	0.00014	-0.4%	-0.8%	-1.2%	-1.6%	-2.0%
Matahuru	0.00002	0.00008	-0.1%	-0.3%	-0.4%	-0.6%	-0.7%
Ohaeroa	0.00001	0.00005	-0.2%	-0.4%	-0.5%	-0.7%	-0.9%
Ohote	0.00004	0.00012	-0.2%	-0.4%	-0.6%	-0.8%	-1.0%

Sub-catchments with suitable CVP growth areas	E. coli loading rate (peta organisms/ha)		*E. coli* reduction from additional CVP area for 1 – 5% total sub-catchment N load increase in Table 11 (t/yr)				
	Horticulture*	Area-weighted sub-catchment average for suitable CVP land	1%	2%	3%	4%	5%
Opuatia	0.00001	0.00005	0.0%	-0.1%	-0.1%	-0.2%	-0.2%
Waerenga	0.00002	0.00009	-0.1%	-0.3%	-0.4%	-0.6%	-0.7%
Waikare	0.00003	0.00012	-0.2%	-0.4%	-0.7%	-0.9%	-1.1%
Waikato at Bridge St Br	0.00001	0.00009	-0.4%	-0.7%	-1.1%	-1.4%	-1.8%
Waikato at Horotiu Br	0.00003	0.00010	-0.2%	-0.4%	-0.6%	-0.8%	-1.0%
Waikato at Huntly-Tainui Br	0.00001	0.00013	-0.5%	-1.0%	-1.5%	-2.1%	-2.6%
Waikato at Mercer Br	0.00002	0.00008	-0.1%	-0.3%	-0.4%	-0.6%	-0.7%
Waikato at Narrows	0.00001	0.00008	-0.3%	-0.5%	-0.8%	-1.0%	-1.3%
Waikato at Port Waikato	0.00001	0.00010	-0.3%	-0.5%	-0.8%	-1.0%	-1.3%
Waikato at Rangiriri	0.00002	0.00009	-0.2%	-0.4%	-0.6%	-0.9%	-1.1%
Waikato at Tuakau Br	0.00001	0.00007	-0.2%	-0.4%	-0.5%	-0.7%	-0.9%
Waipa at SH23 Br Whatawhata	0.00002	0.00011	-0.3%	-0.6%	-0.9%	-1.3%	-1.6%
Waipa at Wainaro Rd Br	0.00004	0.00013	-0.2%	-0.4%	-0.6%	-0.9%	-1.1%
Whakapipi	0.00001	0.00004	-0.1%	-0.3%	-0.4%	-0.5%	-0.7%
Whangamarino at Island Block Rd	0.00003	0.00007	-0.1%	-0.3%	-0.4%	-0.5%	-0.7%
Whangamarino at Jefferies Rd Br	0.00003	0.00014	-0.2%	-0.5%	-0.7%	-1.0%	-1.2%
Whangape	0.00001	0.00007	-0.1%	-0.2%	-0.3%	-0.3%	-0.4%
Total	0.0002 (average)	0.00009 (average)	-0.2%	-0.4%	-0.5%	-0.7%	-0.9%
* Catchment average used where no data is available							