Selecting Representative Dairy Farms for the Upper Manawatu River Catchment

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KapAg Growing for Good

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My thanks to all these people.

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Summary

The purpose of this report is to select and describe suitable representative dairy farms for the Upper Manawatu River catchment (through the gorge and above Hopelands) and to use these to assess the likely viability of dairying in that catchment under the current policies and rules of the One Plan. The representative farms are to be selected from a database containing 95% of the dairy farms in the catchment.

The resultant five representative farms meet the following criteria:

- Each of the representative farms is a "real farm" within the catchment[1]. They have not been synthesised or created by modelling.
- An objective and repeatable process has been followed to identify the representative farms.
- Each representative farm is closely related to the other farms in its cluster and dissimilar to the other representative farms in the other clusters.
- None of the representative farms represents an average for the catchment; instead they provide a measure of the variation between farming systems within the catchment.
- Collectively the representative farms approximate the median[2] results for dairy farms in the catchment.
- Every farm in the catchment has a representative farm, "like them".

The Manawatu River has the second largest catchment in the region and the upper reaches provide high quality water from rain falling on the eastern side of the Ruahine Ranges. Dairy farming is undertaken in the area on well drained soils under moderate to high annual rainfall. Only about 10% of the dairy farms there use irrigation.

The Tararua District where the catchment is situated has over one third of the dairy farms in the region (304) and the Upper Manawatu River catchment contains over half of these (133). Information collected about individual farms by the Regional Council was used to describe the range of attributes associated with dairy farms in the catchment. The data was complete for 126 farms in the catchment. The variability between farms was such that there were no successful predictors identified from these attributes for production or nutrient losses.

The data from all of the farms was entered into a cluster analysis to identify the groups of farms that were simultaneously similar to other farms in their group and dissimilar to the farms in other groups. Cluster analysis is a particular method specifically used in statistics for "knowledge discovery in databases"[3]. By applying the cluster method to recognise patterns in the data, six clusters of dairy farms were identified in the catchment. The smallest cluster was of only seven farms and so this cluster was combined with the nearest other cluster to make five clusters overall.

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[1] Every effort has been made to keep farm owners' identities confidential in this report.

[2] In this report results for the *average* (mean) and the *median* are presented. The average is a single value used to represent a point mid-way between the highest and lowest results in the data. The mean is used to represent the point in the data where there are as many instances above it as below it. When there is enough data points and they are "normally distributed" the average and the mean become almost the same value.

[3] János Abonyi and Balázs Feil 2007. *Cluster Analysis for Data Mining and System Identification.* Birkhäuser Verlag AG, Berlin.

The descriptions of the farms in each of the clusters are provided in Table (i)[4]. The patterns in the data linking farms within clusters were "discovered" by the clustering process. The first three clusters contain farms on the minority soil orders in the catchment: allophanic, recent and gley. Cluster 4 contains the farms in lower rainfall areas that are more intensively farmed than is general. Clusters 5&6 are farms on both brown and pallic soils and are of a farm size often found in the catchment.

In Table (i) the last two rows provide the medians estimated from the clustering results and the medians of the actual farms in the catchment.

After the farms had been grouped together into their clusters, within each cluster a median farm was identified to meet the criteria in the bullet points above. These farms are listed in Table (ii)[5]. Although the collective data from these farms contain some differences when compared with the overall results for farms within the catchment, the five farms have been "discovered" in the data using an objective and repeatable statistical method already used in a number of policy studies in New Zealand[6]. This is still the best way for a limited number of actual farms to be used to represent the catchment in further analyses for policy development.

The financial impact on dairy farm systems of Table 14.2 'Cumulative nitrogen leaching maximum by Land Use Capability Class' in the One Plan was described in an earlier report to the Manawatu Wanganui Regional Council. This report updates that information by applying the financial information in the earlier report to the farm clusters developed in this report. The farm system descriptions in the earlier report were compared with the cluster medians in this report (shown in Table (i). That enabled the appropriate farm system financial data to be aligned with the cluster farm medians. The farm system data was then adjusted to match the cluster median for "milking platform area".

The resultant financially updated information is summarised in Table (iii). For the majority of dairy farmers in this catchment achieving the nitrogen reductions required for a Controlled Consent would require a reduction in their operational profit of 24-61%.

[4] This Table is repeated as Table 3 later in the report.
[5] This Table is repeated as Table 4 later in the report.
[6] Joey Au, Andrew Coleman and Trudy Sullivan, 2015. A Practical Approach to Well-being Based Policy Development: What Do New Zealanders Want from Their Retirement Income Policies? New Zealand Treasury Working Paper 15/14. http://www.treasury.govt.nz/publications/research-policy/wp/2015/15-14/twp15-14.pdf .

Table (i). Clustering results for farms in the Upper Manawatu River catchment with their medians for selected attributes

Cluster	Soil Order	Rainfall (mm)	Milking Platform Area (ha)	Milking Cows (Peak)	Production per cow (kgMS/cow/yr)	Production per hectare (kgMS/ha/yr)	Dairy System Type (I-V)	Nitrogen Loss to Water (kgN/ha/yr)	Phosphorus loss to water (kgP/ha/yr)
1	Allophanic	1376	116	370	327	896	III	40	0.9
2	Recent	1211	112	336	369	968	III	47	1.0
3	Gley	1241	99	256	340	917	II	26	1.3
4	Brown	1255	131	385	387	1136	IV	47	1.0
5&6	Brown & Pallic	1354	108	270	336	830	II	39	0.9
Median of cluster medians	NA	1190	95	220	305	829	III	43	1.5
All farms in the catchment	Brown	1298	111	309	340	902	II	39	1.0

Table (ii). Representative farms for the Upper Manawatu River catchment selected from the median farms within each cluster

Cluster	Farm	Soil Order	Rainfall (mm)	Milking Platform Area (ha)	Milking Cows (Peak)	Production per cow (kgMS/cow/yr)	Production per hectare (kgMS/ha/yr)	Dairy System Type (I-V)	Nitrogen Loss to Water (kgN/ha/yr)	Phosphorus loss to water (kgP/ha/yr)
1	16	Allophanic	1551	179	530	258	765	IV	58	0.9
2	25	Recent	1176	197	510	360	933	IV	33	1.8
3	14	Gley	1588	74	220	309	921	II	32	1.8
4	112 (irrigated)	Brown	1255	86	250	369	1068	III	32	0.8
5&6	54	Brown	1082	113	260	362	829	III	27	0.6
Median of representative farms		NA	1255	113	260	360	921	III	32	0.9
All farms in the catchment		NA	1298	111	309	340	902	II	39	1.0

Table (iii). Financial Impact of Applying Table 14.2 (One Plan) to Dairy Farming Clusters in the Upper Manawatu River Catchment[7]

Cluster	Number of farms affected	System Type	Median Milking Platform Area (ha)	Initial Farm Profit ($)	Final Farm Profit ($)	Reduction in Profit (%)
1	27	Self-contained	108	189,432	73,245	61
2	10	Low-intensity	116	276,769	159,326	42
3	18	Moderate-intensity	99	282,135	215,652	24
4	16	Moderate-intensity	131	373,968	285,845	24
5&6	55	Self&Low-intensity	112	226,826	115,756	49

This table builds on the results presented in Table 4 in Parminter 2018. An impact assessment of One Plan policies and rules on farming systems in the Tararua District and the Manawatu Region. A Client Report for Manawatu Wanganui Regional Council.

[7] This Table is repeated as Table 8 later in the report.

1. Purpose

The purpose of this report is to select and describe suitable representative dairy farms for the Upper Manawatu River catchment (above the Manawatu Gorge) and to use these to assess the likely viability of dairying in that catchment under the current policies and rules of the One Plan.

In order to address the purpose this report brings together a number of data sources and the results of applying cluster analysis to the known farm data. The first data source is a description of the natural resources in the region and their variability at catchment and farm scales. The second is a description of the dairy farming systems being used by the dairy industry within the district and the catchment to adapt farm practices and management strategies for achieving farmer, community and industry goals. Information from these two approaches are brought together at the farm scale in this report using a cluster analysis to select suitable farm examples that can be used to represent the dairy industry when evaluating the impact of natural resource policy in the Upper Manawatu River Catchment.

2. Approach

The context for this report is the Manawatu Wanganui Region and the Tararua District where streams in the Upper Manawatu River catchment provide the headwaters for the Manawatu River. The Upper Manawatu River catchment comprises only a small portion of the region and is only a part of the Tararua District. However, a lot of the natural resource information used in this report has been collected at a regional scale and/or a district scale. This more general information about the region and the district is covered first before the report focusses on the specific catchment of interest and how it compares with the other catchments in the region.

The Regional chapters of this report describe its physical resources, its rainfall, soils and dairying statistics. The Tararua District is then introduced and describes these same resources in further detail.

DairyNZ have established that there are five types of dairy farming systems commonly being used in New Zealand. Although these systems use resource inputs quite differently, they are able to achieve similar levels of operating profit (Shadbolt 2012)[8]. These systems have been used in a range of other studies to explore the impacts of changes in industry strategies, along with regional policies on farming profitability, and farmer resilience and innovation.

The section in this report describing dairying in the Upper Manawatu River catchment examines some of the farm variables often associated with waterway contamination. These are used to establish the key components that underpin the representative farms selected from this part of the study. The farm results are used to make an assessment of dairy system viability and these results are applied to the Tararua District. Finally in the discussion and conclusions, the results are further developed for application by the Regional Council.

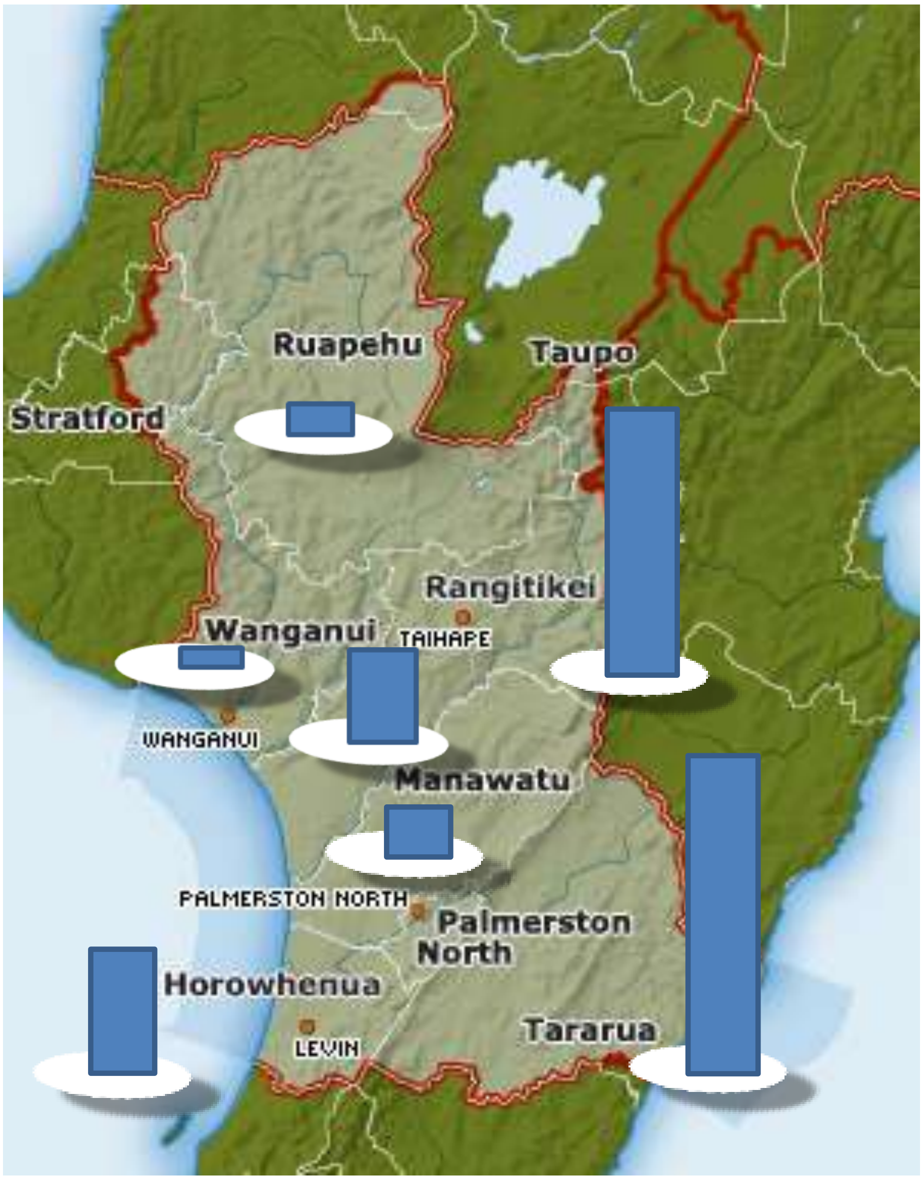
[8] N. Shadbolt 2012. Competitive strategy analysis of NZ pastoral dairy farming systems. International Journal of Agricultural Management, Volume 1 Issue 3 pp19-27.

3. Regional Dairying Statistics[9]

In the 2015-16 there were 837 dairy farms in the Manawatu Wanganui Region (Figure 1). Palmerston North City and Ruapehu and Wanganui Districts each had 50 herds or less. Horowhenua and Rangitikei Districts had about 100 dairy farms each. The districts with the greatest number of dairy farms were Tararua District with 304 dairy farms and the Manawatu District with 255 dairy farms.

The average farm in the region had an effective area for the milking platform of 137 ha and 376 cows in the herd and an average stocking rate of 2.73 cows/ha. Milk production averaged 362 kgMS/cow or 990 KgMS/ha.

Figure 1. Distribution of dairy farms across Manawatu Wanganui Districts



http://www.localcouncils.govt.nz/lgip.nsf/wpg_url/Profiles-Councils-by-region-Manawatu-Wanganui

[9] The industry information is sourced from: New Zealand Dairy Statistics 2015-16. Livestock Improvement Ltd and DairyNZ Ltd, and personal communication with DairyNZ.

4. The One Plan and Sensitive Catchments

The Manawatu Wanganui Region is described in Appendix A. In that description it is apparent that there are a number of catchments to be addressed in policy documents and that the natural resources with the catchments vary considerably from each other. To bring all that variety together under one set of principles, the regional statement and regional plan for the Manawatu Wanganui Region have been combined into one plan. The One Plan became fully operative in 2014. Across the region the One Plan identified sensitive catchments where " collectively, land use activities *[specifically intensive farming]* are significant contributors to elevated contaminant levels in groundwater or surface water" (Policy 5-7). These sensitive catchment zones are described in Table 1 and shown in Figure 2.

Table 1. Sensitive catchment zones listed in the One Plan (where they are shown in Table 14.1)

Catchment	Water Management Sub-zone	Colour in Figure 3	Total number of dairy farms requiring a landuse consent	Number of farms consented 31st Dec 2017
Mangapapa	Mangapapa Mana_9b	Purple	5	5
Waikawa	Waikawa West_9a Manakau West_9b	Plum	8	8
Other south-west catchments (Papaitonga)	Lake Papaitonga West_8	Light blue	1	1
Mangatainoka	Upper Mangatainoka Mana_8a Upper Mangatainoka Mana_8b Upper Mangatainoka Mana_8c Makakahi Mana_8d	Blue	83	72
Other coastal lakes	Northern Manawatu Lakes West_6 Kaitoki Lakes West_4 Southern Wanganui Lakes West_5	Light green	33	17
Coastal Rangitikei	Coastal Rangitikei Rang_4	Dark green	77	58
Lake Horowhenua	Lake Horowhenua Hoki_1a Hoki Hoki_1b	Yellow	10	10
Upper Manawatu River above Hopelands	Upper Manawatu Mana_1a Mangatewainui Mana_1b Mangatoro Mana_1c Weber-Tamaki Mana_2a Mangatera Mana 2_b Upper Tamaki Mana_3 Upper Kumeti Mana_4 Tamaki-Hopelands Mana_5a Lower Tamaki Mana_5b Lower Kumeti Mana_5c Oruakeretaki Mana 5_d Raparapawai Mana_5e	Khaki	133	35
Manawatu above gorge	Hopeland Tiraumea Mana_6 Upper Gorge Mana 9_a Mangaatua Mana_9c	Brown	34	11
Total number of dairy farms			384	217

Figure 2. Catchment zones within the Manawatu Wanganui Region with the sensitive catchment zones highlighted (see Table 1)

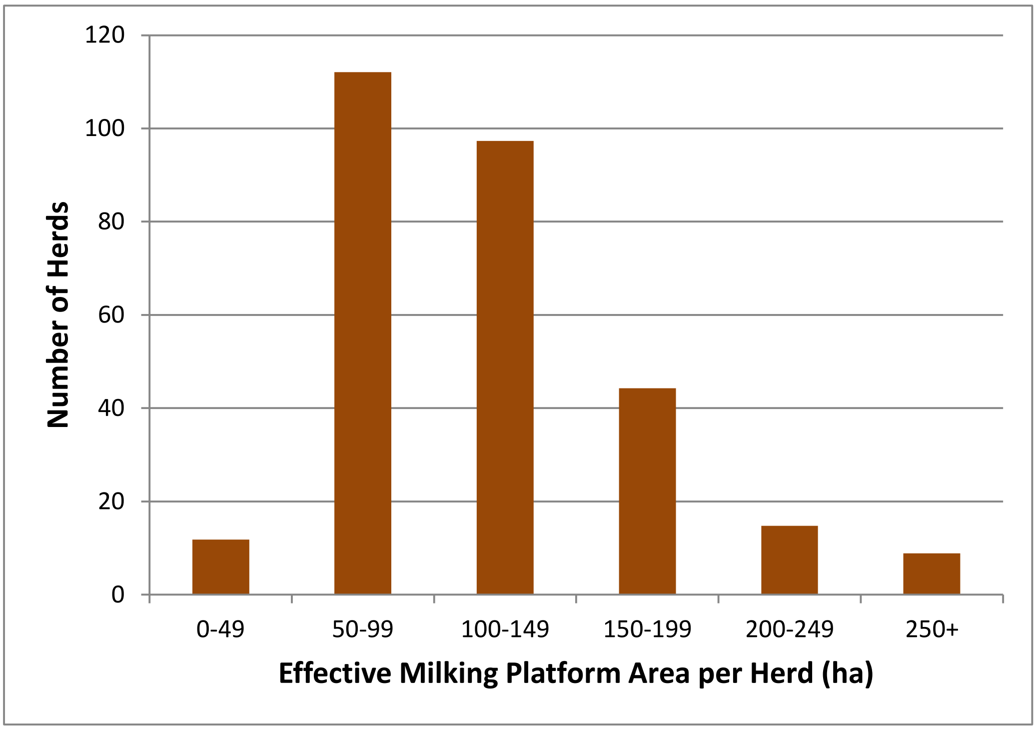
The Upper Manawatu River catchment is important to the Region for its trout fishery and natural state values (Appendix A).

Table 1 also shows the number of dairy farms in each sensitive catchment and therefore that under the One Plan that also require an intensive landuse consent to continue operating. About half the dairy farms in the Manawatu Wanganui Region require a consent, and of these almost 60% had received a consent by 31st December 2017. The largest number of outstanding consents remaining to be completed is for dairy farms in the catchments of the Tararua District. These dairy farms include a number with high relative annual rainfall and those on free-draining brown soils (Appendix A).

5. Dairy Industry Statistics for the Tararua District

The distribution of farm size of dairy farms in the Tararua District as determined from dairy industry statistics is shown in Figure 3. The average area of the effective milking platform was 120ha in the Tararua District. This figure is well below the regional average farm size of 150ha (excluding Tararua). In the Tararua District the median area was 100ha therefore there were more farms smaller than the average for the district compared to the number of farms above the average[10].

Figure 3. The Distribution of Dairy Farm Areas in the Tararua District (2015/16)



The average number of animals in dairy herds in the Tararua District was 324 cows (Figure 4). The median herd number was 250 cows. These figures are about 10% lower than regional results.

[10] In this report results for the average (mean) and the median are presented. The average is a single value used to represent a point mid-way between the highest and lowest results in the data. The mean is used to represent the point in the data where there are as many instances above it as below it. When there is enough data points and they are "normally distributed" the average and the mean become almost the same value.

The average production being achieved in the Tararua District was 964 kg/ha of milk solids per year (Figure 5). This ranged from about 650kg MS/ha/yr to over 1300 kgMS/ha/yr and they are very similar to the regional results.

Figure 4. The Distribution of Dairy Farm Herd Sizes in the Tararua District (2015/16)

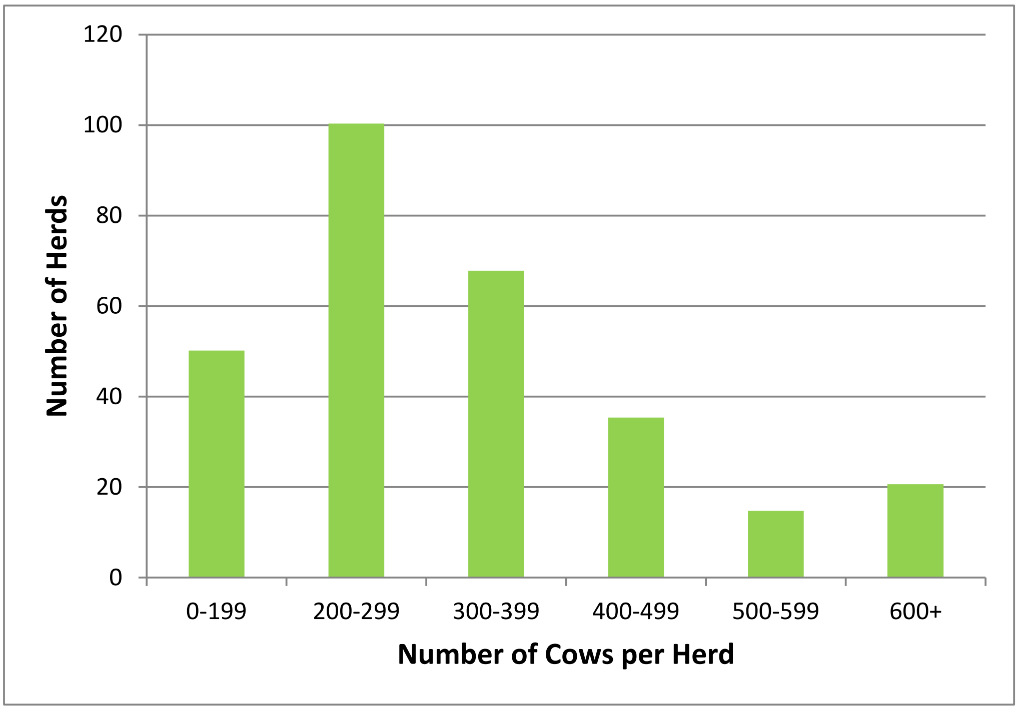
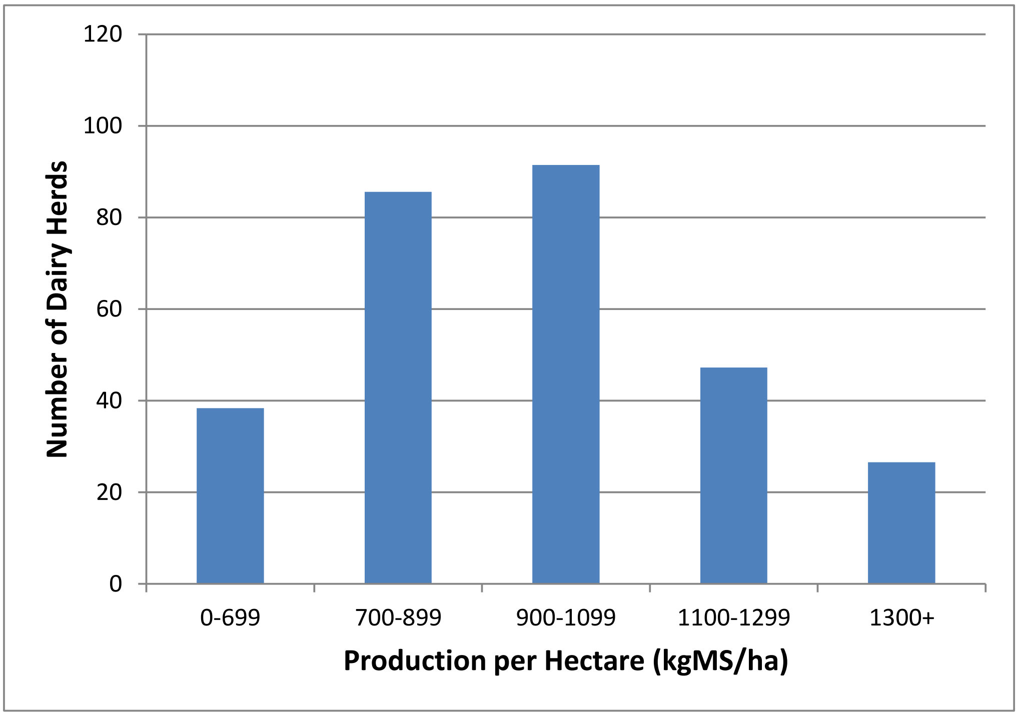


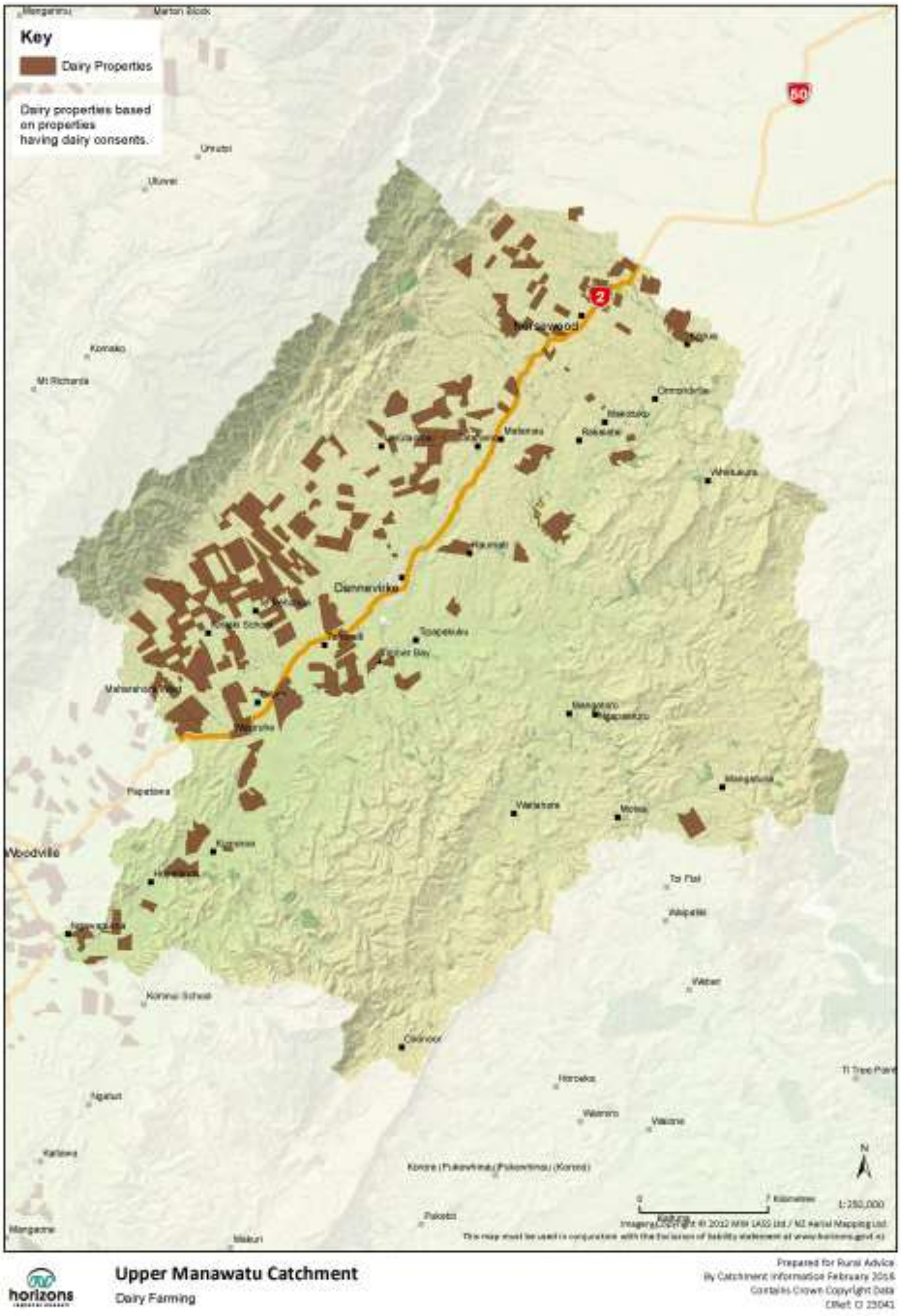
Figure 5. The Distribution of Dairy Farm Production in the Tararua District (2015/16)



6. Description of Dairy Farms in the Upper Manawatu River Catchment

In the Upper Manawatu River catchment, by the 31st December 2017, there were 51 dairy farms that had been issued with a landuse consent, and the Regional Council was waiting on landuse consent applications from a further 121 dairy farmers[11]. The dairy farms in the catchment tend to be on the western side of the catchment between the main road and the foothills of the Ruahine Range (Figure 6).

Figure 6. A map of the Upper Manawatu River catchment showing the distribution of dairy farms



[11] At 31st December 2017

A comparison of Figure 6 and the map in Figure 7 shows that dairying is the main landuse for all the flat and rolling country in the catchment. That is where moderately well drained silt loams and clay loams can be found (Figure8 and Appendix B).

Figure 7. A map of the Upper Manawatu River catchment showing the distribution of land slope

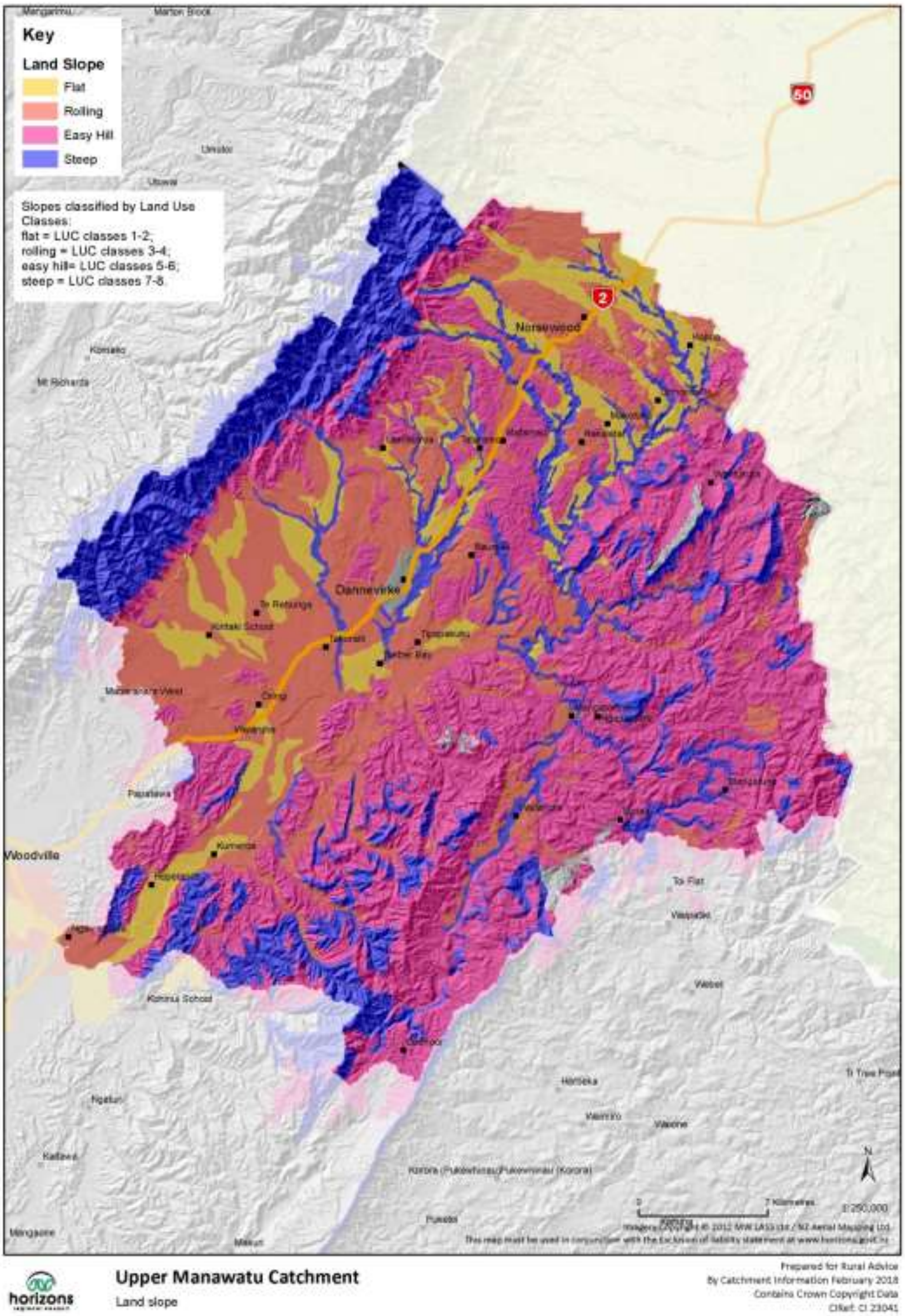
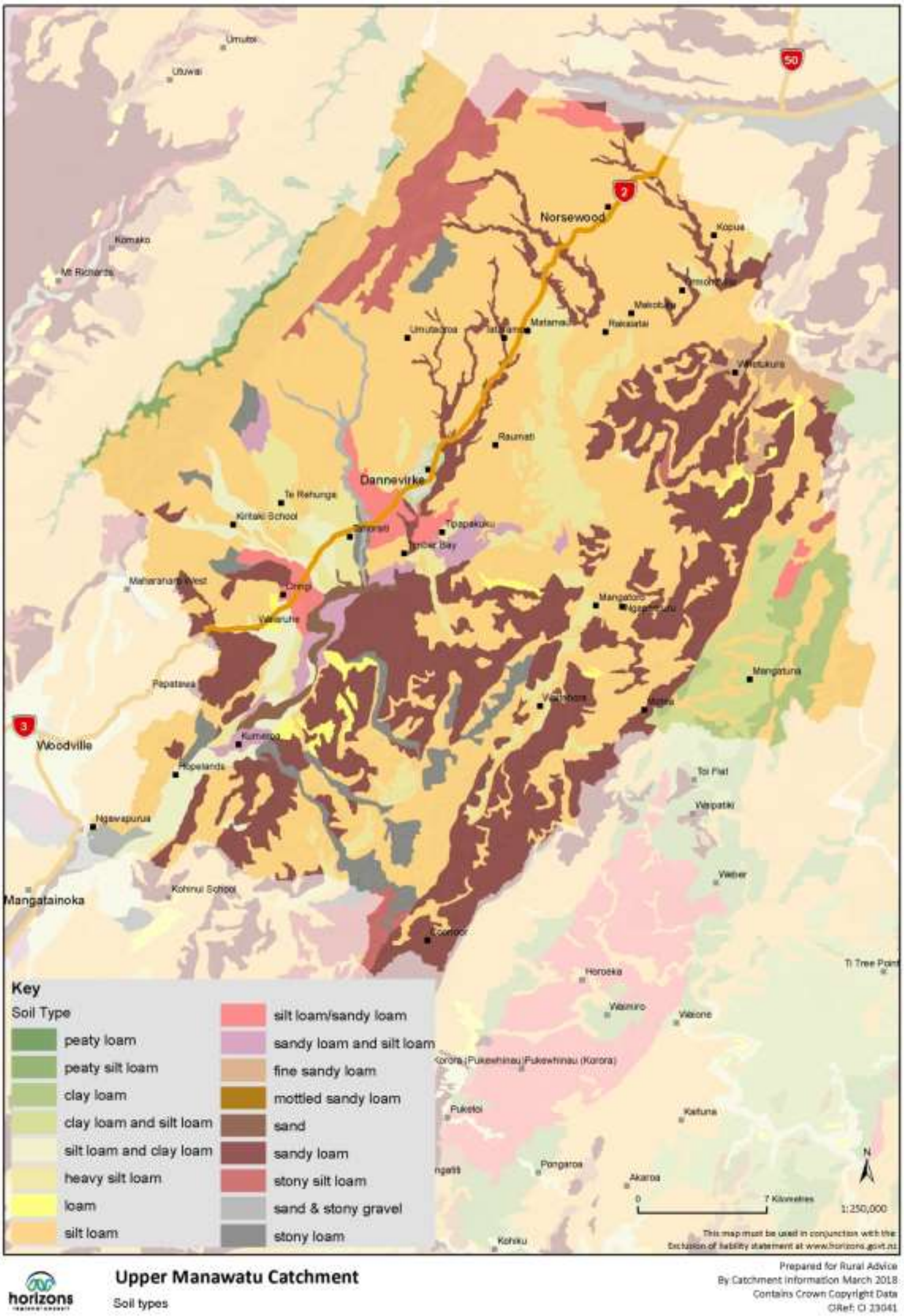


Figure 8. A map of the Upper Manawatu River catchment showing the distribution of soil textures



7. Analyses of Dairy Farm Attributes

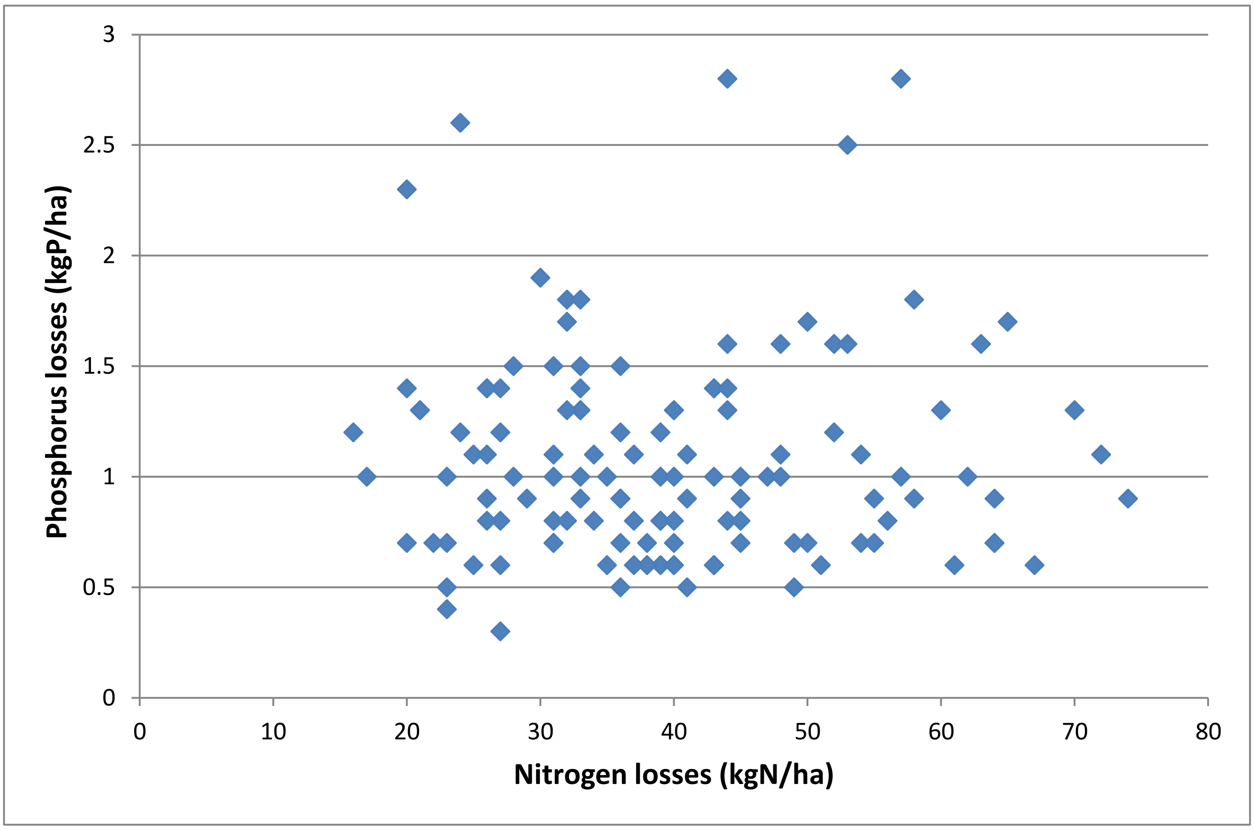
From the total number of dairy farmers in the Upper Manawatu River Catchment, there were 126 farmers that had provided DairyNZ and the Regional Council with enough information for this report to be prepared. These farms became part of a project database for further analysis.

All the dairy farms together had a total area of 23,000ha. Of this the milking platform area was 72%. The average farm milking platform area was 130 ha; the median was 110 ha, and they ranged in size from 39 to 355 ha.

The average farm had 345 milking cows. The median was 310 cows and the range was from 100 to 1,110 cows. These figures are higher than the industry results reported earlier in this report for the whole of the Tararua District. The average farm was producing 915 kg milk solids per hectare per year (kgMS/ha/yr). Median production was 900 kgMS/ha/yr and the farms ranged from 460 to 1450 kgMS/ha/yr. On average, farms grazed 50% of their cows off-farm over winter.

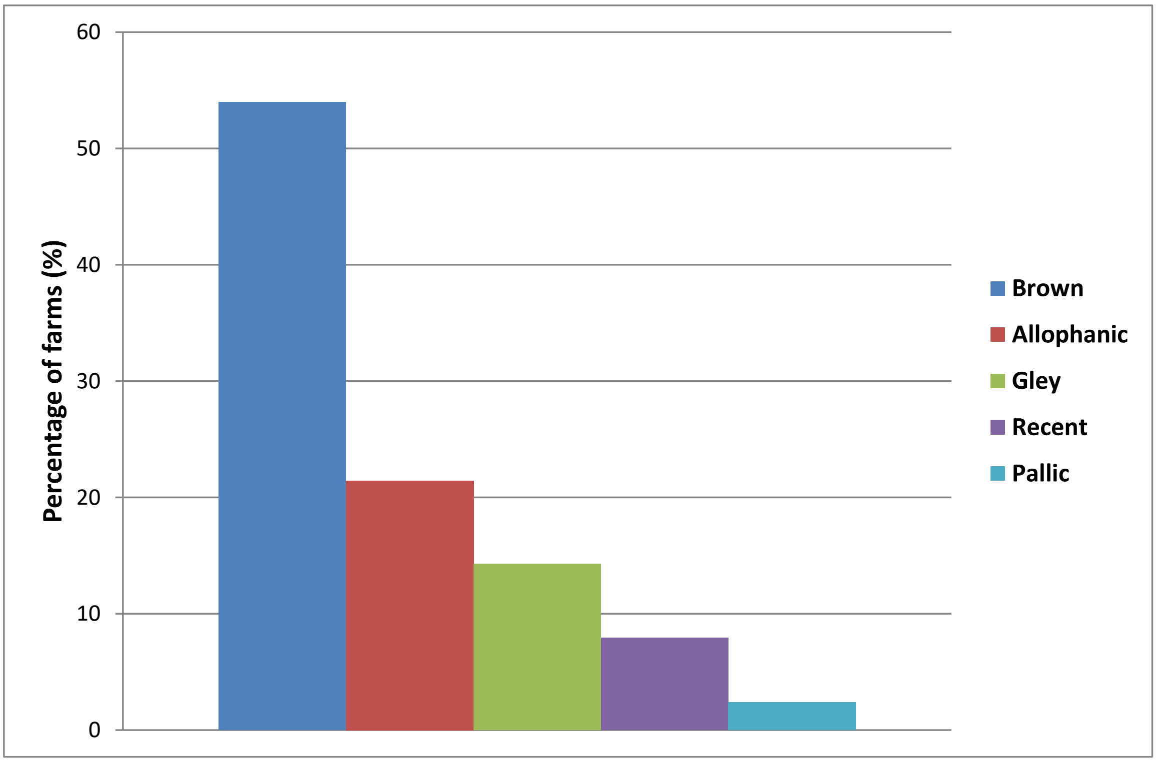
The estimated average 'whole farm' loss of phosphorus to water was 1.08 kgP/ha/yr. The average 'whole farm' loss of nitrogen to water was 40 kgN/ha/yr. This is also shown in Figure 9 where the losses of the two nutrients are shown to be unrelated to each other, highlighting that different farm risk factors are involved in generating each of them.

Figure 9. Estimated dairy farm nutrient losses – nitrogen and phosphorus.



Most of the farms in the catchment are on Brown soils (silt – clay loams), which are free to moderate draining and easily leached (Figure 10). The farms on the Brown soils had an average rainfall of 1350mm and nitrogen losses of 40 kgN/ha/yr. The average rainfall and nitrogen losses for farms on all the soils shown in Figure 12 were similar except that dairy farms on Gley Soils had a lower average rainfall of 1260mm/yr and average nitrogen losses of 30 kgN/ha/yr.

Figure 10. The percentage of farmers with their primary soil type



The stocking rate of milking cows on these farms did not have statistically significant relationships with their milk production or their nitrogen losses Figures 11, 12 and 13). Only when stocking rate and intake were considered together was it possible to estimate their milk production and their expected nitrogen losses with enough confidence (Equations 1&2).

Equation 1. Regression relationship of stocking rate and cow intake with milk production[12]

Milk production (kgMS/ha) = 218 * cows/ha + 70 * total DMintake/cow … R^2=0.97

Equation 2. Regression relationship of stocking rate and cow intake with nitrogen loss

Nitrogen loss (kgN/ha) = 9.7 * cows/ha + 2.8 * total DMintake/cow … R^2=0.91

[12] Total DMintake is the total amount of feed (including pasture) estimated in 'dry matter' (DM) that the cows are consuming each year.

Figure 11. Milking cow stocking rate and milk production

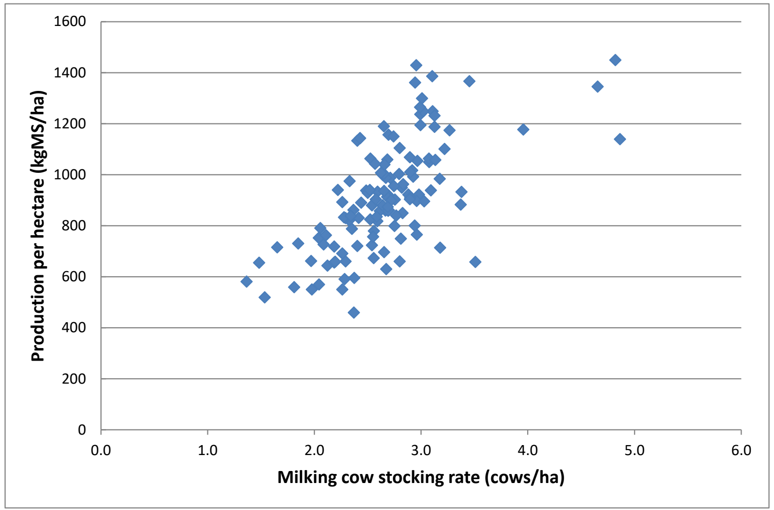


Figure 12. Milking cow stocking rate and nitrogen losses

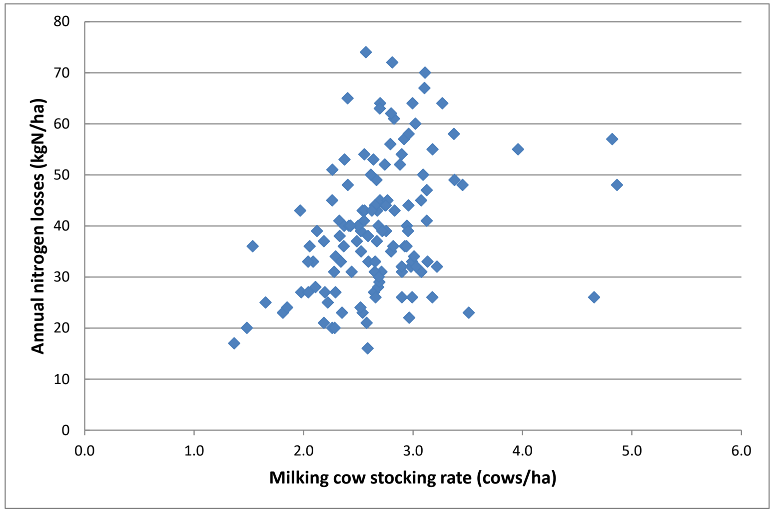
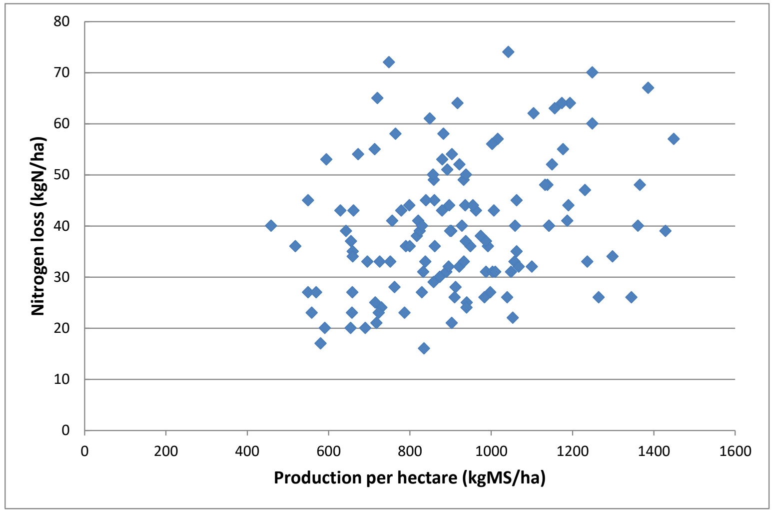
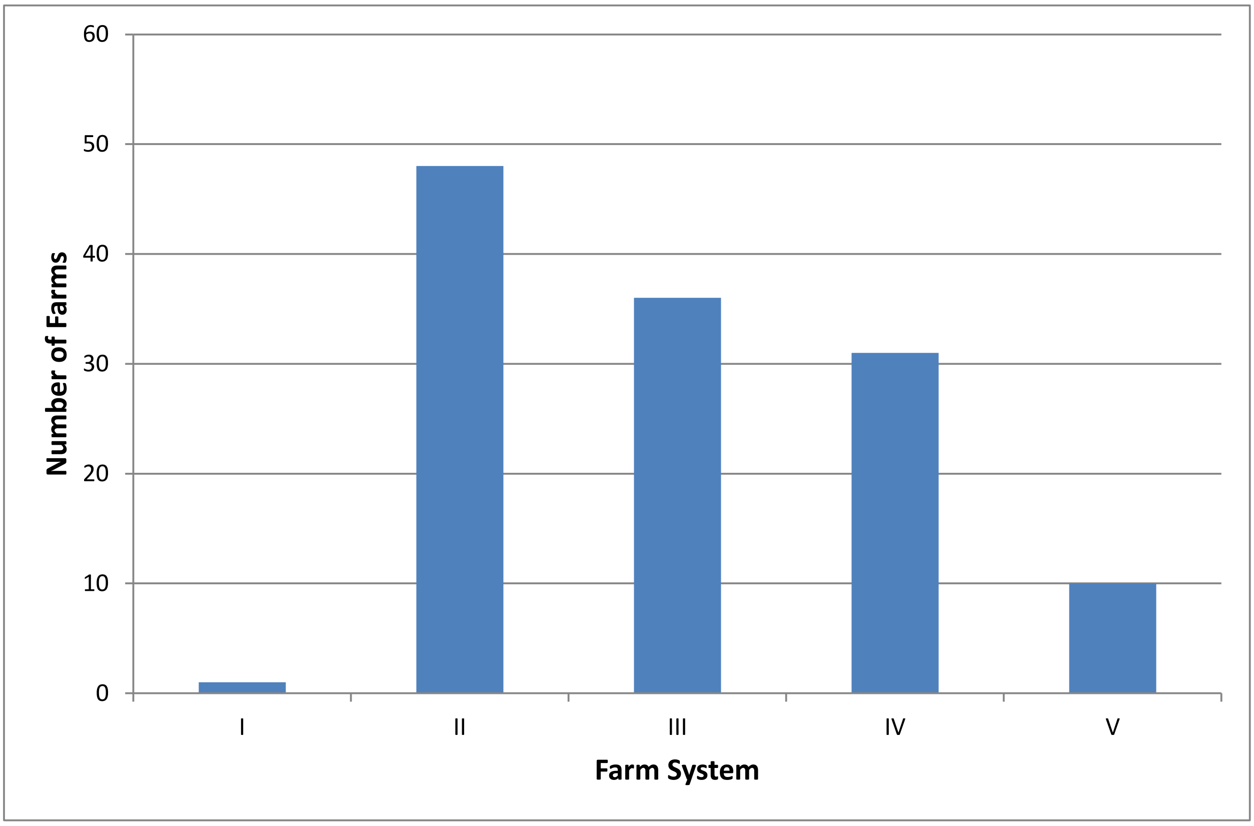


Figure 13. Production per hectare and nitrogen losses per hectare



The effects on the environment of dairy farming landuse is moderated through the farm management practices and the intensity of inputs used. DairyNZ has developed a typology of dairy systems that encapsulates some of these factors (Appendix C). The least intensive and most self-contained dairy systems (Type 1) only had one example in the catchment (Figure 14). Most farms were dairy systems II or III.

Figure 14. The percentage of dairy farms estimated to be operating in dairy systems I to V



The dairy systems III and IV in Figure 15 had very similar average milk production to each other (kgMS/ha/yr) and different from dairy systems II and V (P>95%). In Figure 16, all of the systems have similar nitrogen losses to each other, although system II has significantly lower nitrogen losses compared with systems IV and V but not system III (P<0.95).

Figure 15. The relationship between dairy farm systems and milk production (kgMS/ha/yr)

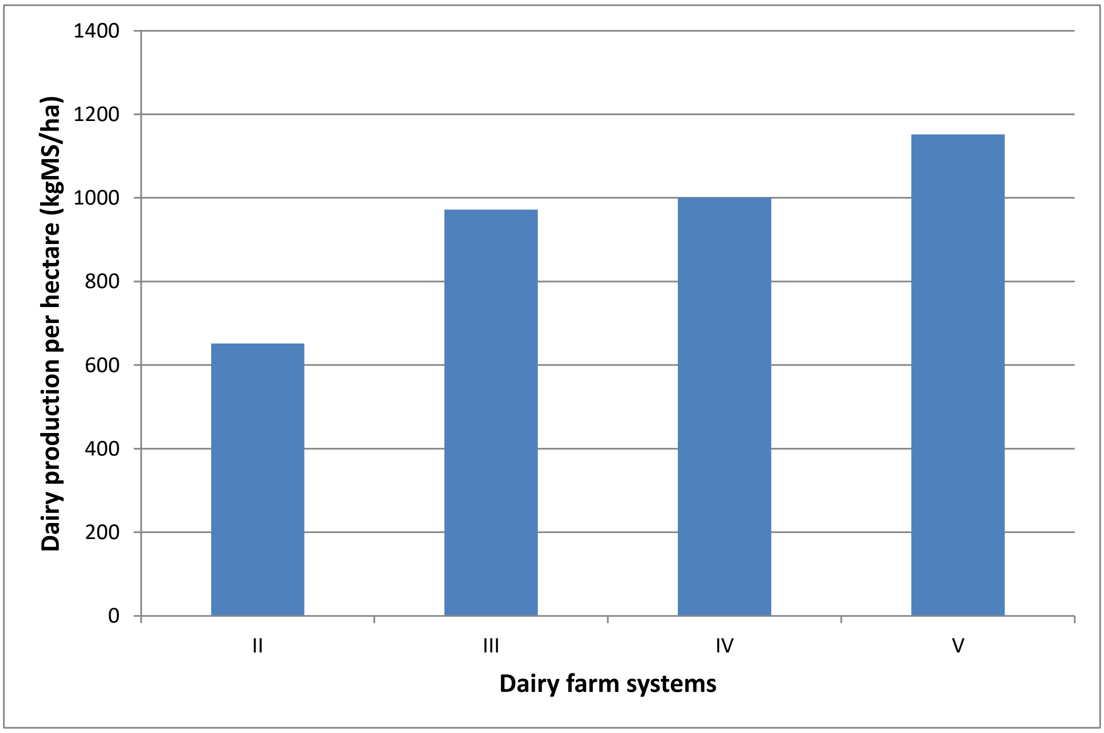
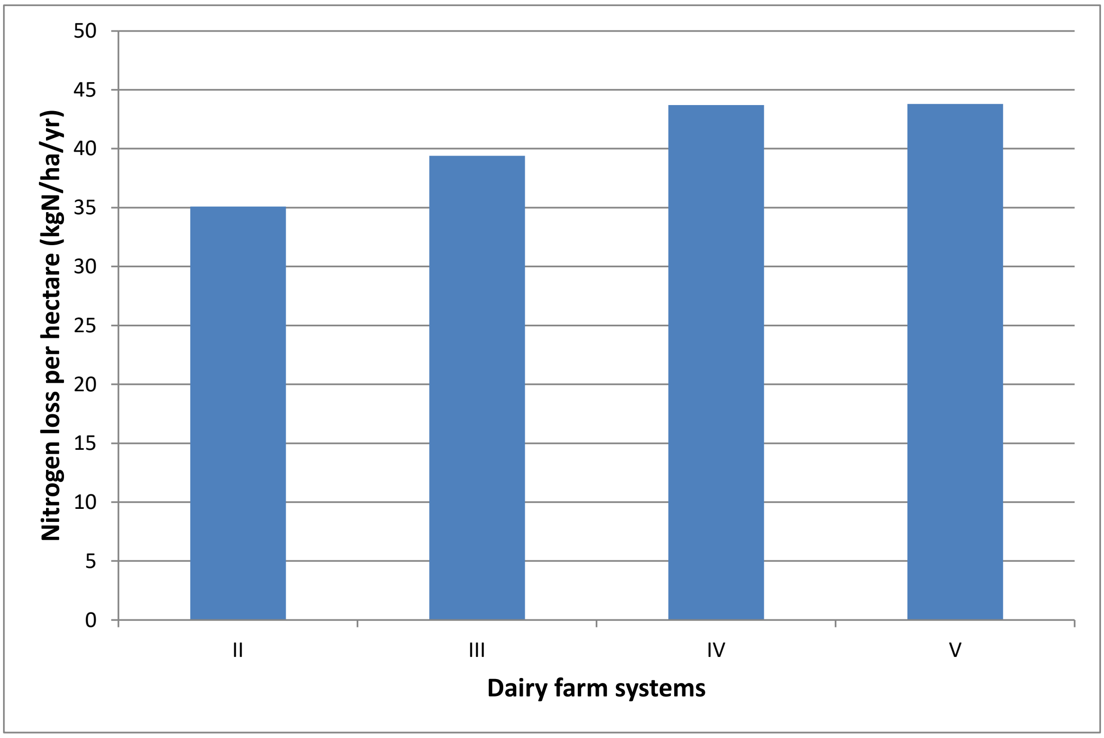


Figure 16. The relationship between dairy farm systems and nitrogen losses (kgMS/ha/yr)



8. Cluster Analyses

All of the farms in the project database were entered into a cluster analysis to identify groups of farms that were similar enough to provide representative dairy farms for the Upper Manawatu River catchment[13].

Cluster analyses are used widely in policy and marketing organisations to assist in recognising patterns and to analyse complex and large data bases[14]. The attributes used for clustering the farms in this study are shown in Table 2. For an understanding of the distribution of the main soil orders and dairy types referred to in this report go to Figures 10 and 14 respectively.

Table 2. Statistical data summary of the attributes contributing towards the cluster analysis (126 farms, 15 with irrigation)

Variable	Mean	Minimum	Median	Maximum	Included in Cluster Analysis
Size of milking platform (ha)	131	39	111	355	Yes
Average annual rainfall (mm/yr)	1346	1023	1298	1827	Yes
Percentage platform irrigated (%)	61	21	63	94	Yes
Peak number of milking cows	343	100	309	1110	No
Production per cow (kgMS/a/yr)	343	187	340	483	No
Stocking rate (cows/ha)	2.7	1.4	2.7	4.9	Yes
Production per area (kgMS/ha/yr)	915	459	902	1449	Yes
Percentage of feed imported (%)	18	1.0	16	54	Yes
One Plan nitrogen allocation 2014[15] (kgN/ha)	22	14	22	27	Yes
Nitrogen loss to water (kgN/ha/yr)	40	16	39	44	Yes
Main soil order	54% brown				Yes
Dairy type	48% II				Yes

Taken from Tables 1 and 2 in Newman and Harvey 2018.

13 Newman & Harvey, 2018. Dairy Farm Cluster Analysis for Horizons Regional Council. A DairyNZ client report for KapAg Ltd

14 Joey Au, Andrew Coleman and Trudy Sullivan, 2015. A Practical Approach to Well-being Based Policy Development: What Do New Zealanders Want from Their Retirement Income Policies? New Zealand Treasury Working Paper 15/14. http://www.treasury.govt.nz/publications/research-policy/wp/2015/15-14/twp15-14.pdf .

15 From Table 14.2 and based on average LUC for farms. Flatter land as greater allocations, i.e. larger numbers

Some of the variables in Table 2 have very similar distributions and these correlations can unduly influence results. For that reason, in the Table, the "No" entries in the last column identifies those variables that were analysed but not included in the final clustering.

Every farm was included in the cluster analysis and they are all listed in Figure 17. The Figure (technically a dendrogram) shows all the unclustered farms (from 1 to 126) on the right and the connections between the farms to the left.

The length of the connections vertically within the clusters shows the degree of similarity of the farms within clusters. Within the clusters, the farms widely apart are more dissimilar than farms close together. The length of the connections horizontally in the Figure indicates the degree of connection between clusters. The connections on the left become increasingly weaker the further they are from the list of individual farms on the right.

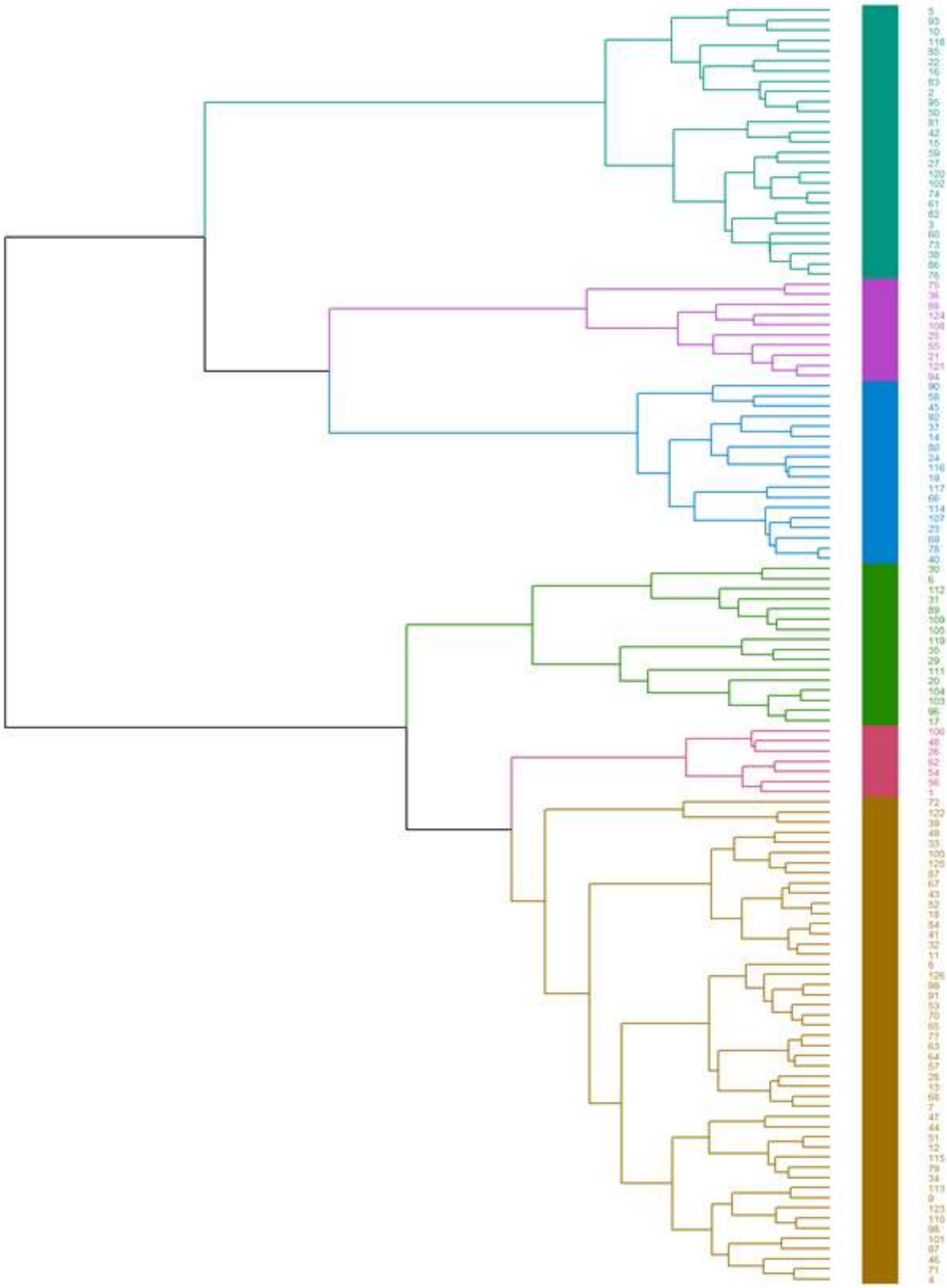
Figure 19 uses different colours to highlight six clusters with similar levels of connectivity across the population. In the Figure, increasing the levels of connectivity by moving one step towards the right increases the number of clusters from six to twelve. Decreasing the level of connectivity by one step to the left would decrease the number of clusters to two and lose a lot of the similarity within clusters. The six clusters are a compromise between being able to discriminate between different farms and the level of parsimony required for catchment scale analysis.

The selected six clusters contain the following numbers of farms and the colours can be found in Figure 17:

- Cluster 1. Teal green, twenty seven farms.
- Cluster 2. Purple, ten farms.
- Cluster 3. Blue, eighteen farms.
- Cluster 4. Green, sixteen farms.
- Cluster 5. Red, seven farms.
- Cluster 6. Brown, forty eight farms.

Cluster five only contains a limited number of farms and the six clusters were reduced to five clusters by combining clusters five and six. This addressed the relatively low number of farms in cluster 5.

Figure 17. A diagram of the results from clustering dairy farms in the Upper Manawatu River catchment



The descriptions of each of the five clusters are provided in Table 3. The first three clusters are of farms on the minority soil orders in the catchment: allophanic, recent and gley. Cluster 4 contains the farms in lower rainfall areas that are more intensively farmed than is general. Clusters 5&6 are farms on brown and pallic soils and are of a farm size often found in the catchment.

A median farm was identified within each one of the five clusters by calculating the medians for every farm and every attribute within each cluster. The farm nearest the centre of each cluster was identified as a representative farm for that cluster (Table 4). Together, these provide representative farms for the whole of the catchment in further catchment scale analyses. The resultant five representative farms meet the following criteria:

- Each of the representative farms is a "real farm" within the catchment[16]. They have not been synthesised or created by modelling.
- An objective and repeatable process has been followed to identify the representative farms.
- Each representative farm is closely related to the other farms in its cluster and dissimilar to the other representative farms in the other clusters.
- None of the representative farms represents an average for the catchment; instead they provide a measure of the variation between farming systems within the catchment.
- Collectively the representative farms approximate the median results for dairy farms in the catchment.
- Every farm in the catchment has a representative farm, "like them".

[16] Every effort has been made to keep farm owners' identities confidential in this report.

Table 3. Clustering results for farms in the Upper Manawatu River catchment with their medians for selected attributes

Cluster	Soil Order	Rainfall (mm)	Milking Platform Area (ha)	Milking Cows (Peak)	Production per cow (kgMS/cow/yr)	Production per hectare (kgMS/ha/yr)	Dairy System Type (I-V)	Nitrogen Loss to Water (kgN/ha/yr)	Phosphorus loss to water (kgP/ha/yr)
1	Allophanic	1376	116	370	327	896	III	40	0.9
2	Recent	1211	112	336	369	968	III	47	1.0
3	Gley	1241	99	256	340	917	II	26	1.3
4	Brown	1255	131	385	387	1136	IV	47	1.0
5&6	Brown & Pallic	1354	108	270	336	830	II	39	0.9
Median of cluster medians	NA	1190	95	220	305	829	III	43	1.5
All farms in the catchment	Brown	1298	111	309	340	902	II	39	1.0

Table 4. Representative farms for the Upper Manawatu River catchment selected from the median farms within each cluster

Cluster	Farm	Soil Order	Rainfall (mm)	Milking Platform Area (ha)	Milking Cows (Peak)	Production per cow (kgMS/cow/yr)	Production per hectare (kgMS/ha/yr)	Dairy System Type (I-V)	Nitrogen Loss to Water (kgN/ha/yr)	Phosphorus loss to water (kgP/ha/yr)
1	16	Allophanic	1551	179	530	258	765	IV	58	0.9
2	25	Recent	1176	197	510	360	933	IV	33	1.8
3	14	Gley	1588	74	220	309	921	II	32	1.8
4	112 (irrigated)	Brown	1255	86	250	369	1068	III	32	0.8
5&6	54	Brown	1082	113	260	362	829	III	27	0.6
Median of representative farms		NA	1255	113	260	360	921	III	32	0.9
All farms in the catchment		Brown	1298	111	309	340	902	II	39	1.0

The five representative farms are described in summary form in Table 4. The farm numbers are not related to any on-farm identifier. Although the collective data from these farms contains some differences when compared with the overall results for farms within the catchment, the five farms provide the best way for a limited number of actual farms to represent the catchment.

Each of the clusters still contains a range of farming systems around the representative farms and this diversity is consistent with the diversity present in the original population. Tables 5 and 6 illustrate this by showing the diversity for two attributes: farm area (milking platform) and nitrogen losses. Individually the representative farms highlighted in the table include examples that are high and low for each attribute. Collectively the representative farms also approximate the median for the population.

Table 5. The percentage of farms within each cluster and the areas of their milking platforms (%). The coloured cells highlight the representative farm results.

	Farm Areas (ha)						
Clusters	<100 ha	100-149 ha	150-199 ha	200-249 ha	250-299 ha	>299 ha	Total (%)
1	41	22	26	4	7	0	100
2	30	40	20	10	0	0	100
3	50	28	22	0	0	0	100
4	31	25	13	6	19	6	100
5&6	38	35	15	7	2	4	100

Table 6. The percentage of farms within each cluster and their annual nitrogen losses (%). The coloured cells highlight the representative farm results.

	Annual Nitrogen Losses to Water (kgN/ha/yr)				
Clusters	15-29 kgN/ha/yr	30-44 kgN/ha/yr	45-59 kgN/ha/yr	60-74 kgN/ha/yr	Total (%)
1	4	59	30	7	100
2	10	40	30	20	100
3	67	28	6	0	100
4	0	44	25	31	100
5&6	27	49	18	5	100

Examining Table 6 shows that one representative farm (farm 54 from cluster 5&6) is within the lowest leaching quartile of farms (<31 kgN/ha/yr). Another representative farm (farm 16 from cluster1) is within the quartile with the highest losses of nitrogen to water (>48 kgN/ha/yr). Despite the large variation, there are no consistent differences in management between the five farms in Table 4 to explain the differences.

9. Assessment of Changes in Dairy Profitability from One Plan Application of Table 14.2

In late 2017 the impact was assessed of nutrient allocations through Table 14.2 in the One Plan for dairy farms in the Upper Manawatu River catchment (Parminter 2018). That assessment was made using models of four dairy farming systems.

- A Self-contained farming system using limited inputs (Dairy Type II)
- A Low-intensity farming system using limited inputs (also Dairy Type II)
- A Moderate intensity farming system using a range of farm inputs (Dairy Type III)
- A High-intensity farming system that incorporated irrigation and a feed pad (Dairy Type IV)

In Table 7a and Table 7b the statistics for all the farms in the catchment are compared to the results for farms in the clusters and for the dairy farming system models in the 2018 report.

The dairy farming system models tended to be larger farms and all four were mainly on allophanic soils. The most intensive dairy farming system (system IV) has levels of production higher than the median results for any of the clusters.

In Table 8 the systems models are aligned with the clusters that they most approximate. Although the same process described earlier for selecting the representative farms was used for this process, the representative farms themselves were not used in this step. Two clusters can be associated with the Moderate intensity models. Cluster 5&6 can be associated with the medians of the Self-contained system and the Low-intensity system, so the only system model not applied is the High-intensity farming system.

In Table 8 the financial returns from the four farming systems reported in Parminter (2018) have been adjusted according to the median areas of the farms in each cluster. This assumes that the adjusted farms are able to maintain the integrity of their production systems and use the same management mitigations.

These results in Table 8 show that the dairy farms within the catchment would typically need to be prepared to reduce their annual operational profitability by $600 to $1,000 per hectare if they are to meet the year 20 allocations in Table 14.2 of the One Plan.

Table 7a. Clustering median results for farms in the Upper Manawatu River catchment

	Soil Order	Rainfall (mm)	Milking Platform Area (ha)	Milking Cows (Peak)	Production per cow (kgMS/cow/yr)	Production per hectare (kgMS/ha/yr)	Dairy System Type (I-V)	Nitrogen Loss to Water (kgN/ha/yr)	Phosphorus loss to water (kgP/ha/yr)
All farms in the catchment	Brown	1298	111	309	340	902	II	39	1.0
Clusters									
1	Allophanic	1376	116	370	327	896	III	40	0.9
2	Recent	1211	112	336	369	968	III	47	1.0
3	Gley	1241	99	256	340	917	II	26	1.3
4	Brown	1255	131	385	387	1136	IV	47	1.0
5&6	Brown & Pallic	1354	108	270	336	830	II	39	0.9

Table 7b. Median results for farm systems in the Tararua District

	Soil Order	Rainfall (mm)	Milking Platform Area (ha)	Milking Cows (Peak)	Production per cow (kgMS/cow/yr)	Production per hectare (kgMS/ha/yr)	Dairy System Type (I-V)	Nitrogen Loss to Water (kgN/ha/yr)	Phosphorus loss to water (kgP/ha/yr)
Farm system types									
Self-contained	Allophanic	1271	120	270	319	718	II	32	0.6
Low-intensity	Allophanic	1271	150	400	361	962	III	42	0.7
Moderate-intensity	Allophanic	1271	200	600	401	1203	III	54	0.7
High intensity	Allophanic	1174	200	640	440	1407	IV	64	0.8

Parminter 2018. An impact assessment of One Plan policies and rules on farming systems in the Tararua District and the Manawatu Region. A Client Report for Manawatu Wanganui Regional Council

Table 8. Financial Impact of Applying Table 14.2 (One Plan) to Dairy Farming Clusters in the Upper Manawatu River Catchment

Cluster	Number of farms affected	System Type	Median Milking Platform Area (ha)	Initial Farm Profit ($)	Final Farm Profit ($)	Reduction in Profit (%)
1	27	Self-contained	108	189,432	73,245	61
2	10	Low-intensity	116	276,769	159,326	42
3	18	Moderate-intensity	99	282,135	215,652	24
4	16	Moderate-intensity	131	373,968	285,845	24
5&6	55	Self&Low-intensity	112	226,826	115,756	49

Information taken from Table 4 in Parminter 2018. An impact assessment of One Plan policies and rules on farming systems in the Tararua District and the Manawatu Region. A Client Report for Manawatu Wanganui Regional Council

10. Conclusions

Dairying in the Upper Manawatu River catchment is a significant landuse within the catchment and within the Tararua District. An impact assessment of the nitrogen loss maximums in Table 14.2 has previously been carried out focussed on four of the main dairy systems being used in the District.

This report has identified that by undertaking a clustering analysis of almost all the farms in the catchment (95%), it has been possible to identify five representative farms for the catchment. These representative farms can now be used to carry out further assessments of policy options for natural resource management.

Information from the previous report and the 5-6 clusters themselves have been used to calculate the on-farm financial impacts of Table 14.2 across all the farms in this catchment.

Appendix A. Regional Description of Natural Resource Management

The Region's Catchments

The Manawatu Wanganui Region spans three major river catchments in the centre of the North Island. The largest catchment, the Whanganui River Catchment (7,380 km^2) begins in Ruapehu District and extends 290 km south to Wanganui and the South Taranaki Bight. The Manawatu River Catchment (5,898 km^2) begins on the East Coast of the North Island in the Tararua District and flows westward 235 km through the Manawatu Gorge to the Tasman Sea at the Horowhenua Coast. The Rangitikei River Catchment (3,948 km^2) begins just south of Lake Taupo and flows 253 km along the length of the Rangitikei District to the Tasman Sea. In each catchment, the rainfall and soils can change markedly from the mountainous headwaters until they reach the river mouths.

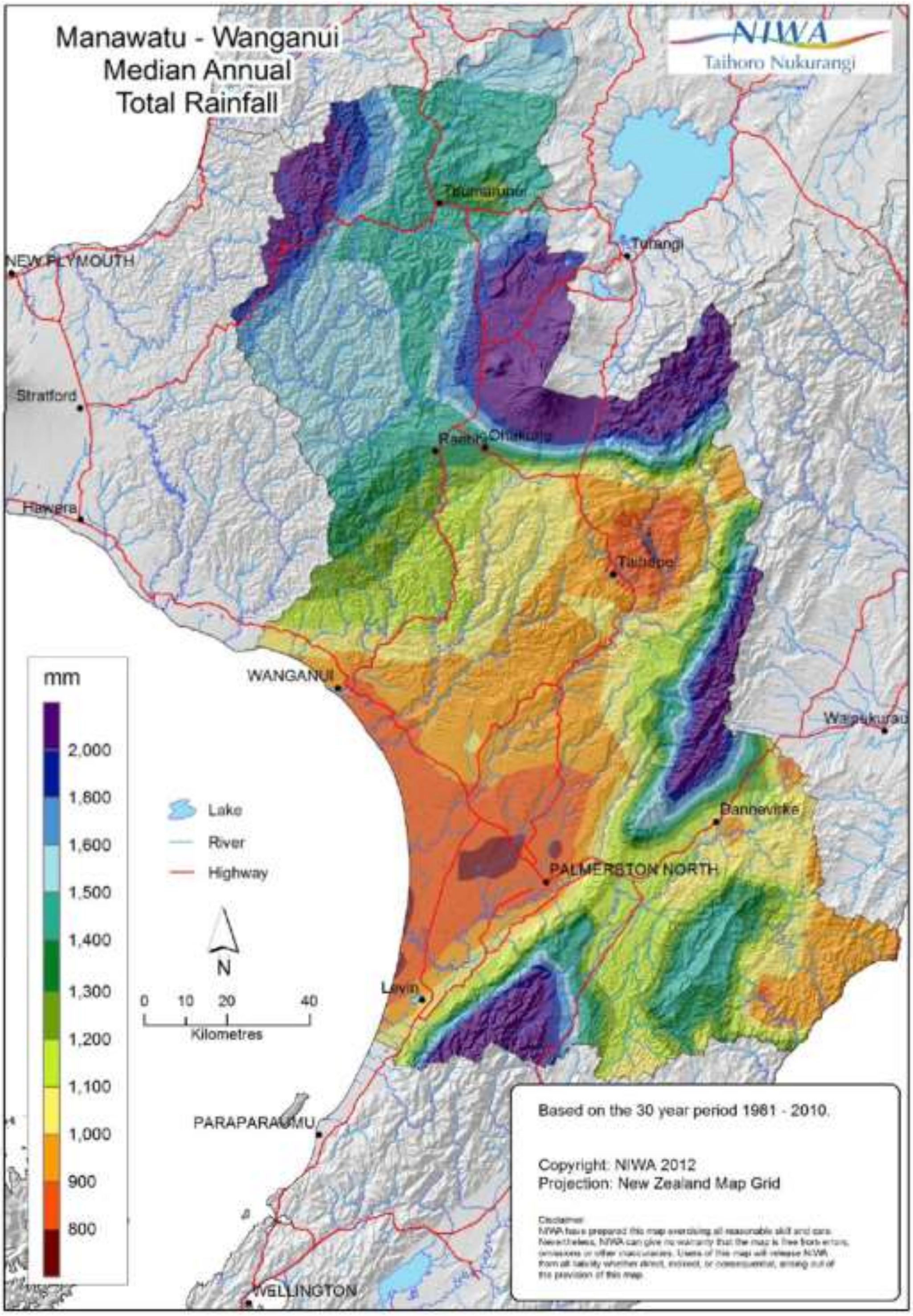
Regional Rainfall Distribution

The geographical distribution of annual total rainfall is shown in Figure 18. The headwaters of all three major rivers include hilly areas with annual rainfall over 2000 mm/yr. The coastal plains, where the three rivers flow into the Tasman Sea, receives less than 1000 mm/yr on average.

Regional Soil Distribution

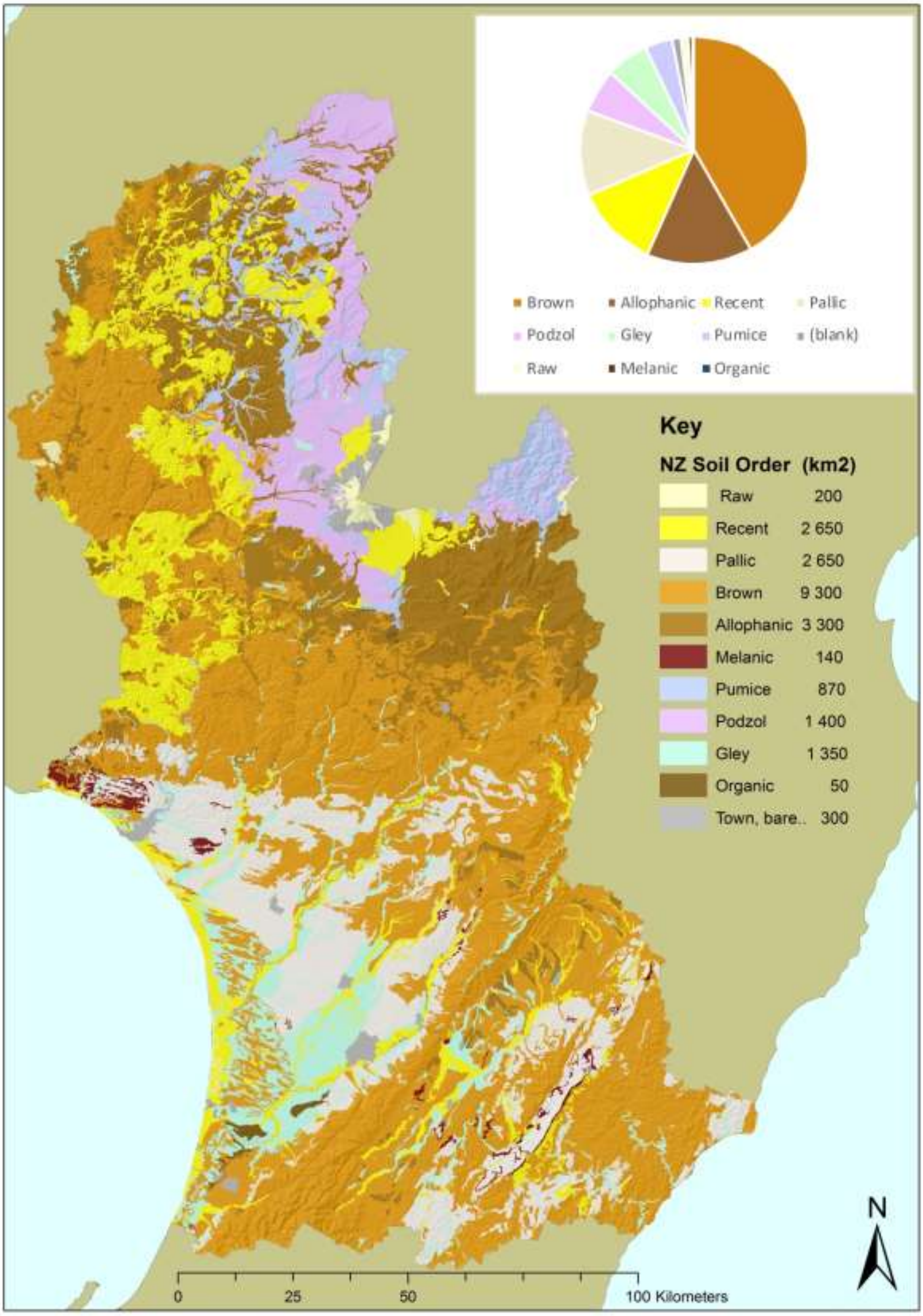
The Region has a number of soil groups derived from volcanic rock, sedimentary rock (sandstone, mudstone and greywacke), organic material and sands (Figure 19). The *Allophanic soils* are formed from volcanic rock. They are found in the mountainous area to the north of the region. *Brown soils* formed from sedimentary rock and sands can be found across the Manawatu Plain, on river terraces and valley bottoms; under moderate rainfall. These soils have good water holding capacity and are generally free draining although that also means that they have high levels of nitrate losses when intensively farmed. *Pallic soils* are formed from the loess of windblown sedimentary rock that built up around the hills in the centre and to the east of the region. They are found on poorly drained terraces and have a water impeded sublayers of clay. When they are artificially drained, pallic soils can have high nitrate losses under intensive farming. *Organic (peat) soils* are formed from organic parent material. They are generally wet and poorly drained with high water storage. They have very low nitrate leaching. *Sandy Recent soils* along the west coast are generally well drained with moderate levels of nitrate leaching. *Orthic Recent soils* to the north west have high natural fertility, high plant-available water capacity and moderate levels of nitrate leaching.

Figure 18. Median annual rainfall across the Manawatu Wanganui Region[17]



[17] From a map of median annual total rainfall for the Manawatu-Wanganui Region, printed by Horizons Regional Council with permission from NIWA. Source NIWA report on the Climate and Weather of the Manawatu Wanganui Region (Chappel, 2015). http://www.horizons.govt.nz/HRC/media/Media/Agenda-Reports/Catchment-River-Management/16-16%20-%20Presentation%20NIWA%20-%20Annex%20A.pdf

Figure 19. Manawatu Wanganui Regional soil groups



Water Quality in the Upper Manawatu River

The One Plan addresses surface water quality by establishing water quality targets for rivers and lakes, in order to give effect to the values associated by the Council with those waterways. The One Plan aims to maintain water quality in those Water Management Sub-zones that meet their water quality targets, and improve water quality over time, in those Water Management Sub-zones that do not.

The middle reaches of many rivers in the One Plan were considered “unsafe to swim in because of bacterial contamination, or are unpleasant to swim in because of slime (periphyton) growth. The slime also impacts on fish and instream invertebrate communities.” “The lower reaches of many rivers have high concentrations of bacteria, nitrates, phosphates and sediments, and these levels are increasing.”

“Nitrate levels are high in shallow groundwater in parts of the Region, but the levels have not changed during the period of monitoring.”

There are a number of values shared by all waterways in the catchments within the Tararua District (One Plan, Schedule B):

- Life supporting capacity
- Aesthetics
- Contact recreation
- Mauri
- Industrial abstraction
- Irrigation
- Stock water
- Existing infrastructure
- Capacity to assimilate pollution

Other values are zone specific. In the Tararua District the most common of these are:

- Natural state
- Sites of significance – aquatic
- Trout spawning
- Trout fishery, including some that are considered outstanding for the region
- Flood control and drainage

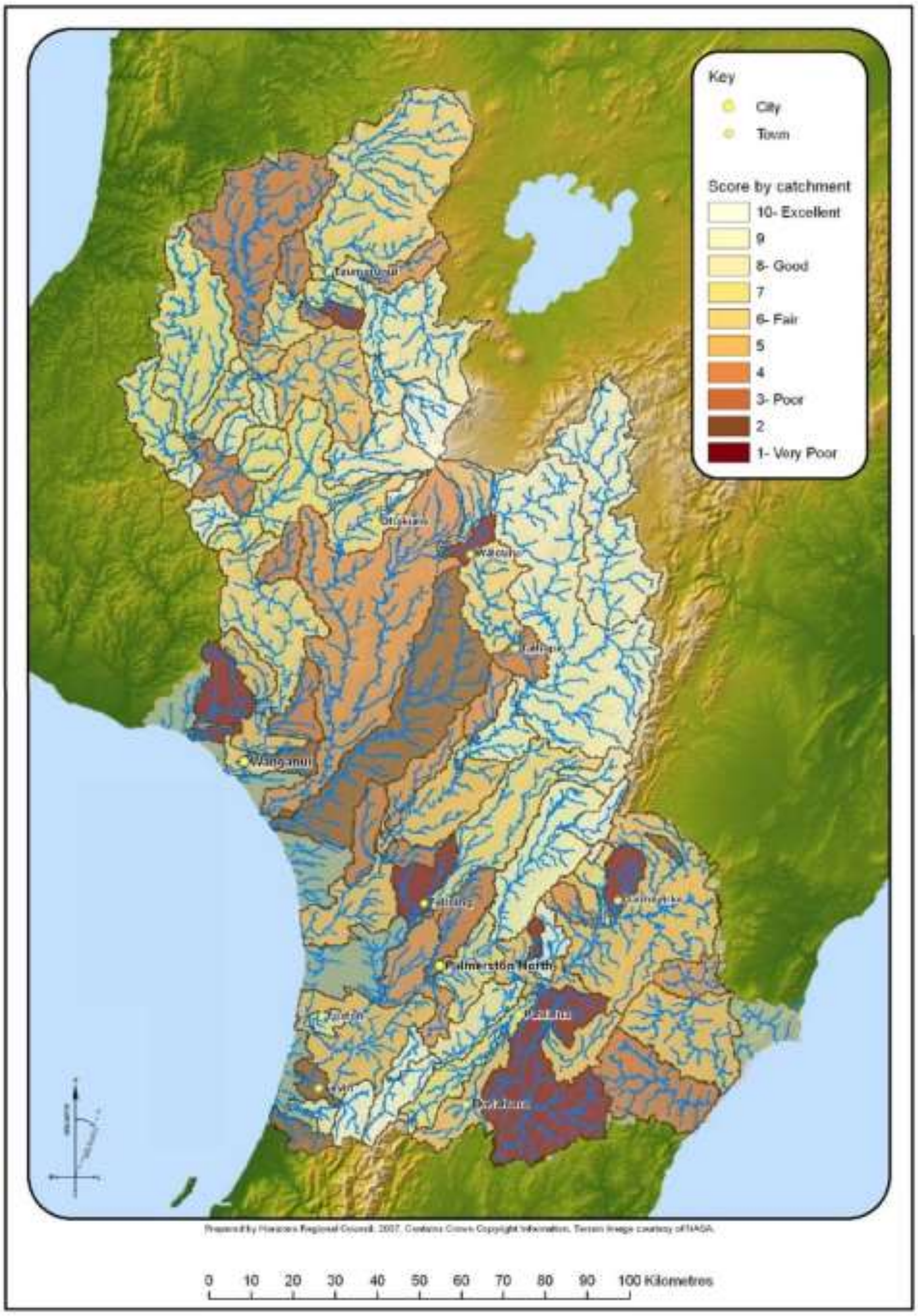
In the One Plan, the water quality standards associated with these values are listed in One Plan Schedule E.

A map of water quality in the Manawatu Wanganui Region is included in Chapter 5 of the One Plan. The map shows the distribution of water quality results relative to the value of ‘contact recreation’ in the first list of values above (shown here in Figure 20).

The map in Figure 20 highlights that for ‘contact recreation’, there is “very poor quality” water in the Mangatainoka, Mangapapa and Mangatera Streams, (all in the Tararua District) and associated with a number of land uses, including dairying.

According to LAWA, "the Mangatainoka at SH2 monitoring site sits within the [best] 25% of all lowland rural sites for visual clarity, dissolved reactive phosphorus and total phosphorus. It is within the [best] 50% of lowland rural sites for E. coli and ammoniacal nitrogen but is within the worst 50% for both measures of nitrogen shown on the website [total nitrogen and total oxidised nitrogen]"[18].

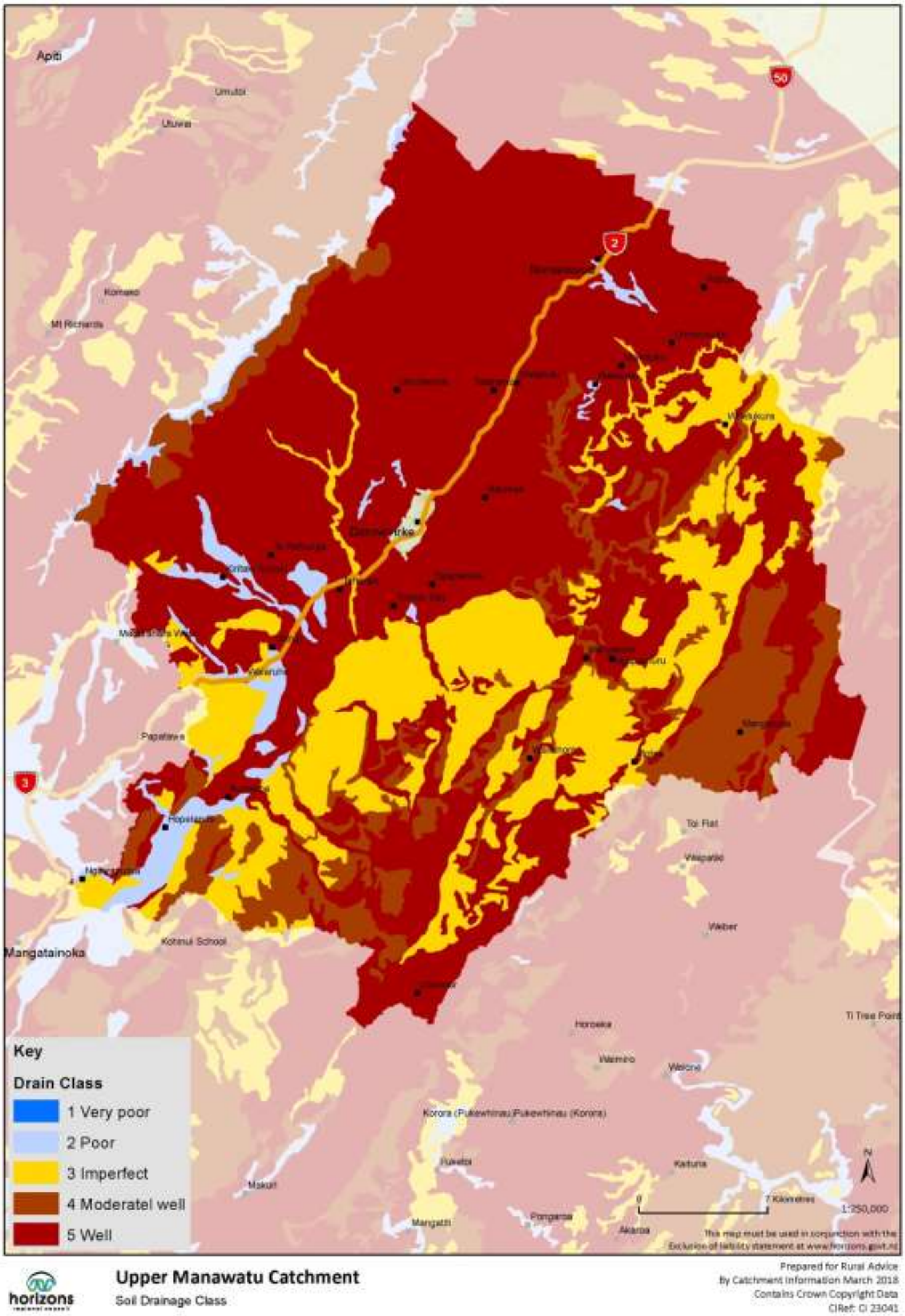
Figure 20. A map of the Manawatu Wanganui Region highlighting the water quality for contact recreation differences between sub-catchments



18 https://www.lawa.org.nz/get-involved/news-and-stories/horizons-regional-council/2014/october/mangatainoka-river-of-the-month/ . Accessed February 2018.

Appendix B. Soil drainage classes

Figure 21. A map of the Upper Manawatu River catchment showing the distribution of drainage classes



Appendix C. Pasture-based dairy systems

The definition of the dairy farm systems used in this report has been developed from the systems described on page 24 of DairyNZ Facts & Figures.

Type of System	Imported Feed (%)	Dry cow grazing	Milking cow grazing	How imported supplements used
I	0%	On effective milking area	On pasture with some home-grown grass supplements	NA
II	1 - 10%	On effective milking area with imported supplements, crops and/or grazed-off	On pasture with some home-grown grass supplements	Wintering dry cows
III	11 – 20%	On effective milking area with imported supplements, crops and/or grazed-off	On pasture with some home-grown grass supplements and/or crops or imported supplements	Extending the lactation further into Autumn
IV	21 - 30%	On effective milking area with imported supplements, crops and/or grazed-off	On pasture with some home-grown grass supplements and/or crops or imported supplements	Extending both ends of the lactation (Spring and Autumn)
V	31 – 50% plus	On effective milking area with imported supplements, crops and/or grazed-off	On pasture with some home-grown grass supplements and/or crops or imported supplements	Used throughout the lactation