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Memorandum

To:	Ruamahanga Whaitua Committee	**CC:**	Natasha Tomic, Greater Wellington RC
From:	John Bright	**Date:**	30 Nov 2016
Subject:	**Nutrient Load Mapping Methodology – Draft Version 2**		

Dear Natasha,

This memo describes the methodology used to develop maps of nutrient loads for the Ruamahanga from the outputs of the representative farm systems modelling results provided by MPI. It also presents some summary results derived from the outputs of the mapping to illustrate the range and scale of nitrate losses to water bodies across the catchment.

Best regards,

John Bright
Lead Modeller
Ruamahanga collaborative modelling team

1) Introduction

The Ruamahanga Collaborative Modelling Project (CMP) has been commissioned by Greater Wellington Regional Council (GWRC) to develop and calibrate a modelling system for simulating the effects of water and land use on a broad range of environmental, social, cultural and economic values and associated attributes. A key requirement of this modelling system is to simulate contaminant movement from all locations where they are discharged to waterways, or mobilised by water flow, to down-stream locations of interest in rivers, aquifers, lakes and streams.

In order to simulate contaminant movement from land-based activities to, and through, fresh waterways, the CMP team required information on the spatial distribution of average annual contaminant losses from land-based activities across the whole of the catchment.

Farm type, farm (management) system, soil type and climate are key determinants of contaminant loss from farms and core data inputs for Overseer, the software chosen to model average annual contaminant loss from farms across the catchment. GWRC had previously developed a land-use map for the Ruamahanga catchment, Landcare Research Ltd. had previously mapped the catchment's soils and NIWA had develop climate time series data sets for locations set out on a 500m grid covering the whole of the catchment.

Farm systems data was not available for each farm in the Ruamahanga catchment. This is generally the case in New Zealand. The Ministry for Primary Industries engaged farm consultants to provide the Ruamahanga whaitua committee and GWRC with a description of farming systems in the Wairarapa and to provide information to help develop an understanding of their base-line, or current, loss of the following contaminants: nitrogen and phosphorous (Parminter and Grinter, 2016)[1].

Farm systems information was developed for 16 farms chosen to be representative of the range of farm systems in the Ruamahanga catchment. The consultation and overall process by which specific farms were selected, information obtained and representative farm systems developed is described in Parminter and Grinter (2016). Data and information describing each representative farm was used as an input to Overseer V6.2.1 to estimate average annual nutrient budgets for each of the 16 farms.

2) Purpose of this report

This report describes the methodology used to extrapolate the nutrient leaching data from these 16 farms to estimate nutrient leaching rates for all relevant land uses in the Ruamahanga catchment. The results of this are summarised in Section 4.

[1] Parminter, T and J Grinter (2016). Farm-scale Modelling Report Ruamahanga Whaitua Collaborative Modelling Project. MPI Report No: 2016/TBC, prepared for the Ruamahanga Whaitua Committee

3) Methodology

The GWRC land use map provides a map of pre-dominant land use (e.g. dairy, sheep & beef) across the Ruamahanga catchment. Within a given predominant land use there is a range of farm systems, which typically reflect the combination of soil, rainfall and topography at the farm's location. Rainfall and topography tend to be highly correlated in this catchment so one is broadly representative of the other.
Representative farms are based on actual farms and are therefore associated with a specific combination of pre-dominant land use, soil type, annual rainfall and topography. The following table illustrates this. For example, there are dairy farm system variants suited to low, medium and high rainfall areas.

Table 1: Modelled nutrient losses from representative farm (copy of Table 5 in Parminter and Grinter (2016).

Representative Farm	Farm Background					Leaching losses from the root zone				Runoff to surface water	
	Area (ha)	Revised Stocking Rate (RSU/ha)	Predominant Soil Type (soil order)	Annual Rainfall (mm/yr)	Average annual drainage depth (mm)	Average annual nitrate lost (kgN/ha/yr)	Average annual N concentration in drainage water (ppm)	N lost in urine (kgN/ha/yr)	Annual P loss (kg P/ha/yr)	Average annual N loss in runoff (kgN/ha/yr)	Average annual P loss in runoff (kgP/ha/yr)
Low rainfall dairy, high production	367	22	Pallic	967	514	42	7.7	37	1.0	0.0	0.6
Low rainfall dairy, moderate production	171	23	Gley	1356	465	34	4.2	13	1.5	0.0	0.9
Moderate rainfall dairy	301	21	Pallic	1100	452	24	5.2	19	1.2	0.0	0.9
High rainfall dairy	204	20	Brown	1546	742	47	5.3	31	1.7	1.0	1.3
Irrigated dairy	426	20	Gley	915	408	24	4.7	17	0.9	0.0	0.6
Organic dairy	355	17	Recent	801	498	35	6.6	30	0.8	0.0	0.5
Summer dry sheep and beef finishing	620	12	Brown	825	229	10	1.8	6	0.2	0.0	0.1
Summer wet sheep and beef breeding	380	11	Pallic	1340	498	23	1.2	7	2.6	1.0	2.5
Summer wet sheep and beef finishing	540	10	Pallic	1491	696	10	2.0	6	0.2	0.0	0.1
Sheep and bulls	1110	9	Pallic	870	271	8	2.3	5	0.7	0.0	0.7
Irrigated sheep and beef trading	370	13	Gley	778	293	15	3.4	8	0.8	0.0	0.7
Arable, lamb and bull trading	93	14	Pallic	880	159	20	6.3	6	0.6	0.0	0.3
Summer dry sheep and beef breeding	680	10	Brown	825	235	8	2.0	5	0.2	0.0	0.1
Arable, sheep & beef finishing	380	9	Pallic	910	335	21	5.9	8	0.5	0.0	0.4
Low rainfall dairy support	284	9	Gley	970	362	16	4.5	7	0.3	0.0	0.2
High rainfall dairy support	300	10	Gley	1300	617	98	15.1	19	1.0	0.0	1.0

This information was exploited to develop the map of farm systems required to use Overseer to generate the data needed to build nutrient loss maps for the Ruamahanga catchment. The initial focus was a nitrate leaching map. The process to generate this map followed four major steps.

1) Identify combinations of land use, soil type and rainfall zones in the Ruamahanga catchment

The whole catchment was divided up into different areas (polygons) based on variations in pre-dominant land use (sheep and beef, dairy, finishing etc), soil type, and rainfall using GIS mapping. The following figures show the GWRC land-use, soil and rainfall zone maps that were the primary inputs.

This procedure resulted in approximately 240 unique combinations of land use, soil type and rainfall zone. Figure 4 shows resulting polygons for part of the Wairarapa, where the pre-dominant land use, soil and rainfall is the same within each of the coloured-up polygons.

Figure 1: GWRC land-use map

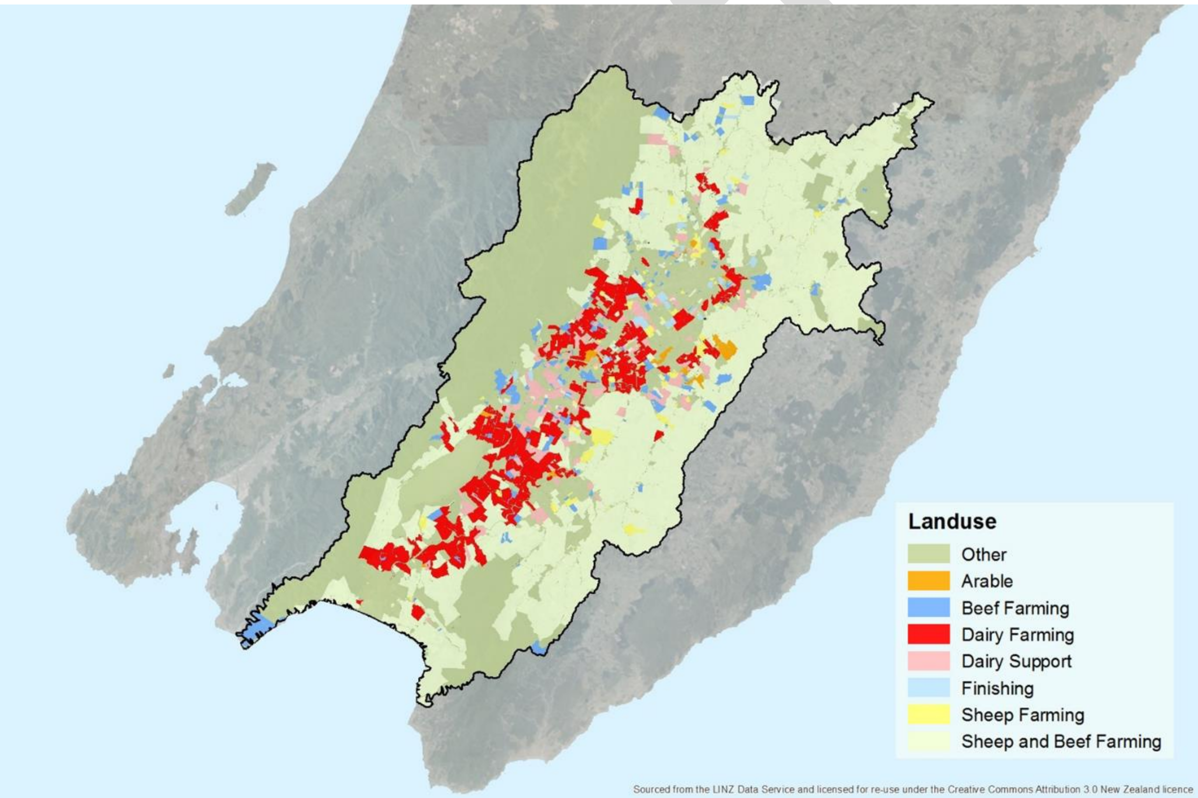


Figure 2: Mapped soils (data from Landcare Research Ltd.)

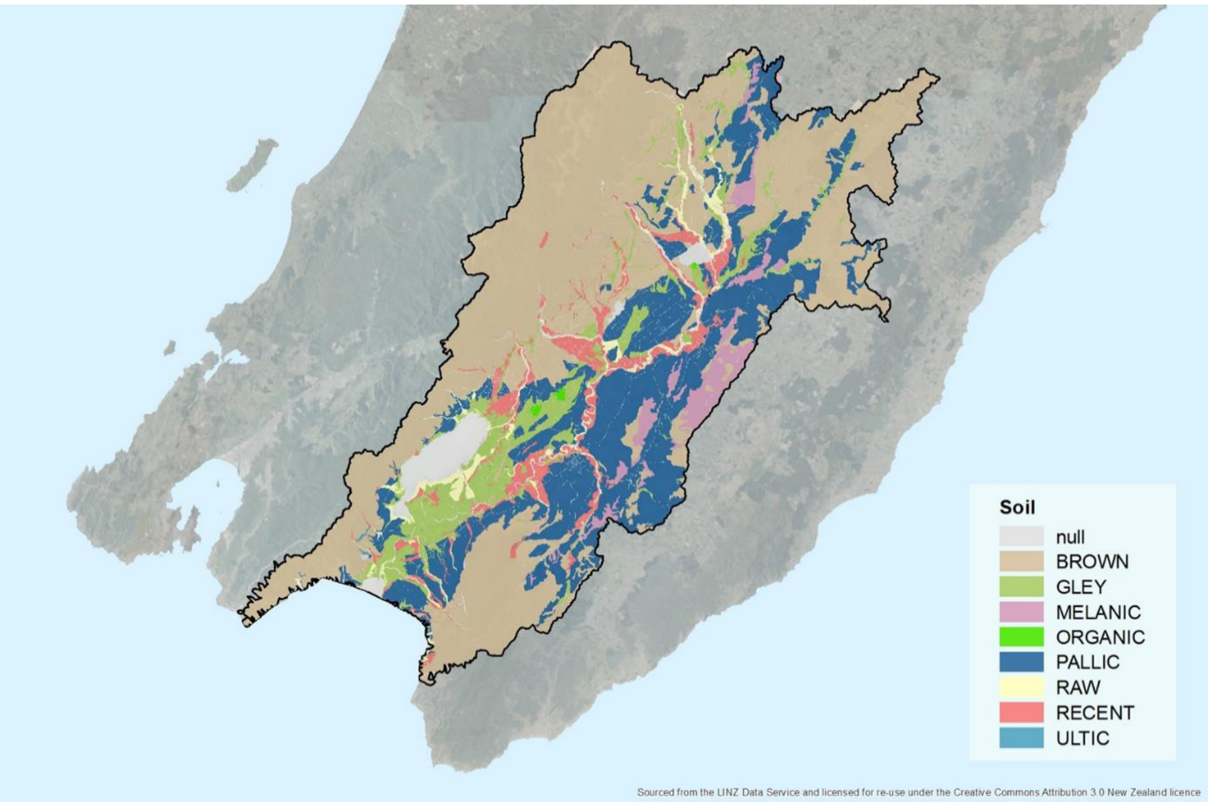


Figure 3: Mapped rainfall bands, based on NIWA data

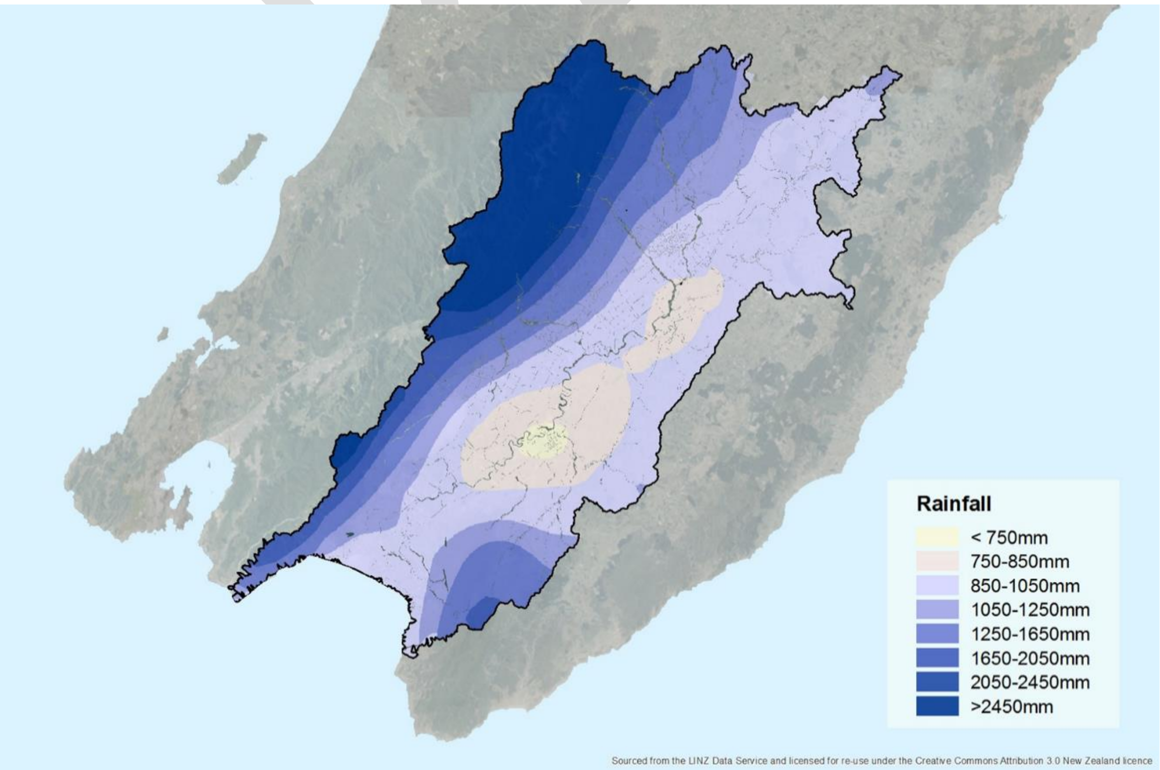
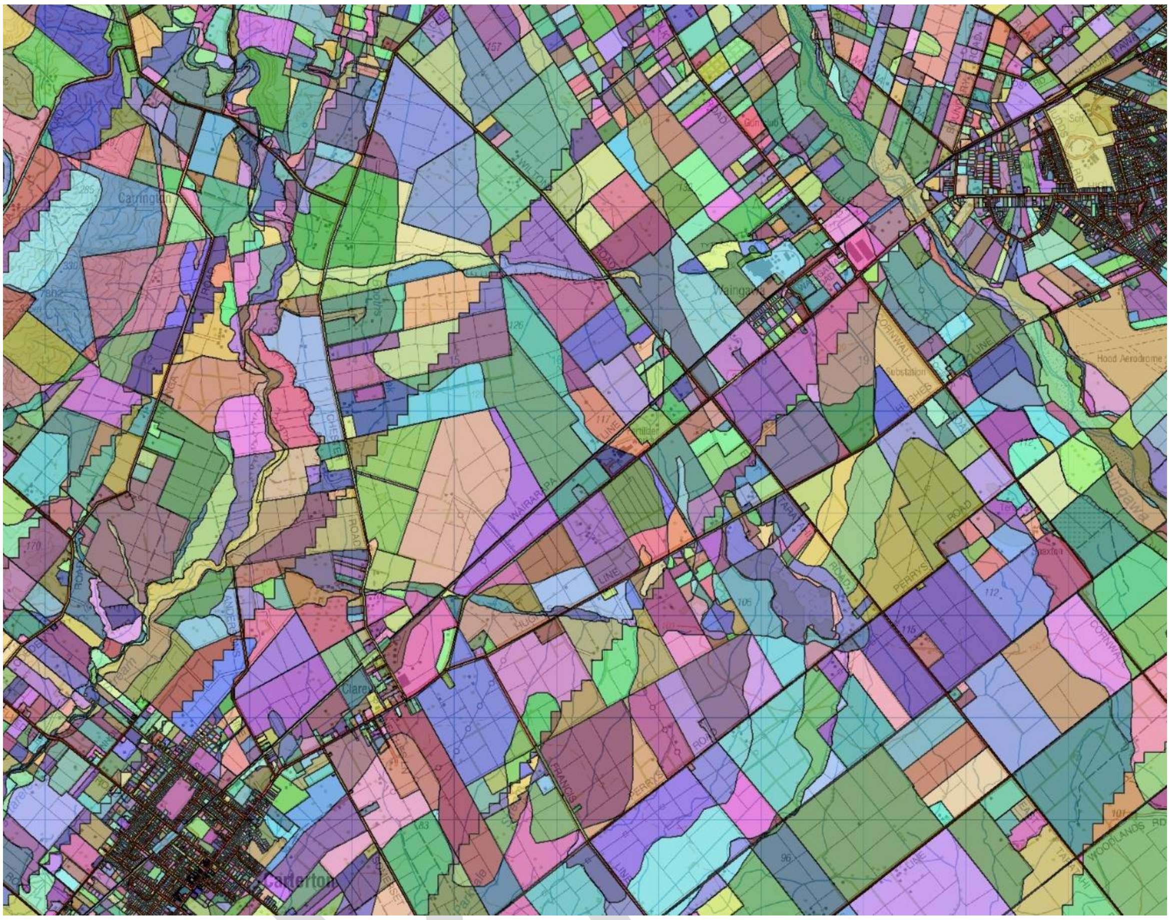


Figure 4: A sub-area of the Ruamahanga catchment showing polygons within which land-use, soil type and rainfall zone are constant.



2) Assign appropriate representative farm to each combination of land use, soil type and rainfall within a polygon

The next step associated one or more representative farms to each polygon.

Where there was an exact match between the land use, soil type and rainfall zone in a polygon and the primary farm enterprise type, predominant soil type and rainfall of one of the Representative Farms, that representative farm system was assigned to that polygon. Most farms contain more than one soil type and so are represented by more than one polygon on the nutrient load map.

For the polygons where there was not an exact match the most appropriate representative farm was selected by applying the following steps:

- Representative Farms that have the same primary farm enterprise type as the polygon's land use code were identified. For a polygon with "Dairy" land-use this step identified 6 representative dairy farm candidates to choose from.
- The average annual rainfall of each of the candidate representative farms was reviewed and representative farms that have a higher rainfall than the polygons rainfall were discarded on the basis that pasture or crop production on such farms is

likely to be higher than for the polygon and therefore the representative farm may not be feasible for that polygon. Topography, to which rainfall is correlated, was also a factor considered in this step.

- Candidate representative farms left after the rainfall and topography based filtering were then assessed based on soil type. If a candidate representative farm had the same soil type as the polygon then that representative farm was assigned to the polygon. If an exact match could not be found then the representative farm with the nearest matching soil was assigned to the polygon, where ‘nearest’ was judged on the basis of leaching characteristics.

The above process was applied by the lead modeller and this ‘first cut’ was passed to the MPI farm modelling team to review and finalise the farm system(s) chosen for each polygon. In a number of instances the MPI team assigned more than one farm system to a polygon to best reflect the range of farm systems expected in that area, based on their considerable local knowledge. The MPI team focussed on the combination of land use, soil type and rainfall class that covered 80% of the farmed catchment area. An example of the resulting assignments are presented in the following table.

The farm system used for each of the smaller polygons that covered the remaining 20% of area was chosen by the lead modeller, based on the results of the MPI modelling team’s review and re-assignments.

Polygon characteristics			Representative farm assigned (MPI Farm Codes)			Comments
Land Use (GWRC GIS map)	**Soil**	**Rainfall**	**Rep 1**	**Rep 2**	**Rep 3**	
Dairy Farming	GLEY	750-850mm	2	4		50:50 split.
Dairy Farming	PALLIC	750-850mm	2	4		50:50 split.
Dairy Farming	BROWN	1250-1650mm	3			100%
Dairy Farming	PALLIC	850-1050mm	1a			100%
Dairy Farming	GLEY	1050-1250mm	1a	2		50:50 split.
Dairy Farming	PALLIC	1050-1250mm	1a	2		50:50 split.
Dairy Farming	GLEY	850-1050mm	1b1	1b2		A 1b system, but at two levels of intensity. 1b1 is higher intensity, 1b2 is lower intensity (800 MS/kg). This area would have a combination of 1b1 and 1b2 (50:50).
Dairy Farming	RECENT	850-1050mm	1b			A 1b system, but at two levels of intensity. 1b1 is higher intensity, 1b2 is lower intensity (800 MS/kg). This area would have a combination of 1b1 and 1b2 (50:50).
Dairy Farming	RECENT	750-850mm	1b			A 1b system, but at two levels of intensity. 1b1 is higher intensity, 1b2 is lower intensity (800 MS/kg). This area would have a combination of 1b1 and 1b2 (50:50).
Dairy Support	BROWN	1050-1250mm	11a			100%
Dairy Support	PALLIC	750-850mm	11b			100%
Sheep and Beef Farming	MELANIC	750-850mm	7			Soil free draining, dry - similar to Brown. Coded E in database. Not as steep as 9, more finishing than breeding. Has a bit of irrigation.
Sheep and Beef Farming	BROWN	850-1050mm	9			100%
Sheep and Beef Farming	PALLIC	850-1050mm	9			Could be some dairy grazers
Sheep and Beef Farming	MELANIC	850-1050mm	9			Soil free draining, dry - similar to Brown. Coded E in database.

Sheep and Beef Farming	PALLIC	750-850mm	10	7	5	All flat land. Farm 10 is 65% cropping, would cover approx 10% of the area. More intensive cropping than the rest of the area. Trading represented by Farm 7 (25%) and 5 (25%) (Flat drystrock, beef finishing, bulls). Competing with dairy; quite dry like Gladstone area. Remaining 40% is dairy (Dairy Farming, P, 750-850mm).
Sheep and Beef Farming	PALLIC	1250-1650mm	11a			6b has higher rainfall than 11a (11a includes dairy support).
Sheep and Beef Farming	BROWN	1250-1650mm	6a	6b		50% 6a (south-east); 50% 6b (north)
Sheep and Beef Farming	BROWN	1050-1250mm	6a			100% 6a is at smaller end (remember for economics)
Sheep and Beef Farming	PALLIC	1050-1250mm	6a	7		6a - northern areas. 7 - southern areas.
Sheep and Beef Farming	GLEY	1250-1650mm	6a	6b		50:50 split.
Sheep and Beef Farming	BROWN	1650-2050mm	6b			Fits 100% of area. Wetter, breeding cows. 6b is directly in the area.
Sheep and Beef Farming	BROWN	2050-2450mm	6b			100%
Sheep and Beef Farming	GLEY	850-1050mm	8a	11a		50:50 split between 8a and 11a. Some dairy support (with small amount of cropping) around Lake Wairarapa.
Sheep and Beef Farming	GLEY	750-850mm	8a			Flat land (9 is too step). Policy for 9 wouldn't be run on this type of land.
Sheep and Beef Farming	RECENT	850-1050mm	8b			Small scale (remember for economics)

3) Estimate nutrient loss (kg/ha per year) for each combination of land use, soil type and rainfall within a polygon

Nitrogen and phosphorous losses from each polygon were estimated using Overseer.

The Overseer soil type and rainfall inputs where changed from those for the representative farm assigned to a polygon, where this was necessary to match the actual soil type and rainfall for that polygon. Because of these changes to the soil and rainfall inputs, we refer to the farms modelled using Overseer as 'virtual farms'. For a polygon that had more than one farm system assigned to it the Overseer modelling was done for each virtual farm in that polygon and the nutrient loss estimates were then aggregated using the appropriate proportions to provide loss rates for each polygon.

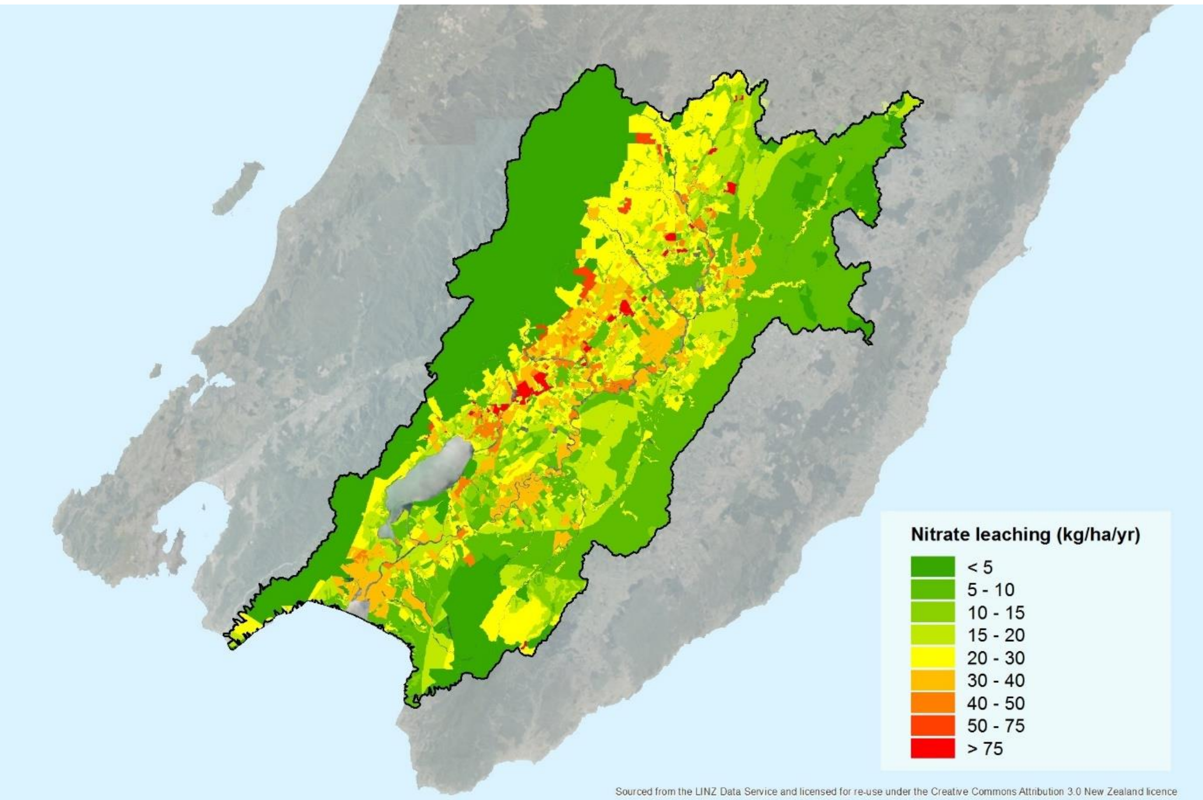
The first version of the nitrate leaching map was reviewed by MPI, GWRC and the lead modeller in May. Following this review some changes were made to the assignment of representative farm system to some Dairy Support farms, and to the soil texture class setting in Overseer for 'virtual farms' on Brown and Recent soils. Jacob's undertook new Overseer runs, where necessary to give effect to the revisions, and produced a new nitrate leaching map. One further review and improve cycle was completed prior to the loss map being passed to others for modelling contaminant concentrations in groundwater and surface waterways.

Nutrient leaching rates for land uses that were not covered by the representative farms (eg, deer, equine, urban etc) were estimated from literature values. These were applied to polygons with that land use and not adjusted for soil type or rainfall.

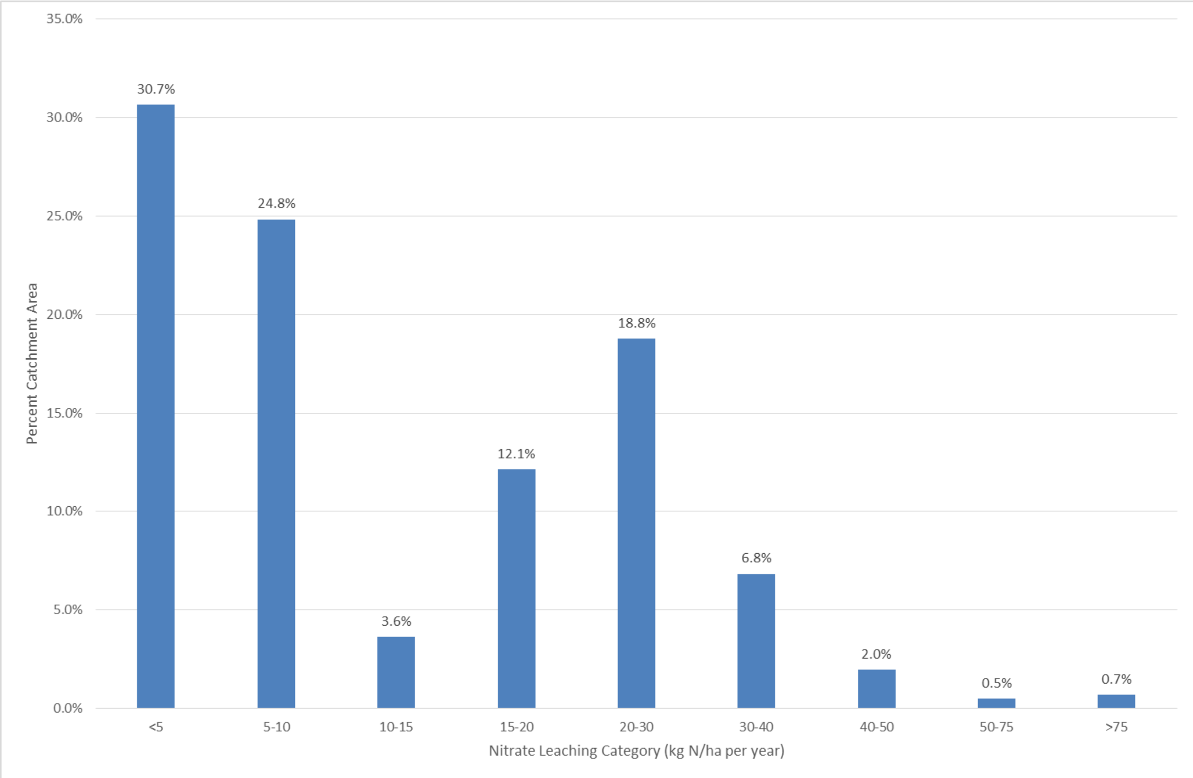
4) Map the nutrient loading and calculate summary statistics to assist benchmarking against results of other work.

4) Results

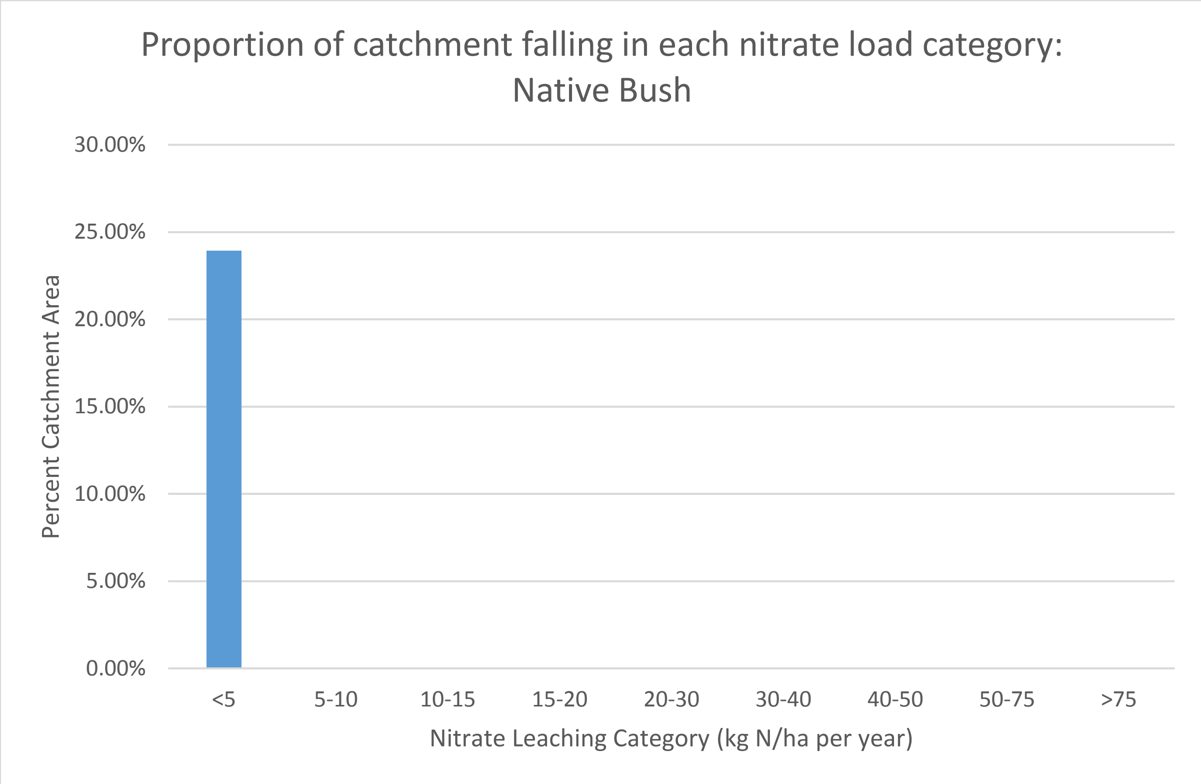
The spatial distribution of the average annual nitrate leaching estimated by the methodology described in the previous section is shown in the following figure.

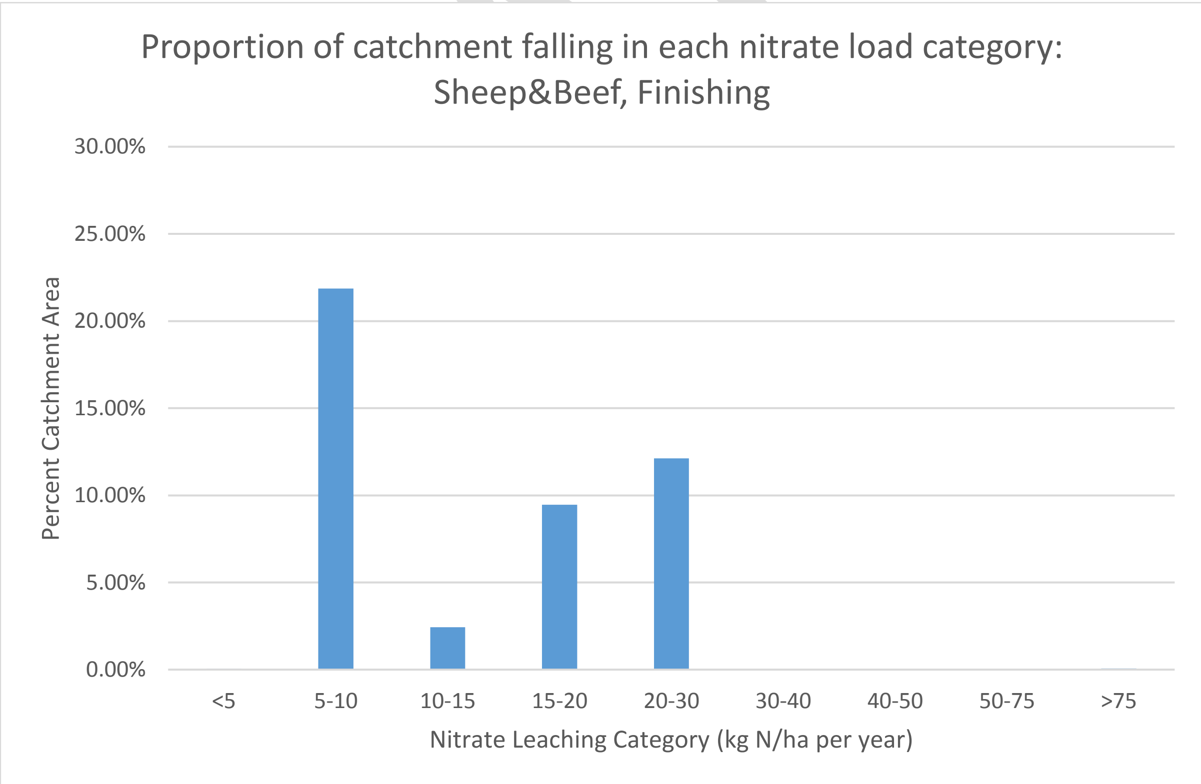


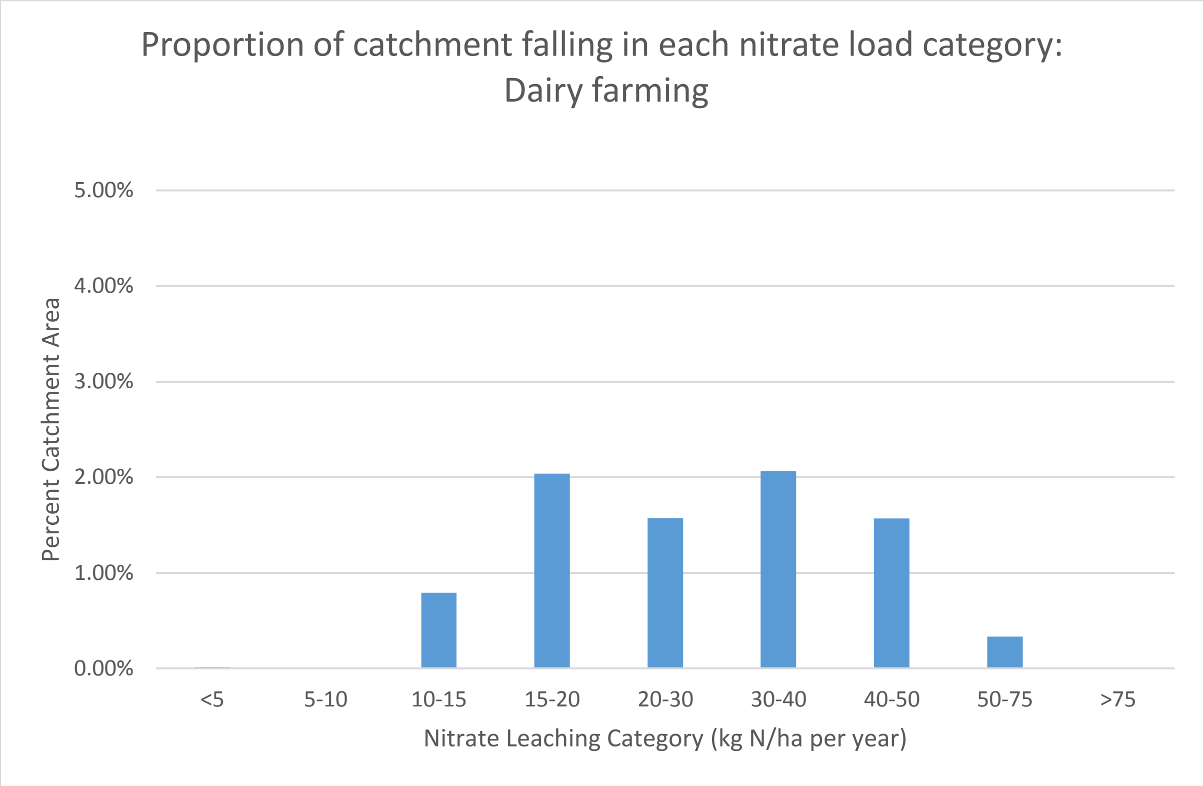
The proportion of the catchment that falls within each nitrate leaching class is shown in the following figure.

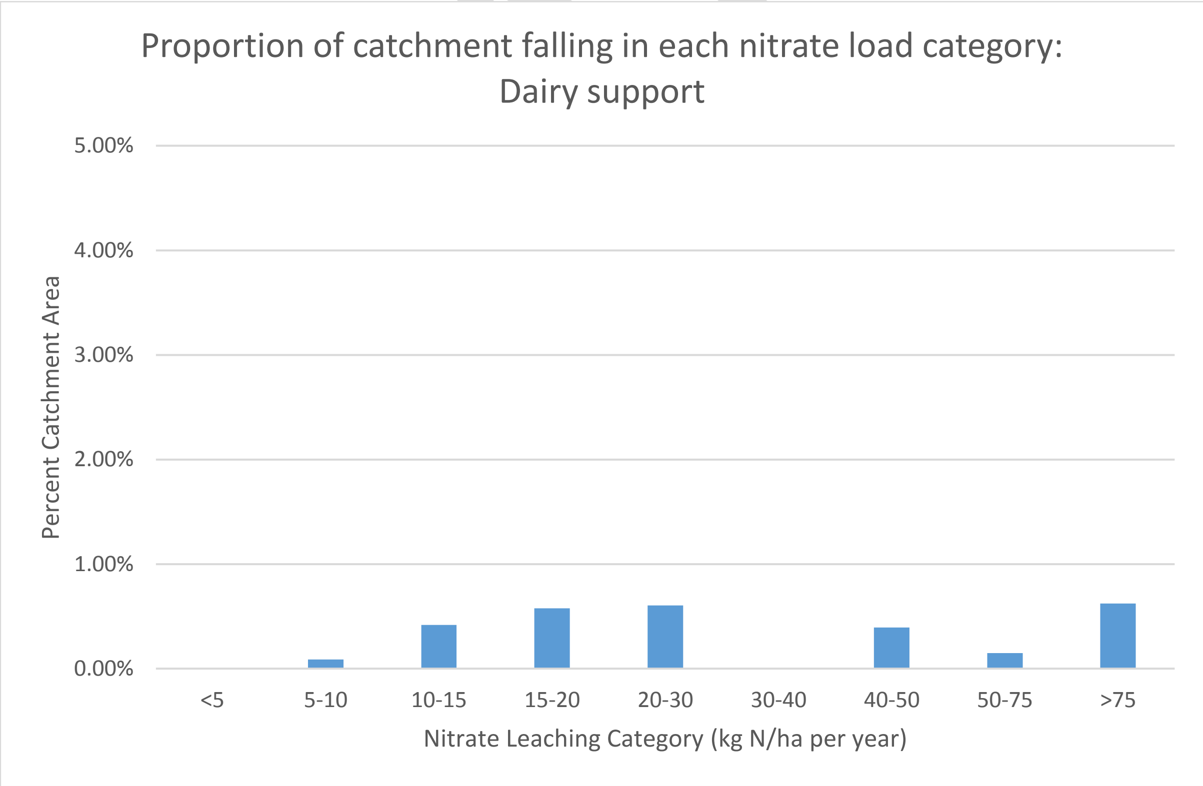


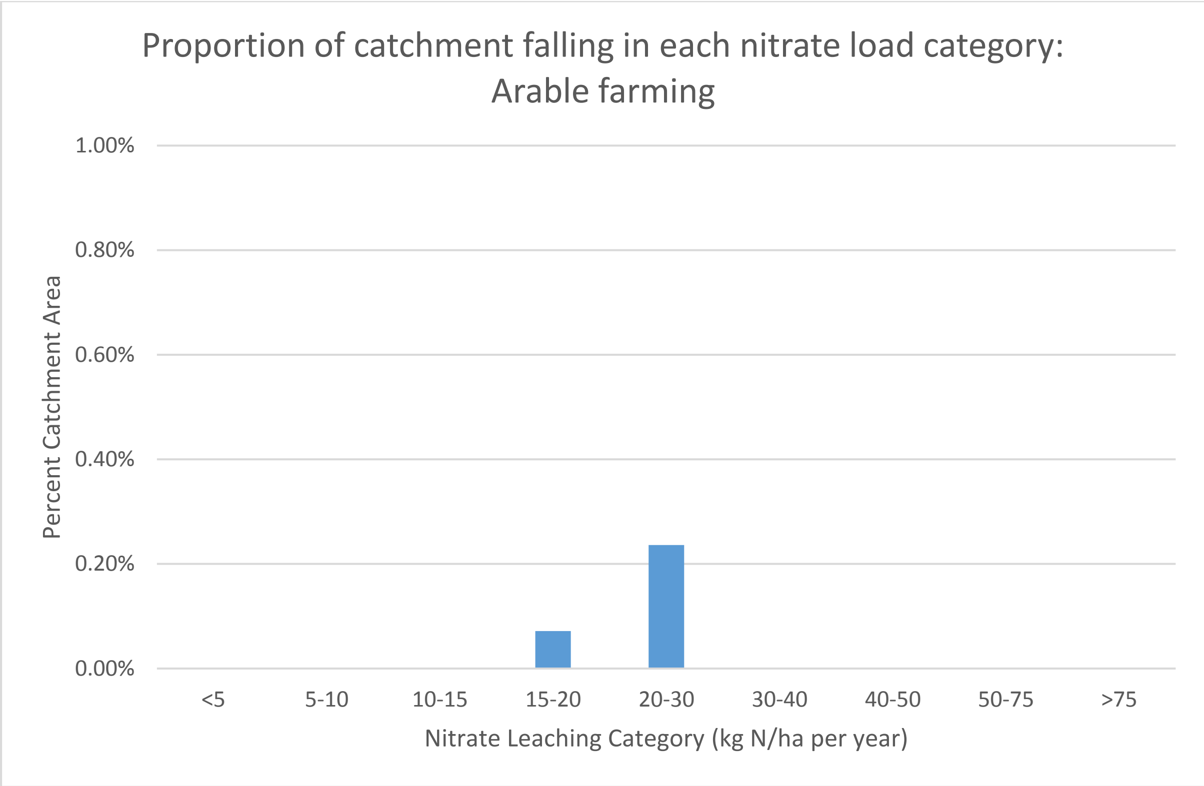
To facilitate comparison between our estimates of nitrate leaching and those obtained by primary sector organisations, the proportion of area falling within each nitrate leaching class has been determined for each of the largest land uses in the catchment. The following figures present this information by land use.

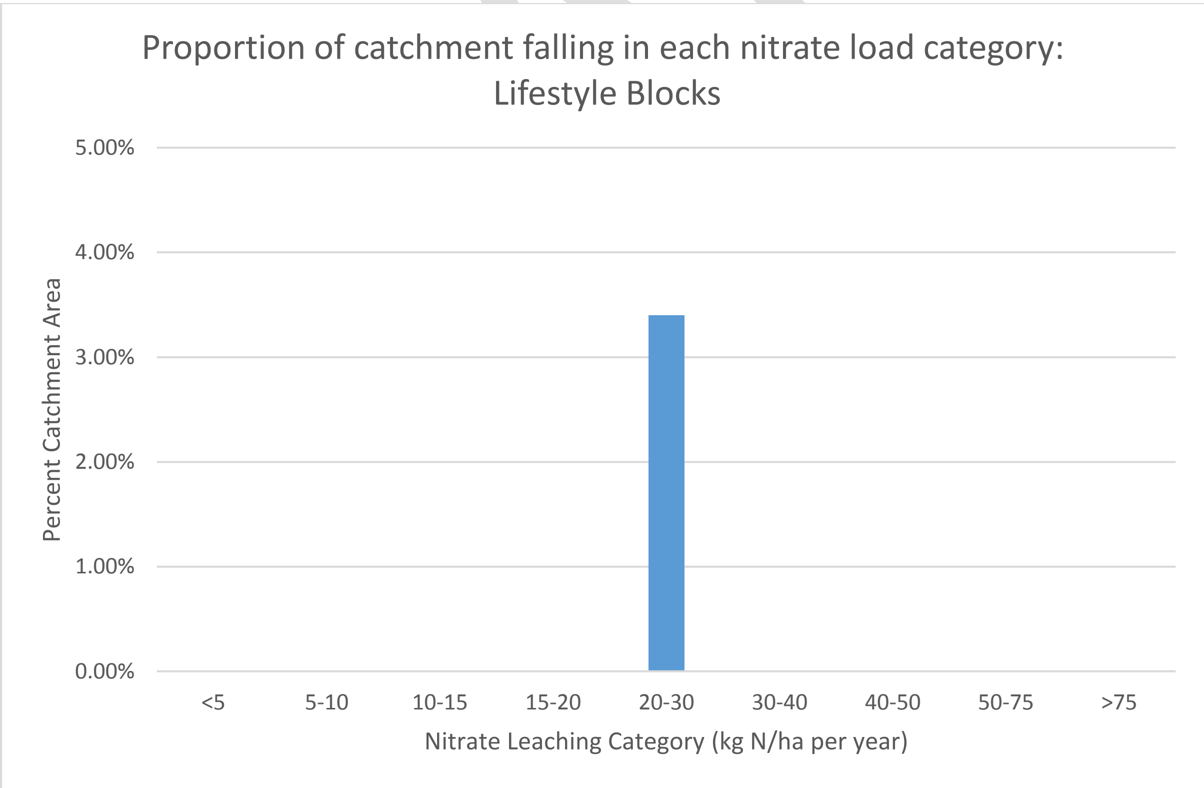

Proportion of catchment falling in each nitrate load category:
Native Bush
30.00%
25.00%
20.00%
15.00%
10.00%
5.00%
0.00%
Percent Catchment Area
<5
5-10
10-15
15-20
20-30
30-40
40-50
50-75
>75
Nitrate Leaching Category (kg N/ha per year)


Proportion of catchment falling in each nitrate load category:
Sheep&Beef, Finishing
30.00%
25.00%
20.00%
15.00%
10.00%
5.00%
0.00%
Percent Catchment Area
<5
5-10
10-15
15-20
20-30
30-40
40-50
50-75
>75
Nitrate Leaching Category (kg N/ha per year)


Proportion of catchment falling in each nitrate load category:
Dairy farming
Percent Catchment Area
5.00%
4.00%
3.00%
2.00%
1.00%
0.00%
<5
5-10
10-15
15-20
20-30
30-40
40-50
50-75
>75
Nitrate Leaching Category (kg N/ha per year)


Proportion of catchment falling in each nitrate load category:
Dairy support
Percent Catchment Area
5.00%
4.00%
3.00%
2.00%
1.00%
0.00%
<5
5-10
10-15
15-20
20-30
30-40
40-50
50-75
>75
Nitrate Leaching Category (kg N/ha per year)


Proportion of catchment falling in each nitrate load category:
Arable farming
1.00%
0.80%
0.60%
0.40%
0.20%
0.00%
Percent Catchment Area
<5
5-10
10-15
15-20
20-30
30-40
40-50
50-75
>75
Nitrate Leaching Category (kg N/ha per year)


Proportion of catchment falling in each nitrate load category:
Lifestyle Blocks
5.00%
4.00%
3.00%
2.00%
1.00%
0.00%
Percent Catchment Area
<5
5-10
10-15
15-20
20-30
30-40
40-50
50-75
>75
Nitrate Leaching Category (kg N/ha per year)

5. Discussion of results

This section will be completed when a comparison of these results with independent datasets to be supplied by other parties is completed and has been discussed with them.