



Project Report

Environmental Farm Plans Manawatu Freshwater Clean-up Fund Project

December 2014

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Executive Summary

An Environmental Farm Plan (EFP) was completed for 83 of the 88 dairy farms in the Mangatainoka River catchment over a two year period starting June 2012. Farmer participation was voluntary. This project was under the Manawatu River Leaders Accord and the Fresh Start for Fresh Water Clean-up Fund contributed by Ministry for the Environment (MfE), Horizons Regional Council (HRC) and DairyNZ with payment in kind from Ravensdown and Ballance Agri-nutrients fertiliser companies. A further 15 EFPs were completed for dairy farms in the Tiraumea and Pohangina catchments, however these farms are not included in this report.

The Mangatainoka River is a 70 km tributary of the Manawatu River within the Tararua district, about 44,000 ha in area with dairy farming making up 39% (about 17,000 ha) of the catchment. Rainfall distribution varies throughout the catchment from approximately 1000 mm in the north to 2425 mm in the south, close to its headwaters in the Tararua ranges. Potential evapotranspiration and average annual temperature also decrease from north to south.

Soils were derived from a mix of loess, alluvium, alluvial gravels, sandstone and some greywacke with drainage characteristics ranging from well drained or moderately well drained to poorly and very poorly drained. Predominant Land Use Capability classes on dairy farms and dairy support blocks are classes II, III and VI all in approximately equal proportions and totalling some 84% of the catchment.

The Horizons Regional Council One Plan is a combined Regional Policy Statement and Regional Plan. It has nine target catchments where intensive land uses, of which dairy is one, are required to obtain land use consent for the management of land use activities affecting groundwater and surface water quality. The Mangatainoka River catchment is one of these.

With respect to water quality, the Mangatainoka River has concentrations of soluble inorganic nitrogen regularly exceeding target values with periphyton and cyanobacteria being prevalent at times. The EFP's therefore identified opportunities to reduce nutrient losses to waterways off dairy farms in the catchment.

Each EFP contained comprehensive information on each individual farm's physical resources such as: total farmed area, general farm and management descriptions including soils, LUC, rainfall, stock numbers, milk solids production, cropping types and areas, amounts and type of imported feed, quantities of nitrogen (N) and phosphorus (P) fertiliser used and farm dairy effluent management and water use. Dairy support blocks were also analysed as part of the total farm system. Overseer®, a nutrient budgeting model, was used to model this farm input data to estimate N and P losses from each farm and to explore nutrient mitigation options for reducing N and P losses. The modelling was completed using Overseer® version 6.0.1 through to 6.1.2.

Over the period of the project approximately 25,000 dairy cows were milked each year averaging 299 per farm at an average of 2.4 cows per ha. Total milk solids production was nearly 9 million kilograms at an average of 361 per cow and 876 per ha. The Mangatainoka catchment, in 2012-2013, produced about 27% of the Tararua District's total production.

Sixty five farms (78%) were low input farms (system 1 and 2 as defined by DairyNZ) based on the amount of imported supplement. Approximately 14,000 tonnes of feed was imported by dairy farmers of which 9,000 tonnes (64%) was maize silage and palm kernel extract. Most farms (77%) carried out some form of fodder cropping with total cropped area 535 ha or 3% of the total dairy farm area. On a per hectare basis this cropping area easily leached the most N, with averages ranging between 94 kg N/ha/yr and 183 kg N/ha/yr for summer and winter crops respectively.

Approximately 850 tonnes of fertiliser N (equivalent of 1,841 tonnes of urea equivalent), and approximately 270 tonnes of fertiliser P (3,000 tonnes of superphosphate equivalent) were applied.

The estimated average predicted N leached per farm was 34 kg N/ha/yr and this totalled about 636 tonnes per year. Approximately 25 tonnes of P is estimated to be lost annually.

Fifty six farms (67%) had some farm dairy effluent storage facility, however at the time the EFPs were prepared only 4 of these ponds were lined and are likely to meet the One Plan permeability standard of 1×10^{-9} . Of the farms with storage 35 of the 56 (63%) had sufficient storage to enable deferred irrigation to be practiced. For those farms with unlined storage it was estimated, using a prototype Farm Dairy Effluent Leaking Pond Calculator (Dr Dave Horne, Massey University) that, conservatively, between 14 and 28 tonnes of N per year was being leached from them which is not

currently accounted for in Overseer®. In addition, for those farms without any storage irrigating effluent daily from a sump, an unknown but possibly significant amount of both N and P is being lost to water due to effluent being applied at depths greater than the soil moisture deficit causing run-off and drainage through the soil profile.

We partitioned milking platform data from dairy support at nutrient management block level and expressed predicted N leaching and N surplus in total kg N/yr and kg N/ha/yr. Statistical analysis of the data collected from the Overseer® output reports showed the following:

- Analysis incorporating the whole farm entity (milking platform and dairy support) using data from the Scenario Report, Nitrogen Overview report showed a moderate correlation between predicted N leached (kg N/ha/yr) and N surplus (kg N/ha/yr) ($R^2=0.47$). N surplus is defined as the total of all N inputs minus N removed as product as estimated in Overseer®.
- For milking platforms and for whole farm entities, there is good correlation for total predicted N leaching (kg/yr) against total N surplus (kg/yr) ($R^2=0.71$ and $R^2 = 0.68$ respectively).
- For milking platforms there is a weak correlation for predicted N leaching (kg N/ha/yr) against N surplus (kg N/ha/yr) ($R^2=0.35$).

To help understand why there was a difference in the correlations between total kg N/yr and kg N/ha/yr we found, using a random sample of 31 farms, which included farms with dairy support, there is a significant difference ($p = 0.00$) between mean whole farm N surplus (kg N/ha/yr) from the Scenario Report, Nitrogen Overview, and the mean whole farm N surplus (kg N/ha/yr) calculated from nutrient management block data found in Scenario Reports, Nitrogen Output report.

Using milking platforms a weak correlation was found between rainfall and predicted N leached (kg N/ha/yr) ($R^2=0.31$), and no correlation with N surplus (kg N/ha/yr) ($R^2=0.00$). There was also no correlation between well drained soils and predicted N leaching (kg N/ha/yr) ($R^2=0.00$), or N surplus (kg N/ha/yr) ($R^2=0.00$).

Multivariate statistical analysis was then used to determine the best combination of factors, at catchment scale, influencing predicted N leaching (kg N/ha/yr) from farms and found that N applied, cropping area, stock rate, and imported feed explained 64% of the variation ($R^2=0.64$). With respect to N surplus (kg N/ha/yr) the best combination of variables were N applied, imported feed, and stocking rate ($R^2=0.76$). In both instances N applied was the dominant variable explaining 32% and 59% of the variation in N leached (kg N/ha/yr) and N surplus (kg N/ha/yr) respectively. Therefore, it was concluded that at catchment scale, farm management practices appeared to have the greatest influence on N leaching regardless of rainfall or soil type.

N applied explains the majority of the variation between whole farms' N surplus (kg N/ha/yr), and contributions to the surplus could happen in two ways: Either directly through inappropriate timing of applications or excessive applications, or, once plants have used what they can, indirectly via other soil sinks of N. Further, if poor pasture utilisation is occurring that will exacerbate N surplus. There is a perception that imported supplements are, in some cases, being used as a substitute for optimum pasture utilisation which in turn appears to also contribute to an increased N surplus.

In conclusion a number of farm management practices have been identified that if changed or implemented would reduce N leaching which in turn, would potentially benefit catchment water quality depending on the extent of implementation. When making these changes there needs to be consideration of the effects on the existing farm system.

- Significantly reduce or eliminate fodder cropping, particularly winter cropping.
- Reduce stocking rates on farms with rates >2.5 cows/ha
- Reduce the amount of imported supplements unless these supplements are high energy and nil or low protein supplements.
- Investigate application practices of fertiliser N in the catchment to understand whether, in the first instance, direct losses are occurring and can be prevented.
- All farms practice deferred or deficit irrigation of effluent by constructing adequately sized and lined effluent storage ponds.
- Reducing N surplus via a range of farm practices as described in Beukes et.al. (2011).

The extent to which any one practice or combinations of practices will be effective will depend on overarching constraints: For example the current Horizons Regional Council consenting regime, is to reduce N leaching off each individual farm from the 2012-2013 milking season without significantly impacting on farm production or profitability. This in turn constrains the extent of feed and fertiliser reductions which would lead to reduced stocking rates and therefore reduced production unless per cow performance is improved.

Contents

1	Introduction	9
1.1	Purpose of the EFP Project	9
1.2	The Mangatainoka River Catchment	9
2	Water Quality Status and Trend	13
2.1	Nitrogen	13
2.2	Phosphorus	15
2.3	Biological Parameters	15
2.4	Trends of Nutrient Concentrations for N and P	16
3	One Plan	19
4	Methodology	21
4.1	Process	21
5	Analysis Tools	23
5.1	Overseer® Nutrient Budget Modelling	23
5.2	Land Use Capability (LUC)	23
5.3	Multivariate Statistical Analysis	24
5.4	Environmental Farm Plan	24
6	Results and Discussion	25
7	Overview of Catchment Land Use	27
8	Dairy Farm Data, Production Systems, and Farm Management Practices	29
8.1	Production Comparisons	29
8.2	Production Systems	29
8.3	Fodder Cropping	30
8.4	Imported Supplements	31
8.5	Fertiliser Use	32
9	Climate and Relationship to N Leaching Rate	33
10	Soils	37
10.1	Soils and their Drainage Characteristics	37
10.2	Drainage Characteristics of Soils and Resultant N Leaching Risk.	37
11	Land Use Capability	39
12	Compliance with One Plan Table 13.2	41
13	Farm Dairy Effluent Management	43
13.1	Current Storage Facilities	43
13.2	Sumps	43
13.3	Unlined Ponds	43
13.4	Lined Ponds	44
13.5	Pond Leakage	44
14	Stock and Cowshed Water Use	47
15	Riparian Fencing	49
16	Nutrient Losses	51

16.1	Nitrogen Leaching	51
16.2	Phosphorus Loss	51
17	Analysis of the relationships between Farm Management Practices and Farm Physical Resources on predicted N Leaching	53
17.1	Nitrogen Surplus and Nitrogen Leaching	53
18	Summary	61
19	References	63
20	Appendix 1	65
21	Appendix 2	67

1 Introduction

This report presents the results of a two year project (June 2012 to August 2014) working with dairy farmers in the Mangatainoka catchment to prepare an Environmental Farm Plan (EFP) for each dairy farm. Participation by farmers was voluntary and the EFP sought to identify opportunities to reduce nutrient losses to water in the catchment.

The EFP project was one of eight projects under the Manawatu River Leaders Accord and the Fresh Start for Freshwater Clean-up Fund.

In August 2010, the Manawatu River leaders' forum signed an Accord with the goal of improving the Mauri (life-force) of the Manawatu Catchment, such that it sustains fish species, and is suitable for contact recreation, in balance with the social, cultural and economic activities of the catchment community. In June 2011, the Manawatu River Leaders established a collaboratively owned action plan for implementation from July 2011. The action plan outlined over 130 actions to be undertaken and further information is available at www.manawaturiver.co.nz.

Funding for the EFP project totalled \$630,000 and was provided by Ministry for the Environment (MfE) (\$300,000), Horizons Regional Council (HRC) (\$230,000) and DairyNZ (\$100,000). Ravensdown and Ballance Agri-Nutrients contributed in kind by offering the services of their respective fertiliser representatives to engage farmers in the project and assist in the completion of nutrient budgets for each farm.

The project was overseen by a Steering Group (Appendix 1) and an Action Group (Appendix 2) who completed this work within the overall management of the Freshwater Clean-up Fund project.

1.1 Purpose of the EFP Project

The Environmental Farm Plan project fits into Objective 3 of the overall work programme of the Manawatu Clean up Fund which aims to reduce the contaminant contribution from dairy farms to the Manawatu catchment by 10% by 2021. A means to achieve this was to complete 60-80 EFP's in the Mangatainoka River catchment identifying where the loss of contaminants off farm (nitrogen, phosphorus, faecal bacteria, and sediment) could be reduced.

The Mangatainoka catchment lent itself to this project due to known water quality issues. It is a focus of many aspects of the overall Clean-up Fund effort and has one of the highest proportions of dairy land area in the Manawatu catchment. As a target catchment within The Horizons Regional Council One Plan, a combined Regional Policy Statement and Regional Plan, it was also seen as an ideal opportunity to accelerate the reduction of the effects of intensive farming activities on water quality. Other project work in the Mangatainoka included upgrades to municipal sewage treatment facilities and riparian fencing and planting. This latter effort was primarily on sheep and beef farms to complement similar work on dairy farms over recent years.

A further 15 EFPs were completed in the Tiraumea and Pohangina catchments. These catchments are high priority for hill country erosion and the completion of EFPs for the dairy farms in these catchments was considered complimentary to the work being carried out through the SLUI (Sustainable Land Use Initiative) program. The results from these plans are not included in this report.

1.2 The Mangatainoka River Catchment

The Mangatainoka is in the Tararua District, on the eastern side of the Tararua Ranges. The District stretches from Norsewood in the north to Mt Bruce in the south and contains the upper part of the Manawatu catchment (Figure 1). The Mangatainoka sub-catchment is approximately 43,790 hectares and the Mangatainoka River about 70km in length with one major tributary, the Makakahi River (60km).

The catchment is predominantly a mix of alluvium, alluvial gravels and sandstone with the upper catchment near the Tararua Ranges mainly greywacke.

The Mangatainoka River has mean annual and mean annual low flows of 17.68 m³/sec and of 1.6 m³/sec respectively at Pahiatua Town Bridge.

Concentrations of soluble inorganic nitrogen almost always exceed the One Plan target (Schedule D) and dissolved reactive phosphorus concentrations regularly exceed the target values. Nitrogen and phosphorus are valuable nutrients on farm – however they can be contaminants in waterways. As contaminants they contribute to the excessive growth of nuisance algae (periphyton and cyanobacteria), and nitrogen and ammoniacal nitrogen can both directly and indirectly adversely impact on aquatic life. Excessive algal growth can lead to adverse impacts on life supporting capacity, recreational use, aesthetic, and economic values.

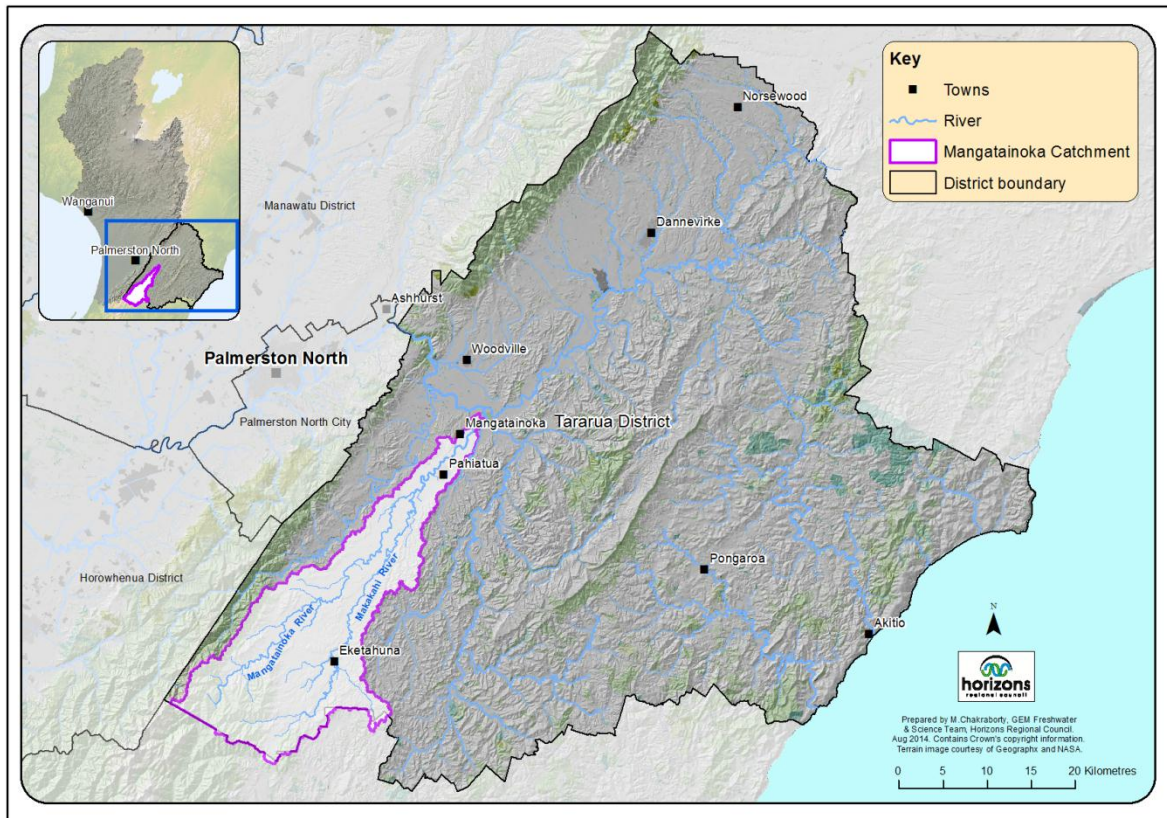


Figure 1: Mangatainoka Catchment and Tararua District

Land use in the catchment is generally typical of many rural landscapes in the region with a mix of native bush cover, extensive sheep and beef, intensive dairy, and small urban communities (Table 1). One aspect of this catchment compared to all others in the region is the high proportion of dairy.

Table 1: Land use areas in the Mangatainoka catchment GIS data derived from the Land Use GIS layer developed by Clark and Roygard, 2008 and updated using information from this project.

Land Use	2014 GIS data		EFP areas
	Area (ha)	Percentage	Area (ha)
Dairy	17,233	39.4	16,227
Sheep and/or beef	16,474	37.6	
Native cover	8,880	20.3	
Exotic cover	673	1.5	
Urban/Parks/Others/Water body	530	1.2	
Total catchment area	43,790		

Note. The area covered by the 83 EFP's is smaller than the catchment total as it excludes 5 farms that were either completed as part of a DairyNZ led Dairylink project or chose not to participate. Further it is noted the area covered by the EFP's does include land outside the catchment that straddles the boundary of the catchment, where the majority of the farm was in the catchment.

2 Water Quality Status and Trend

2.1 Nitrogen

Soluble inorganic nitrogen (SIN) concentrations in the catchment are lowest in the forest park and increase with distance downstream. The monitoring site at the SH2 bridge meets SIN targets in One Plan on 8.8% of sampling occasions over the period January 2005 – December 2011 (Clark et al, 2013).

Roygard and Clark (2012) calculated the measured and target loads of SIN at a number of monitoring points throughout the Mangatainoka Catchment. The loading from point sources was removed from each of the monitoring sites to provide a load from non point sources (Table 1). The monitoring site at the forest park boundary (Putara) meets the water quality target load. With distance downstream within the catchment the load increases to just over two times the target load at SH2. Non-point sources of nitrogen contribute the majority of the total load to the river (Table 2).

Table 2: Summary of SIN loads in the Mangatainoka Catchment (Roygard and Clark, 2012)

Monitoring Site	Target Load Tonnes/yr	Measured Load Tonnes/yr	Point Source Load Tonnes/yr	Non point Source Load Tonnes/yr
Mangatainoka at Putara	3.2	1.3	0	1.3
Mangatainoka at Larsons Road	11.6	15.2	0	15.2
Makakahi at Hamua	91.1	168.05	0.47	167.6
Mangatainoka at SH2	264.3	542.33	4.04	538.3

Recent analysis of the state of water bodies with respect to compliance with SIN targets shows that monitoring sites in the upper Mangatainoka and Makakahi meet their respective targets but lower sites within the Mangatainoka catchments are well in excess of the target (Table 3).

Table 3: Current compliance with the recommended water quality targets in the Mangatainoka Management Zone

Sub-zone	SIN (g/m ³)			
	Target	Sample Size	Recorded Average	Target Met
Upper Mangatainoka (Assessed at Putara)	0.070	50	0.017	✓
Upper Mangatainoka (Assessed at Larsons Rd)	0.070	53	0.059	✓
Middle Mangatainoka (Assessed at Scarborough Konini Rd)	0.444	50	0.986	✗
Lower Mangatainoka (Assessed at Pahiatua Town Bridge)	0.444	48	0.880	✗
Lower Mangatainoka (Assessed at Brechin u/s Fonterra Pahiatua)	0.444	49	1.474	✗
Lower Mangatainoka (Assessed at Brechin d/s Fonterra Pahiatua)	0.444	45	1.073	✗
Lower Mangatainoka (Assessed at u/s Pahiatua STP)	0.444	50	0.858	✗
Lower Mangatainoka (Assessed at d/s Pahiatua STP)	0.444	48	1.055	✗
Lower Mangatainoka (Assessed at SH2 Bridge)	0.444	50	0.850	✗
Lower Mangatainoka (Assessed at d/s DB Breweries)	0.444	45	0.899	✗
Lower Mangatainoka (Assessed at u/s Tiraumea Confluence)	0.444	40	0.820	✗
Makakahi (Assessed at u/s Eketahuna STP)	0.444	50	0.274	✓
Makakahi (Assessed at Ngatahaka u/s Makakahi Confluence)	0.444	33	0.808	✗
Makakahi (Assessed at d/s Eketahuna STP)	0.444	44	0.451	✗
Makakahi (Assessed at Hamua)	0.444	51	0.463	✗

✓: The target is met; ✗: the target is not met. Orange colouring of the tick or cross indicate the site is within 10% of the target.

2.2 Phosphorus

In contrast to SIN the dissolved reactive phosphorus (DRP) target is met on at least 60% of sampling occasions throughout the catchment during the period January 2005 – December 2011 (Clark et al, 2013).

Roygard and Clark (2012) calculated the measured and target loads of DRP at a number of monitoring points throughout the Mangatainoka Catchment. The loading from point sources was removed from each of the monitoring sites to provide a load from non point sources. Non point sources of phosphorus contribute the majority of total loads to the river (Table 4).

Table 4: Summary of DRP loads in the Mangatainoka Catchment (Roygard and Clark, 2012).

Monitoring Site	Target Load Tonnes/yr	Measured Load Tonnes/yr	Point Source Load Tonnes/yr	Non-point Source Load Tonnes/yr
Mangatainoka at Putara	0.3	0.21	0	0.21
Mangatainoka at Larsons Road	1.0	0.68	0	0.68
Makakahi at Hamua	2.1	2.10	0.16	1.94
Mangatainoka at SH2	6.0	6.17	1.12	5.05

This project provides valuable information for resource accounting previously not available which will be available to inform decisions on water quality issues. This includes better information on the extent of dairying and best available estimates of nutrient loss from 94% of the dairy farms in the catchment.

2.3 Biological Parameters

The mix of algae, fungi and diatoms that grow on the beds of our rivers, lakes and streams is also known as periphyton. While some periphyton help ecosystems flourish, too much can have opposite effects by reducing the diversity of aquatic insects and their availability as food; causing large fluctuations in oxygen for aquatic communities; changing the acidity of the water; and diminishing or ruining recreational enjoyment. It can also make water unpalatable for stock to drink, clog irrigation intakes and, in some cases, produce toxins that are harmful to animals and humans.

One Plan targets for periphyton biomass (chlorophyll a) and river bed cover are always met in the headwaters of the Mangatainoka and are met on at least 90% of sampling occasions throughout the rest of the catchment. A major concern in the Mangatainoka catchment is benthic cyanobacteria (blue-green algae) which have been identified as an emerging issue in the Region's rivers. During stable flow conditions this algae can proliferate, forming expansive black/brown leathery mats across large areas of riverbed and release toxins which pose a threat to human and animal health when consumed or after contact. In the Mangatainoka its presence has at times seen parts of the river closed to swimming.

Annual monitoring of aquatic insect communities shows that at Putara the value for insect abundance and diversity (Macro-invertebrate Community Index (MCI)) are rated as "Excellent" and this declines to "Fair" at Mangatainoka SH2 and then improves to "Good" upstream of the Tiraumea River confluence (Table 5).

Table 5: Macro-invertebrate Community Index ratings for Mangatainoka River sites

	Stark (1998) descriptions	Stark & Maxted (2007a) MCI score	Sampling Location
Excellent	Clean water	> 119	<ul style="list-style-type: none"> Putara
Good	Doubtful quality or possible mild pollution	100–119	<ul style="list-style-type: none"> Immediately upstream of Tiraumea confluence
Fair	Probable moderate pollution	80-99	<ul style="list-style-type: none"> Pahiatua Mangatainoka SH2 bridge
Poor	Probable severe pollution	<80	<ul style="list-style-type: none"> None

2.4 Trends of Nutrient Concentrations for N and P

Analysis of trends undertaken for One Plan Environment Court Hearings showed that over the 10 year period July 1993 – June 2003, SIN at the State Highway 2 Bridge was showing a degrading trend (i.e. getting worse) and DRP was showing no trend. Over the 10 year period July 2001 – June 2011 both SIN and DRP were showing an improving trend. During the course of this project water quality trend information has been updated as a part of the reporting to the Manawatu River Accord Action Plan.

In April 2014 a report on state and trends of river water quality in the Manawatu Catchment was completed (Snelder et al, 2014). 5 year trends were reported on for the period July 2009 – July 2013. Caution needs to be taken attributing changes in management to changes in water quality over this time frame as rainfall and climatic conditions can influence these trends as can the length of record available for the analysis (i.e. ability to detect trends within the variability). Climatic influences become particularly apparent when reference sites show significant trends.

The results of the analysis are presented in Table 6 below. Not tested means there was insufficient data to complete the trend analysis. ND means there is no data for this site over the time period.

Table 6: Trends in various water quality parameters, Mangatainoka River. July 2009-July 2013

Site	Chl <i>a</i>	Clarity	DRP	<i>E. coli</i>	Ammoniacal nitrogen	Total oxidised nitrogen
Mangatainoka at Putara	Degrading	Not tested	No trend	No trend	Stable	No trend
Mangatainoka at Larsons Rd	ND	No trend	No trend	No trend	No trend	No trend
Makakahi u/s Eketahuna STP	ND	No trend	Stable	No trend	No trend	No trend
Makakahi d/s Eketahuna STP	ND	Not tested	No trend	Improving	No trend	Improving
Makakahi at Hamua	No trend	No trend	No trend	Improving	No trend	No trend
Brechin u/s Fonterra Pahiatua	ND	Not tested	No trend	No trend	No trend	Not tested
Brechin d/s Fonterra Pahiatua	ND	Not tested	No trend	No trend	Improving	Not tested
Mangatainoka at Pahiatua Town Bridge	ND	Not tested	Not tested	Not tested	Not tested	Not tested
Mangatainoka u/s Pahiatua STP	No trend	Not tested	No trend	No trend	No trend	Not tested
Mangatainoka d/s Pahiatua STP	No trend	Not tested	No trend	No trend	No trend	Not tested
Mangatainoka at Brewery S.H.2	No trend	No trend	No trend	No trend	No trend	Improving
Mangatainoka d/s DB Breweries	No trend	Not tested	Improving	Improving	No Trend	Not tested
Mangatainoka u/s Tiraumea Confluence	Not tested	Not tested	Not tested	Not tested	Not tested	Not tested

Over the 20 year period July 1993 – July 2013 The Mangatainoka at Brewery S.H.2 monitoring site showed an improving trend in Ammoniacal nitrogen, DRP and Total oxidised nitrogen and there was no trend in clarity.

Note: Soluble inorganic nitrogen (SIN) is the sum of Ammoniacal nitrogen and Total oxidised nitrogen.

3 One Plan

The Mangatainoka catchment is a target catchment identified in the One Plan where intensive land uses, of which dairy is one, are required to get land use consent. The purpose of this rule is to reduce contaminant loss from farms to improve water quality in the river.

In particular the rule provides for a nitrogen leaching allocation for each farm based on the farms Land Use Capability (LUC) composition and for this reason an LUC assessment was carried out for each farm. Based on the values in One Plan Table 13.2 (Table 7) the LUC composition of a farm is used to calculate the Cumulative Nitrogen Leaching Maximum (CNLM) and where a farm's actual N leaching meets this value a Controlled Activity consent is granted. Where a farm cannot meet their CNLM, a Restricted Discretionary consent is applied for.

Table 7: One Plan Table 13.2.

Table 13.2: Cumulative Nitrogen Leaching Maximum (Kg N/ha/yr.) by Land Use Capability Class								
	LUC 1	LUC 2	LUC 3	LUC 4	LUC 5	LUC 6	LUC 7	LUC 8
Year 1	30	27	24	18	15	17	8	2
5	27	25	21	16	13	10	6	2
10	26	22	19	14	13	10	6	2
20	25	21	18	13	12	10	6	2

Section 12 comments further on this table and how versions of Overseer® have altered the ability for some farms to comply with it to achieve controlled activity status.

4 Methodology

4.1 Process

Overall the project was managed as one of the eight projects within the Manawatu Freshwater Clean-up Fund reporting through to the governance group of that project. The following section provides an overview of roles and responsibilities.

Steering Group for the EFP Project

A steering group was convened to provide guidance in getting the project off the ground and in its efficient completion. This group consisted of representatives from Ministry for the Environment (MfE), DairyNZ, Ravensdown, Ballance Agri-Nutrients, Federated Farmers and Horizons Regional Council (HRC) (Appendix 1).

Project Leader and Project Coordinator

The Project Leader (HRC) oversaw the project milestones and budget and the Project Coordinator (HRC) was responsible for the day to day management of the project. Emphasis was placed on development and implementation of a logical and streamlined process ensuring EFP's were completed to a high standard, meeting timelines and budget.

Action Group

An action group was set up involving day to day participants in the project and consisted of the Project Leader, Project Coordinator, two contracted consultants, and representatives from Ravensdown and Ballance Agri-Nutrients. A key task of the action group was to develop an EFP template to report on all aspects of the farm system, its resources, and the use of those resources. The action group also agreed on a logical process for the flow of information between the parties to enable efficient completion of an EFP (Appendix 2).

Ravensdown and Ballance Agri-Nutrients staff had a principal role of engaging and encouraging their respective farmer clients to participate in the project and contributing to the completion of a nutrient budget using Overseer® for each farm.

The consultants merged the respective components of an EFP into a coherent document which, amongst other considerations, recommended the simplest and most affordable N reduction mitigations.

The process was as follows:

- a) Farmers were contacted either by their fertiliser company representatives or Horizons Regional Council consents monitoring staff to gauge interest in the voluntary project.
- b) If interest was shown by the farmer a follow up visit was carried out by the Project Coordinator to explain the process and answer any questions the farmers had.
- c) Identification of land parcels farmed was made and maps were produced by HRC staff.
- d) When confirmed as correct by the farmer the maps and any other relevant data was forwarded to a contracted pedologist for the preparation of farm scale soil and LUC mapping (about 1:7,000) for each farm.
- e) Completed soil and LUC assessments were then forwarded to the consultant along with all relevant consent, farm, and catchment information, to be included in the EFP.
- f) Coordination between the consultant and fertiliser company representatives resulted in a farm visit to assess the farm system and complete a nutrient budget.
- g) A draft EFP was then delivered by the Project Coordinator to the farmer for checking of information in the report.
- h) Draft EFP finalised and approved by the farmer.
- i) Data from the EFP were recorded in Excel spread sheets for analysis and reporting.

- j) Each EFP was peer reviewed by the project coordinator for consistency with regard to accuracy of reporting and data input to Overseer® in line with the Data Input Protocols at the time.

Note: As the project was over 2 years some EFP's were completed based on the 2011-2012 dairy season and some were based on the 2012-2013 season.

The project led to a robust and complete Environmental Farm Plan being completed for each individual farm. A key component in achieving that has been establishing the processes and protocols for the various parties to work together. The completion of these EFPs has subsequently provided guidance to the process to move these farms, as well as other dairy farms requiring existing land use consent, smoothly through the consenting process.

5 Analysis Tools

5.1 Overseer® Nutrient Budget Modelling

Overseer® is an agricultural decision support and management tool which models the cycling of nutrients within a farming operation. It is a long term annual average model (3 – 5 years) and assumes the farm is in equilibrium and therefore uses long term climate data for annual rainfall, monthly rainfall, PET and temperature.

It estimates:

- The inputs, outputs and nutrient flows of various farm management scenarios to assist users to optimise production and environmental outcomes.
- Nitrogen and phosphorus loss and greenhouse gas emissions allowing the risk of environmental impacts of farm management options to be taken into consideration.
- The energy requirements for all aspects of animal maintenance, growth, gestation, lactation and production.

Overseer® versions 6.0.1 through to 6.1.2 were used for all nutrient budgets as the project progressed and the version used was noted in the EFP. The final analysis was completed using data generated in the Overseer® nutrient budgets in the version current at the time of completing the EFP. Some further analysis which was then completed used data reported through Overseer® version 6.1.3.

Separate milking platform and dairy support N leaching and N surplus estimates

Deriving separate estimates of milking platform and dairy support predicted N leaching and N surplus was done by opening the Overseer® Scenario Report, Nitrogen output report of Total N lost for each nutrient management block, tabulating this data and summing for kg N/yr and dividing the sum by the total block area to derive kg N/ha/yr. As these estimates were derived from block data they are therefore based on effective farm area (ha) not whole farm area. Only 82 farms contributed to this data as one farm is a very small unit of about 20 cows and was therefore excluded. These files were opened in Overseer® version 6.1.3.

5.2 Land Use Capability (LUC)

All farms participating in this project had a detailed farm scale LUC map completed by an experienced LUC mapping professional. The farm LUC mapping provided more accurate information than is available at Regional scale mapping. The LUC assessments were undertaken to assign a maximum leaching rate per hectare based on the LUC composition of each farm. (Table 6)

The LUC System has been used in New Zealand to help achieve sustainable land development and management on individual farms, in whole catchments and at the district, region and the national level. Within the Horizons region it has been used extensively in the Sustainable Land Use Initiative (a combined Horizons and Ministry for Primary Industries project to substantially reduce hill country erosion) and, as described in Section 3, for establishing a farm's CNLM for consent.

It has two key components. Firstly, Land Resource Inventory (LRI) is compiled as an assessment of physical factors considered to be critical for long term use and management. Secondly, the inventory is used for LUC classification, whereby land is categorised into eight classes according to its long-term capability to sustain one or more productive uses. Classes I-IV are classified as arable land, while LUC Classes V-VIII are non-arable. The limitations or hazards to use increase, and the versatility of use decreases, from LUC Class I to LUC Class VIII. This can be thought of as a rating of “best” to “worst” land for common productive purposes. Further information is available in the Land Use Capability Survey Handbook, 3rd Edition. (This document is available at www.landcareresearch.co.nz).

5.3 Multivariate Statistical Analysis

A Multivariate statistical analysis was carried out to determine the combination of factors influencing N leaching from farms. A nonparametric regression method known as Generalised Additive Models (GAMs) was used for analysis with software called MOPED (Modelling Patterns in Environmental Data, version 3.1) developed by Jowett Consulting (copyright: Ian Jowett 2001-05). Nonparametric regression relaxes the usual assumption of linearity and uncovers structure between the independent variables and dependent variable that might otherwise be missed.

5.4 Environmental Farm Plan

An EFP contains comprehensive information on each farm's physical resources and management system and included:

- Farm legal description and dairy supply number.
- Farm specific long term rainfall.
- General property description.
- Farm management description.
- Farm soils and LUC.
- Catchment information regarding Water Management Zones and Water allocation status.
- Target catchment information relating to One Plan values such as fish spawning values, trout fishing values and riparian and aquatic sites of significance.
- Farm input information included:
 - Land areas (ha) in milking platforms and dairy support land.
 - Total cow numbers and stocking rates.
 - Total milk solids production.
 - Areas of summer and/or winter cropping, types and amounts.
 - Amounts and types of imported feed.
 - Assessed pasture harvest per farm.
 - Quantities of fertiliser nitrogen used.
 - Farm dairy effluent management including storage facility.
 - Water for stock drinking and dairy shed use (if known).

Dairy support properties (runoffs) are any property associated with a milking platform. The dairy support land may be adjoining or some distance away from the milking platform and will typically be used for the following purposes:

- Grazing of replacement stock,
- Harvesting of supplements for the dairy support land and/or the milking platform,
- Grazing of the dairy herd over the winter period,
- Growing of fodder crops to support stock numbers grazed over both summer and winter.

Dairy support blocks were assessed as part of the total farm enterprise in the nutrient budget if they were located in the Mangatainoka Catchment and were identified separately in the Overseer® block setup.

6 Results and Discussion

From a catchment base of 88 dairy farms, 83 EFP's were completed which was an excellent response from the catchment's dairy farmers. Five dairy farms chose not to be included in the voluntary project for the following reasons:

- Two were already engaged in a similar project coordinated by DairyNZ (Dairy Link).
- Three were initially interested in the EFP project but then withdrew for personal reasons.

Figure 2 shows the land area within the catchment used for dairy farming including all milking platforms and dairy support blocks. The map includes areas which are outside and straddle the catchment boundary but have been included in the analysis as the majority of the farm area is inside the catchment.

These additional areas mapped just outside the catchment, along with the five farms excluded from the project explain the difference in Table 1 between the area in dairying as assessed by GIS (17,233 ha) and the total farmed area within EFP's (16,227 ha).

7 Overview of Catchment Land Use

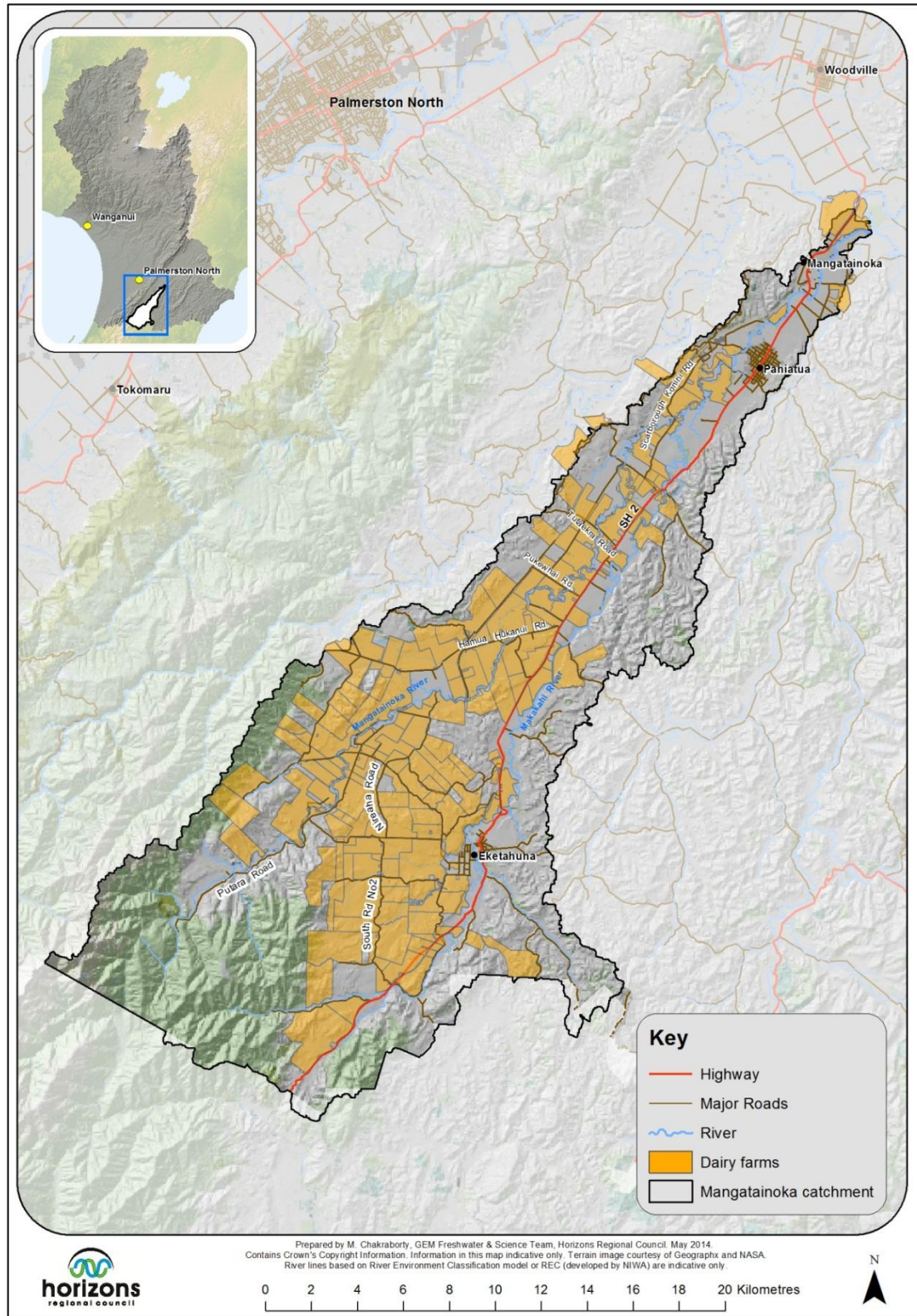


Figure 2: Mangatainoka Catchment Dairy Farms and Dairy support properties

8 Dairy Farm Data, Production Systems, and Farm Management Practices

The Mangatainoka dairy farms are below average for cow numbers per farm, cows per ha, and milk solids per ha compared to Tararua District and National averages (Table 8).

Per cow production is in line with the national average of approximately 364 kg MS/cow but lower than the national average for per hectare production because of the lower overall stocking rate.

The dairy farms in the Mangatainoka are generally family run operations or have share milkers with owners on site.

8.1 Production Comparisons

Table 8: District and National dairy farm data comparisons with Mangatainoka Catchment.

Averages	Mangatainoka	Tararua District (2012/13)	National (2012/13)
Number of dairy cows	24,837	100,306	4,784,250
Total Milk solids (kg)	8,913,800	32,964,432	1.658 billion
Cow numbers per farm	299	327	402
Cows/ha	2.4	2.7	2.85
Milk solids /cow	359	329	346
Milk solids /ha	876	897	988

NB: Comparisons are sourced from New Zealand Dairy Statistics 2012-13 © 2013 DairyNZ Limited.

8.2 Production Systems

Five farm systems have been described by DairyNZ primarily on the basis of when imported feed is fed to dry or lactating cows during the season and secondly by the amount of imported feed and /or off farm dry cow grazing. These definitions do not include grazing or feeding of young stock.

System 1 - All grass self-contained, all stock on the dairy platform.

No feed is imported. No supplement fed to the herd except that harvested off the effective milking platform. Dry cows are not grazed off the milking platform.

System 2 - Feed imported either supplement or grazing off, for dry cows.

Approximately 4-14% of total feed is imported. There is a large variation in % as in high rainfall areas and cold climates most of the cows are wintered off.

System 3 - Feed imported to extend lactation (typically autumn feed) and for dry cows.

Approximately 10-20% of total feed is imported. Feed to extend lactation may be imported in spring rather than autumn.

System 4 - Feed imported and used at both ends of lactation, and for dry cows.

Approximately 20-30% of total feed is imported onto the farm.

System 5 - Imported feed used all year round, throughout lactation and for dry cows.

Approximately 25-40% (but can be up to 55%) of total feed is imported.

Table 9 gives a breakdown of the farm system types within the Mangatainoka catchment and the distribution of leaching ranges within these systems.

Table 9: Nitrogen leaching distribution relative to farm system type.

Leaching Range kgN/ha	DairyNZ Farm System Number				
	1	2	3	4	5
16-20	3	2			
21-30	12	13	3	1	1
31-40	8	12	4	2	2
41-50	1	10	2		1
51-65		4	1	2	
Totals	24	41	9	5	4
% of Total	29%	49%	11%	6%	5%

8.3 Fodder Cropping

The growing of fodder crops has been a traditional method of regrassing damaged pastures on soils that have been pugged in the winter or older pastures dominant in Browntop and other less desirable pasture and weed species. Contouring paddocks and incorporating drainage are also considerations for cropping as well as supplying a relatively cheap bulk alternative feed at times of the year when pasture growth is reduced because of climatic factors.

Cropping was practiced on 64 farms (77%) with the average cropping area of 8 ha and ranging from 0-55 ha (Table 10) and in addition:

- Approximately 3.5% of the effective dairy land is cropped each year.
- Crops sown for summer grazing are turnips, kale and pasja. Paddocks are generally cultivated in late October and sown in November with grazing occurring anytime in January, February and March to be resown in permanent pasture in April.
- Crops sown for winter grazing are cultivated in spring and fed out in May, June, and July to dry cows. Winter crops are more likely to be sown on dairy support blocks and are generally kale or winter oats; and
- Maize and triticale crops are sown in spring and harvested as silage in late summer but these crops are only grown by less than 5% of farmers in the catchment.

The cultivation of paddocks is almost exclusively a full cultivation for the first crop. A second crop may be grown on the same paddock after the first is harvested or grazed and may be direct drilled. When permanent pasture is finally sown, it is always with a full cultivation for a suitable seed bed.

The potential for nitrogen leaching is increased by using full cultivation methods for cropping as opposed to minimum tillage or direct drilling methods. The mineralisation of nitrogen released from the soil organic matter creates a larger N surplus under full cultivation of the crop paddock and will not be fully utilised by the crop, so has the potential to leach via drainage.

Table 10: Cropping Areas

	Farm average	Range	Total area cropped	Proportion of farms with fodder crops
Cropping area	8 (ha)	0-55 (ha)	535 (ha)	77%

Cropping has a significant effect on nitrogen leaching (Table 10a) with the average estimated N leaching rate from the soil estimated to be 113 kgN/ha/yr with the range between 46 and 231 kgN/ha/yr. The estimated N leached from cropping blocks was 61 tonnes N/ha/yr. This is 9.7 % of the total Overseer® estimated leaching loss of 626 tonnes from the project dairy farms in the 2012/13 season (Table 22).

Winter crops and summer crops make up 39% and 61% of the area cropped respectively. On average, on a per hectare basis, winter crops will leach more N than summer crops (Table 10a). This is due to the higher rainfall and drainage expected over May, June and July. In addition to this, the winter crops will generally be grazed over a full 24 hour period with the mobs not removed to pasture at any stage and other supplements (hay and silage) may be fed out on the cropped area. In contrast summer crops are usually grazed for 2-4 hours per day with the milking herds grazing pasture for the remaining 20-22 hours.

Nitrogen released by mineralisation at cultivation and available in the soil is also susceptible to leaching via drainage over this winter period.

With the catchment being generally summer safe with reliable rainfall, species such as chicory and plantain are being explored as alternatives to the traditional crops of turnips and kale.

Summer can be a period where feed quality declines and can influence milk production negatively. Chicory and plantain have high feed quality and comparative yields with other crops and can last up to 2 years before there is a need to replace or renew them. Because of this 2 year rotation the need for cultivation can be reduced and both species can be sown by direct drilling.

The data set collected in this study could be further explored to better understand the range of leaching from the cropping component of dairy farming. With overall leaching rates averaging 113 kg N/ha, nearly 3 times the overall average for dairy farming in the catchment, best practice for cropping, and grazing of cropped areas, is an area where potential water quality gains could be made.

Table 10a : Cropping types and respective areas

Cropping type	Area (ha)	% of Total area cropped	Average N leached (kg N/ha)	Range (kg N/ha)	Kg N leached Total
Summer Cropping (turnips maize, pasja kale)	324.4	61 %	94	46-135	30,494
Winter Cropping (kale)	179.4	33 %	136	54-231	24,398
Winter Cropping (oats)	31.2	6 %	183	112-225	5,710
Totals	535.0		113	46-231	60,602

8.4 Imported Supplements

Hay and silage have always been traditional feeds imported onto farms for production increases or to fill a feed deficit at certain times of the year. Recently with increased milk solids pay-out farmers are relying more on high energy feeds such as maize silage, grains and palm kernel. Some of these high energy feeds have higher protein levels than pasture so generally support production increases on farm and /or higher stocking rates. The types and amounts of these feeds are shown in Table 11.

Increased imported feed has the potential to increase nitrogen lost through the soil either by the additional feed supporting higher stocking rates and therefore creating more urine patches or, at no increase in stocking rate, the imported feed having higher crude protein levels leading to higher per cow production and higher N concentrations in the urine.

Table 11: Imported feed amounts and type.

	Farm average (Tonnes)	Range (Tonnes)	Catchment dairy total
PKE	109	0-450	5,380
Maize/grains	109	0-1,300	4,037
Hay	33	0-148	1,530
Silage	75	0-350	2,774
Total all feeds			13,721 tonnes

8.5 Fertiliser Use

Nitrogen and phosphorus fertilisers are applied to pastures and crops to improve dry matter yields. With extra dry matter grown higher stocking rates can be supported and extra production can be achieved.

847 tonnes of fertiliser N (1,841 tonnes of urea equivalent) was applied annually to the 83 EFP dairy farms (Table 12). Nitrogen applied as fertiliser has a significant impact on farm nitrogen losses (Table 23) although it is noted different forms of fertiliser N are applied at varying rates and concentrations and such losses can be direct or indirect in nature (see Section 17 for further discussion).

The fertiliser industry has a code of practice which if complied with will minimise nutrient losses and fertiliser wastage. Good management practices are as follows:

- Apply smaller amounts more often
- Ensure soil temperatures are above 6 degrees Celsius and soil moisture is optimum for growth. Saturated soils or extremely dry conditions will not ensure optimum uptake of nitrogen by the targeted crop or pasture.
- Minimise nitrogen applications to effluent areas or eliminate completely.
- Apply nitrogen to crops post emergence to ensure maximum uptake from the actively growing plants.
- Avoid direct application to surface water bodies.

Table 12: Nitrogen fertiliser use

EFP Farm average (kg N/ha)	Range (kg N/ha)	EFP N total (tonnes)	EFP total urea equivalent (tonnes)
59	0-328	847	1,841

Table 13 shows 270 tonnes of phosphate applied on farm and this equates to approximately 3,000 tonnes of superphosphate fertiliser equivalent at 9% P for each unit of superphosphate.

Table 13: Phosphorus fertiliser use

EFP Farm average (kg P/ha)	Range (kg P/ha)	Total EFP P applied (tonnes)	EFP fertiliser total Superphosphate equivalent (tonnes)
19	0-45	270	3,000

9 Climate and Relationship to N Leaching Rate

Rainfall distribution varies throughout the catchment. Less rain falls at Mangatainoka in the north of the catchment (1,095 mm) than in the south of the catchment nearer the Tararua Ranges (2,425 mm) (Figure 3). Rainfall information specific to each farm was sourced from NIWA client report; produced for Horizons Regional Council; Tait and Sturman (2008).

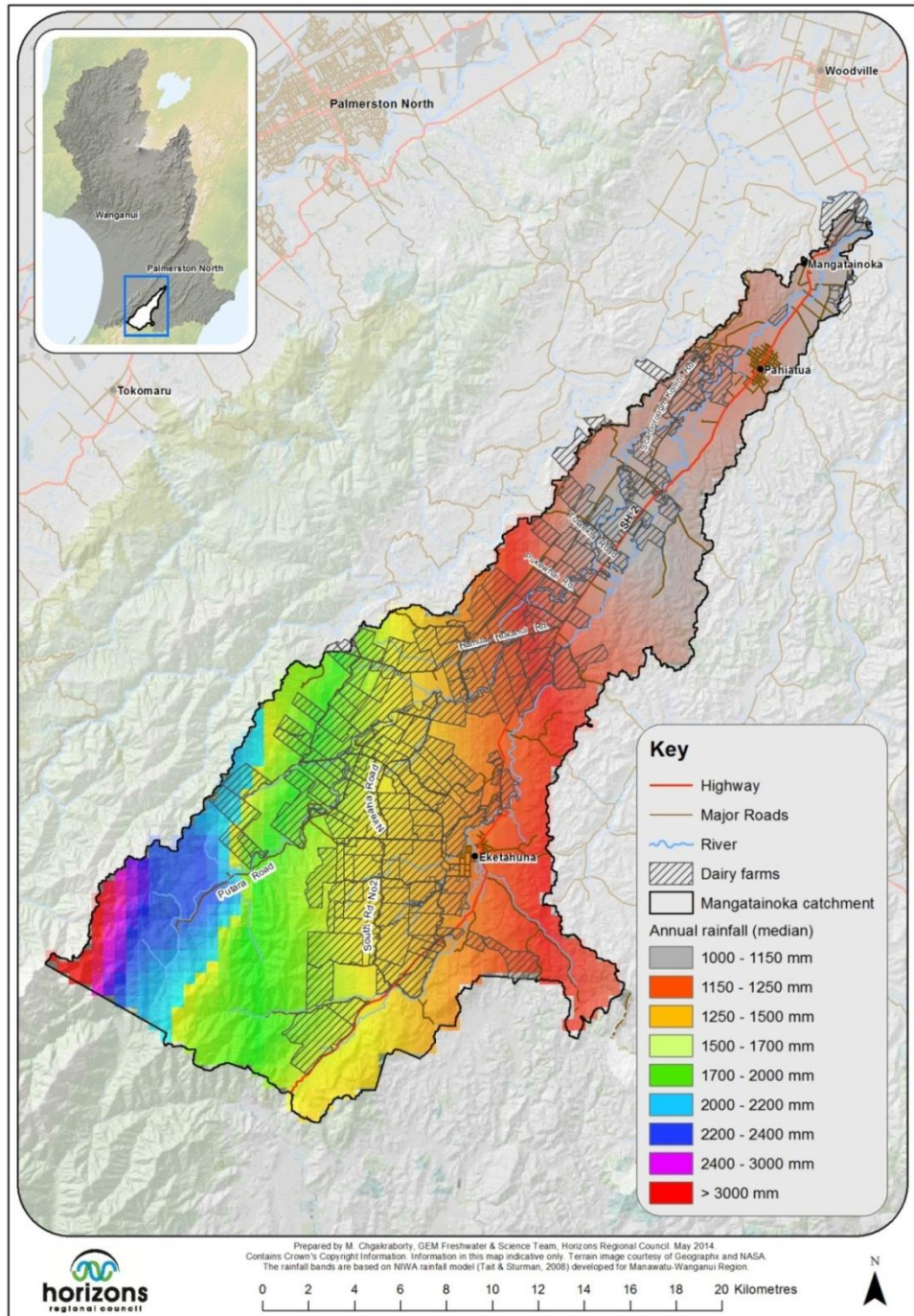


Figure 3: Rainfall distribution Mangatainoka Catchment

Potential Evapotranspiration (PET) decreases from north to south (Figure 4). PET information specific to each farm was sourced from NIWA (Tait, A., and Woods, R., 2007)

As PET values increase and moisture is lost to the atmosphere the drainage potential is decreased, resulting in decreased losses of nutrients through the soil profile.

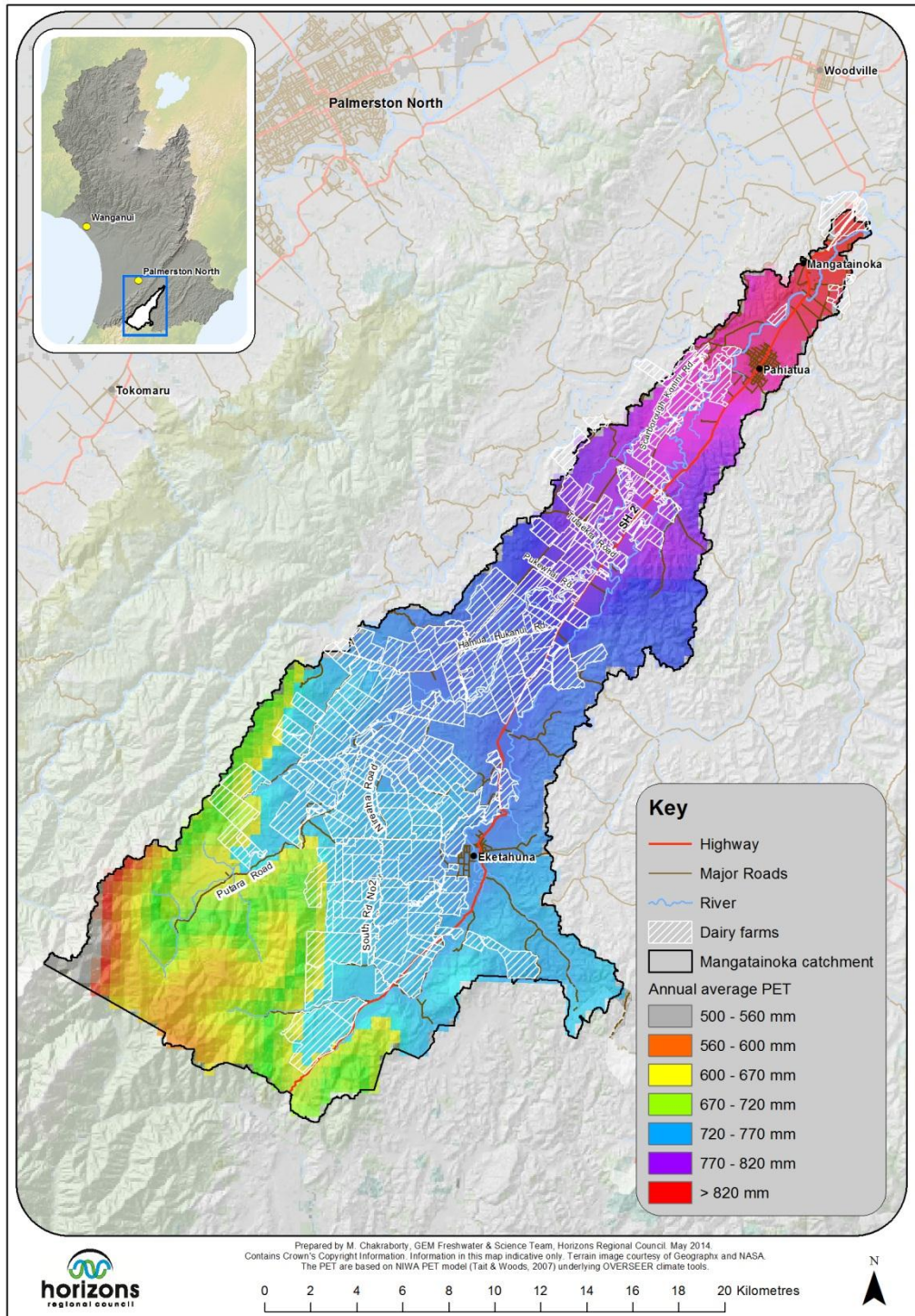


Figure 4: Potential Evapotranspiration distribution Mangatainoka Catchment:

These two climate characteristics and temperature (Table 14) have a marked influence on farm stocking rates and milk solids production by dictating the amounts of pasture grown on farm and the seasonal distribution of that feed.

The Mangatainoka catchment is regarded generally as having adequate summer rainfall, hence only one farm applying water irrigation. Winter is the more challenging part of the year due to low temperatures and high rainfall. It is essential to avoid damage to the soil structure by pugging of pastures and crop areas on all the soil types present in the catchment but more importantly on the impeded or poorer draining soils.

As a general rule, nitrogen leaching from the soil profile will increase with increasing rainfall. This concept is shown in Table 15. Using Overseer® at a stocking rate of 2.5 cows/ha and all other inputs remaining the same, and varying rainfall, nitrogen leaching increases with increasing rainfall.

Table 14: Summary of climate information for the Mangatainoka Catchment,

	Catchment average	Range
Rainfall (mm)	1,675	1,095-2,425
Potential evapotranspiration (mm)		650-780
Average annual temperature		11.5-12.7

Table 15: Modelled N leaching on same farm with differing rainfall.

Stocking rate (cows/ha)	Rainfall (mm)	N leached (kg N/ha)
2.5	1,500	39
2.5	2,250	54

10 Soils

10.1 Soils and their Drainage Characteristics

Soils information is a critical input to the Overseer® modelling and therefore all farms were soil mapped at about 1:7,000. The commonly identified soil types and their drainage characteristics are presented in Table 16.

Table 16: Predominant soil types and drainage characteristics

Soil Type	Drainage Characteristic
Rangitikei fine silt loam or sandy loam	Well drained
Dannevirke silt loam	Well drained
Manawatu silt loam or fine sandy loam	Moderately well drained
Kopua silt loam or stoney silt loam	Moderately well drained
Hokowhitu silt loam	Moderately well drained
Heretaunga mottled silt loam	Imperfectly drained
Matamau silt loam	Imperfectly drained
Cloverlea silt loam	Imperfectly drained
Mangatainoka silt loam	Imperfectly drained
Nireaha silt loam	Poorly drained
Kairanga silt loam	Poorly drained
Raumati silt loam	Very poorly drained

An extensive list of soil types and their respective properties and characteristics from across New Zealand is embedded in Overseer® so the more accurate the identification of soils across a farm, the more reliable the nutrient budget will be with respect to N leaching.

10.2 Drainage Characteristics of Soils and Resultant N Leaching Risk.

Houlbrooke and Monaghan (2009) reported: “Three primary mechanisms exist for the transport of water (containing solutes and suspended solids) through soil: matrix flow, preferential flow and overland flow. These can be described as follows:

- Matrix flow involves the relatively uniform migration of water through and around soil aggregates, therefore generally having greater soil contact time and opportunity for nutrient uptake and attenuation. Soils that have this type of flow are typically well drained to moderately well drained, with fine soil structure and high porosity; however these soils typically have an inherently higher N leaching risk associated with the direct deposition of animal urine patches to land because of their porous nature.
- With preferential flow (bypass flow) water favours movement down direct pathways typically large cracks and connected channels with large pore spaces. The preferential nature of soil drainage creates considerable risk of direct losses of nutrients as they can quickly bypass the pasture root zone when drainage is occurring. This reduces the contact time with the soil and the opportunity for uptake and attenuation.
- Overland flow generally occurs when rainfall or irrigation intensity exceeds the soil’s surface infiltration rate thus on flat land ponding may result and runoff may occur, however on sloping land water will move down slope readily. ”

Soils that are imperfectly drained, poorly or very poorly drained are more likely to exhibit overland flow.

The relationship between soils drainage characteristics and N leached was considered. The results show there is no real difference in the average percentage of well and moderately well drained soils on farm and the likely impact on N leached from the farm (Table 17).

No statistical correlation was found between the amount of well and moderately well drained soils on farm and predicted N surplus or N leached (Figures 7a and 7b).

Because of the large variation in rainfall across the catchment and all soils being susceptible to winter pugging damage to the soil structure, most farmers (59%) see value in owning a dairy support unit to graze their herds off their respective milking platforms over the winter months.

Soils that have been pugged and damaged will experience substantially reduced pasture production in terms of total dry matter grown most noticeably in the spring following.

Table 17: Percentage of well and moderately well drained soils over N leaching ranges for 83 dairy farms in the Mangatainoka catchment.

Leaching Range (kg N/ha)	Percentage of well & moderately well drained soils	
	Average	Range
16-20	63	31-87
20-30	65	0-99
30-40	67	28-100
40-50	54	12-88
50-65	71	50-90

As a general rule, soil drainage characteristics do have an impact on N leaching when all other inputs to the farm system remain constant. Using Overseer® and 1500 mm rainfall and modelling five different soil types with four different drainage characteristics the N leaching changes from 50 kg N/ha for Rangitikei fine silt loam (well-drained soil) to 13 kg N/ha for Kairanga silt loam (poorly drained soil) (Table 17a). The reason for this is more N is lost to groundwater through soil drainage in a well-drained soil whereas more is lost to atmosphere (denitrification) in a poorly drained soil.

Table 17a: Nitrogen leaching rates of various soil types as modelled in Overseer®

Soil Type	Drainage Characteristics	Leaching (kg N/ha/yr)
Rangitikei fine silt loam	Well drained	50
Manawatu silt loam	Well drained	49
Matamau silt loam	Imperfect	45
Kairanga silt loam	Poorly	13
Raumati silt loam	Very poorly drained	15

11 Land Use Capability

Dairying is predominately on the lowland part of the catchment where the geology is alluvial with alluvial gravels and loess.

The predominant LUC Classes occupied by dairying in the Mangatainoka catchment – milking platforms plus dairy support – are Class II and III making up 54 % followed by Class VI at 30.1 % (Table 18). The predominant LUC Classes on the milking platforms are Classes II and III making up 64 % followed by Class VI at nearly 21 %. The majority (61%) of dairy support land at 2,350ha is Class VI (Table 19).

Table 18: Land Use Capability totals by Class for all dairying land assessed by EFP's

LUC Class	EFP Totals (ha)	EFP Totals (%)
I	777.4	4.8
II	4,520.5	27.9
III	4,240.5	26.1
IV	1,114.9	6.9
V	113.1	0.7
VI	4,891.4	30.1
VII	454.4	2.8
VIII	114.8	0.7
Totals	16,227	100

Table 19: Composition of LUC classes on dairy milking platforms and dairy support assessed by EFP's

LUC Class	Milking platform (ha)	% of EFP catchment	Dairy support (ha)	% of EFP catchment	Total %	
I	756	4.7	21	0.1	4.8	
II	4295	26.4	226	1.4	27.8	
III	3643	22.3	598	3.7	26.0	
IV	856	5.3	259	1.6	6.9	
V	92	0.6	21	0.1	0.7	
VI	2542	15.7	2350	14.5	30.2	
VII	66	0.4	389	2.4	2.8	
VIII	106	0.7	9	0.1	0.8	
Totals	12,354	76.1	3,873	23.9	100	16227 ha

12 Compliance with One Plan Table 13.2

In evidence presented to the Environment Court, Taylor (Section 42A Report, 2009) reported on 18 dairy farms in the region that were assessed to test the impact of the nutrient management rule (Rule 13-1). Of these 18 farms it was estimated that 28% and 22% were able to meet the Year 1 and Year 20 Cumulative Nitrogen Leaching Maximums (CNLM) respectively without applying additional (more than those practiced at the time of assessment) N loss mitigation practices. If high to medium cost effective N loss mitigation options were implemented (the low to medium hanging fruit) about 78% and 61% of farms could meet Year 1 and Year 20 respectively.

These farms were assessed using Overseer® versions 5.3 and 5.4 and the Year 1 values in Table 13.2 were based on evaluations of farm scenarios using version 5.2. The change to Overseer® version 6 in 2012 put much greater emphasis on soil drainage characteristics generally leading to increased estimates of N leaching for farms with a dominance of well drained soils. Farms with a predominance of impeded or poor draining soils generally had a reduced estimation of on farm N leaching (NB: While the estimate of N loss modelled by Overseer® changes with version changes, the receiving water gets the same amount).

The impact of this now is many more farms cannot meet Year 20 Table 13.2 CNLM because of the increase in N leached estimated by Overseer® 6. The numbers of Mangatainoka farms that comply at each year (1, 5, 10, and 20) are shown in Table 20.

Table 20: Number of EFP farms meeting or exceeding Year 1 to Year 20 Cumulative Nitrogen Leaching Maximums in (One Plan Table 13.2) modelled using Overseer® (v 6.1.2).

Numbers of farms								
kg N/ha/yr. leached	Year 1		Year 5		Year 10		Year 20	
		%		%		%		%
Meets N leaching max.	11	13	5	6	5	6	3	4
1 to 5 units over	19	23	17	21	6	7	8	10
6 to 10 units over	11	13	13	16	20	25	16	19
11 to 20 units over	23	28	26	31	26	31	29	35
21 to 50 units over	19	23	22	26	26	31	27	32
Totals	83	100	83	100	83	100	83	100

13 Farm Dairy Effluent Management

13.1 Current Storage Facilities

Each EFP contained a section on farm dairy effluent management which looked into the types of storage on farm and the adequacy of that storage. Efficient effluent management is a key factor in reducing nutrient losses off farm.

The availability of adequate effluent storage facilities on farm varies throughout the catchment from sumps (not considered storage), to unlined and lined ponds some with adequate storage (Table 20). The purpose of having adequate storage is to practice deferred irrigation so effluent is only applied to land when soil and weather conditions are suitable, i.e. when the soil moisture deficit meets or exceeds the depth of effluent being applied. This in turn means the maximum amount of nutrients can be treated by the soil/plant ecosystem, avoiding runoff and drainage of nutrients to water.

Of the 83 farms 27 (33%) had no storage and operated from a sump only; 52 (63%) had unlined ponds and 4 (5%) had lined ponds (Table 20).

Adequate storage volumes are calculated using the 'Dairy Effluent Storage Calculator' (DESC) developed by Massey University and HRC. The DESC model was populated with customised information from each farm to determine a range of possible leakage rates based on infrastructural, soil permeability and climatic information.

Of the 83 farms 56 (67%) had some storage of which on 35 farms (63%) this storage was adequate, however only 3 of these were lined (Table 21).

Table 21: Effluent storage

Effluent storage type	Numbers	Adequate storage	Inadequate or no storage
Sump only	27		27
Unlined ponds	52	32	20
Lined ponds	4*	3	1
Total	83	35	48

*This figure was the estimate in 2012-13; the number now is believed to be 8.

13.2 Sumps

A sump is a concrete facility that captures effluent to be spread daily to land. A sump will often only hold a minimal amount of effluent and is not considered storage so therefore if soils are wet or saturated, runoff and/or drainage will likely occur. There is no risk management with sumps so if a system failure occurs, and no effluent storage is available, overflow is likely leading to ponding, drainage, and runoff of effluent to water. Losses from farm dairy effluent application areas, where sumps are the only facility, are likely to be considerably higher than similar application areas of a system managed with adequate storage. Adequate effluent storage facilities allow for deferred irrigation to be practiced reducing runoff and drainage. Research at Massey University showed that on poorly drained soil with mole and tile drainage in place, when 25mm effluent was applied at 6mm soil moisture deficit, 40% was lost to tile drainage and 30% to surface run-off. These losses equated to 12 kg N/ha/yr and 2 kg P/ha (Dr DJ Houlbrooke S42A report, 2009).

13.3 Unlined Ponds

Unlined ponds are the most common storage system found in the Mangatainoka catchment. Many of these ponds have been in existence for many years and were initially constructed as effluent 'treatment' ponds (anaerobic and aerobic) which then discharged to water.

The sites often chosen for these ponds were for convenience of operation, not for the prevention or minimisation of leakage from the ponds. At the time of construction no

regulation required that these facilities be sealed. These requirements will come into place in many cases when effluent discharge consents expire and new consents are granted.

13.4 Lined Ponds

Lined ponds are considered to be those with a liner (either synthetic or clay) whose design specifications meet the permeability standard of 1×10^{-9} m/s. While this sealing layer may not be completely impervious, the allowed leakage rate is only 0.1mm/day.

Of the 4 lined ponds in the catchment (as at 2012-13) all but one are large enough to allow deferred irrigation to be practiced.

13.5 Pond Leakage

Through the EFP Project it has been identified that a significant number of farms in the catchment have effluent storage facilities that are unlined. Overseer® assumes best practice for a number of farm management areas. One of these assumptions is that all effluent storage facilities are sealed so that no leakage occurs. However, unless ponds are lined to specifically meet the permeability maximum of 1×10^{-9} m/s it is likely that there is a degree of leakage from these ponds.

To assess the overall catchment level of N leakage from ponds they were assessed using the 'Pond Leakage Calculator' developed by Dr. Dave Horne from Massey University. The calculator provides an estimation of pond leakage on a Kg N/yr basis to allow a comparison with the farm's total N leaching calculated in Overseer®, as well as a percentage of the annual farm dairy effluent produced.

The calculator uses information provided in the DESC and Overseer® nutrient budgets including:

- Pond dimensions (to calculate the surface area from which effluent leaks).
- Annual farm dairy effluent generated.
- Effluent application area and rate of N applied as effluent (taken from Overseer 'Effluent Report').
- Total farm area.

An average nitrogen concentration of pond stored effluent of 175 g/m^3 was used in calculating the overall N load from the leaked effluent. This is a typical value (Dr. Horne pers comm.).

A permeability rate has been used that reflects the soil type that effluent ponds may commonly be constructed within. For this assessment these included clay at 5 mm/day leakage rate (high end of the clay permeability range of 1-5 mm/day) and silt at 10 mm/day leakage rate (low end of the permeability range of 10-30 mm/day) (Dr. Horne pers comm.). These rates have been chosen as a conservative indication of likely leakage rates, as in reality many ponds in the Mangatainoka catchment have been constructed in gravel soils which likely have a much higher leakage rate (up to 1000 mm/day). These rates also allow for an extent of 'self-sealing' that may occur due to the build-up of a sludge layer in the bottom of an effluent pond, however the extent of this sealing is unknown and where there is groundwater infiltration into the pond this sealing layer is likely to be ineffective for at least part of the year and will also potentially mislead visual observation of a ponds ability to hold effluent. Also occasionally sludge is cleaned out and after cleaning the leakage rate will be much greater for an unknown period of time – likely years – before some degree of self-sealing occurs.

Of the 56 farms with effluent storage facilities in the Mangatainoka catchment, 52 of these are unlined. Of these 52 unlined ponds 41 were assessed using the Pond Leakage Calculator.

With a leakage rate of 5 mm/day (clay) effluent lost from unlined ponds ranged from 0.1 kg N/ha/yr to 6.1 kg N/ha/yr on a whole farm basis. The average N leached over the total farm area with this leakage rate was 2.4 kg N/ha/yr. On average this was 14.4% of the total annual farm dairy effluent produced (Table 22).

With a leakage rate of 10 mm/day (silt) effluent lost ranged from 0.9 kg N/ha/yr to 12.1 kg N/ha/yr on a whole farm basis. The average N leached over the total farm area with this leakage rate was 4.8 kg N/ha/yr. On average this was 29.0% of the total annual farm dairy effluent produced (Table 22).

With an average of 2.4 to 4.8 kg N/ha/yr added onto the overall N leaching rate for each farm, losses via this pathway potentially add a very large amount to the estimated N load being leached off dairy farms in the Mangatainoka catchment. At the conservative leakage rates of 5 mm/day and 10 mm/day it is estimated the equivalent of at least 14,072 kg N/yr and 28,161 kg N/yr respectively is lost from unlined effluent ponds in the catchment. These losses are additional to those estimated in Overseer® as N lost from unlined ponds is not taken into account and contribute an additional 2.2% and 4.3% to the total N lost from dairy farms in the catchment.

Table 22: Unlined pond leakage rates from 'Pond Leakage Calculator'.

	Leakage Rate on a whole farm basis (kg N/ha/yr)			% Total FDE Leaked		
	Min Leakage	Max Leakage	Average leakage	Min	Max	Average
Clay 5 mm/day	0.1	6.1	2.4	0.0	41.0	14.4
Silt 10 mm/day	0.9	12.1	4.8	1.0	83.0	29.0

When considering potential mitigation options for farms to reduce N leaching, adequate pond storage and pond sealing should be considered as one of the first options even though it is not currently represented in Overseer®. At catchment scale, our conservative estimation is that substantial reductions in N leached could be gained. Having a sealed effluent storage facility is considered best practice within the industry and therefore there is an expectation that it be provided irrespective of any regulatory regime.

14 Stock and Cowshed Water Use

Water use on farm was reported for stock water and cowshed use.

Very few farms have metered water supplies and of those that are metered many did not record their volumes used. Farms using less than 50 m³ of groundwater per day, or 30m³ of surface water, can do so as a permitted activity. Above these amounts consent for the water take is required and all consents were reported in the EFP's.

With surface water in Mangatainoka fully allocated, combined with shed water use contributing to effluent volumes, it is imperative farmers are made more aware of the need to conserve and use water more efficiently in their farming operations. There are many reasons why striving for efficiency of water use on farm is good practice. For example any additional water use in the dairy shed results in greater volumes of shed effluent to manage.

For the EFP's where water use was not known a default volume of 70 litres/cow/day was used in calculations both for stock water and dairy shed use making a combined volume of 140 litres/cow/day.

With new technologies such as green water recycling for yard wash down it is possible to reduce dairy shed volumes.

15 Riparian Fencing

Riparian fencing was mentioned in all the EFP's if applicable to a particular property.

Verifying riparian fencing is a time consuming activity therefore, because of the pressure to meet project milestones this information was not well reported as to lengths of stream fencing completed and yet to be completed.

Under the Sustainable Dairying Water Accord and as part of Fonterra supply agreement with farmers, Fonterra staffs have been verifying riparian fencing of all waterways on dairy farms. The Accord commitment is for 90% stock exclusion from Accord waterways by 31 May 2014 and 100% exclusion by 31 May 2017. That said, as the Mangatainoka is a target catchment One Plan Rule 13-1 requires stock exclusion from all permanent waterways and from ephemeral waterways that have an active bed wider than a meter from the time consent is granted. This includes bridging or culverting all stock crossings.

16 Nutrient Losses

16.1 Nitrogen Leaching

The total estimated N leached from the 83 EFP farms and the average per farm is presented in Table 23. The catchment average was 39 kg N/ha/yr. This catchment average value represents the total modelled N leached from Overseer® of dairy farms in the catchment and was 626 tonnes (Table 23) of N divided by the total area of all the 83 dairy farms (16227 ha).

Table 23: Estimated Nitrogen leached from EFP farms using Overseer® Versions 6.0.1 and 6.1.2 which includes milking platforms and dairy support lands.

Catchment average over total dairy ha (kg N/ha/yr)	Farm average of 83 farms (kg N/ha/yr)	Range (kg N/ha/yr)	EFP farms' total (tonnes N)
39	34	16-65	626

Tables 23a and 23b show modelled farm N leaching data separated into milking platforms and dairy support lands. This analysis was done several months after the analysis contributing to Table 22 and therefore the use of new versions of Overseer® was necessary. Therefore comparisons between Table 23 and Tables 23a and 23b are not valid. Also, the N leached data in Table 22a and 22b are based on effective hectares whereas data in Table 23 are based on total farmed area. The reason for this later analysis was to explore a potential relationship between N leached and rainfall specific to milking platforms. This had been done for the whole farm entity – milking platforms and dairy support lands combined (see Section 16) and the location of dairy support lands tended to be in higher rainfall areas therefore confounding any correlation.

Table 23a: Estimated Overseer® modelled Nitrogen leached from EFP farms' milking platforms using Overseer® Version 6.1.3 (n=82).

Average (kg N/ha/yr)	Range (kg N/ha/yr)	Total (tonnes)
40	16-78	409

Table 23b: Estimated Overseer® modelled Nitrogen leached from EFP farms' dairy support lands using Overseer® Version 6.1.3. (n=51).

Average (kg N/ha/yr)	Range (kg N/ha/yr)	Total (tonnes)
25	6-66	91

16.2 Phosphorus Loss

The average estimated P loss per farm and the estimated total for the catchment based on the 83 EFP farms is presented in Table 24.

Table 24: Estimated Phosphorus loss from EFP farms using Overseer® Versions 6.0.1 and 6.1.2 which includes milking platforms and dairy support lands (n=83).

Farm average (kg P)	Range (kg /P/farm)	EFP farms' total
295.5	34 -2,444	24.5 tonnes

Overseer® estimates “risk” of P loss off a farm not P lost to water as with N leached. Forty-six farms (55%) had one or more blocks with a P loss risk of high or extreme and as it is a risk assessment it is not surprising that these blocks were predominantly on dairy support properties and on rolling to steep areas where run-off and/or erosion is the risk.

Assessment of opportunities to reduce the area that is subject to high or extreme risk of Phosphorus loss is recommended. Particularly given that Phosphorus is an important nutrient in periphyton growth in the Mangatainoka catchment.

17 Analysis of the relationships between Farm Management Practices and Farm Physical Resources on predicted N Leaching

17.1 Nitrogen Surplus and Nitrogen Leaching

Nitrogen leaching is driven by complex biophysical processes influenced by farm inputs along with a range of other geological and climatic factors (such as rainfall and drainage). Predicted whole farm N leaching and whole farm N surplus is taken from Overseer® Scenario Report, Nitrogen Overview output report.

Overseer describes N surplus as: “Farm N surplus is the sum of all N inputs less N removed in product. It represents the extra N in the system, which is allocated to N leaching, gaseous losses, immobilisation, supplement removal, transfers and other losses in the model. It was used in some European countries as a means to reduce N inputs and hence N losses. In New Zealand pasture systems, and within Overseer, there is a balance between N fixation and N immobilisation, and hence its interpretation is more difficult. A low leaching loss but high N surplus (>200 kg N/ha/yr) indicates that there could potentially be higher leaching losses at a future date.”

It was found that whole farm (milking platforms and dairy support lands) predicted N surplus (kg ha/yr) and N leaching (kg ha/yr) are correlated ($R^2 = 0.47$) (Figure 5). Beukes et al. (2012) in a study of 247 Waikato dairy farms reported a much stronger relationship ($R^2 = 0.743$). We subsequently collated predicted N leaching and N surplus using milking platforms only to re test this relationship and that with rainfall. Using the milking platforms total kg N/yr of predicted N leaching against N surplus we found a much stronger relationship ($R^2 = 0.71$) (Fig.5a). However when we used predicted kg N/ha/yr of N leaching against kg N/ha/yr of N surplus the relationship was weak ($R^2 = 0.35$) (Fig. 5b). A summary of these results is presented in Table 25.

Table 25: Summary of N surplus and N leached relationship for whole farm and platform only

Relationship Variables		Farm Area for Analysis	R^2
N Surplus kg/ha/yr	N Leached kg/ha/yr	Whole Farm	0.47
N Surplus kg/ha/yr	N Leached kg/ha/yr	Platform Only	0.35
N Surplus Total kg/yr	N Leached Total kg/yr	Platform Only	0.71

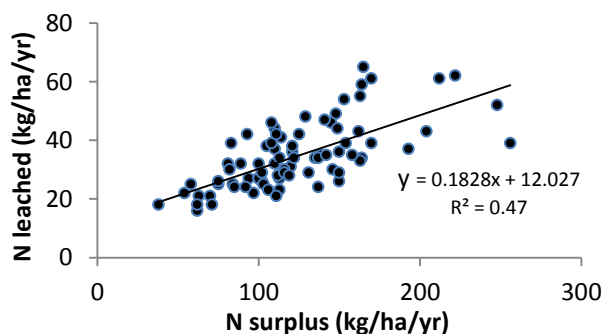


Figure 5: Plot showing a linear relationship between predicted whole farm (milking platforms and dairy support lands) N leaching and N surplus (kg ha/yr) for 82 farms.

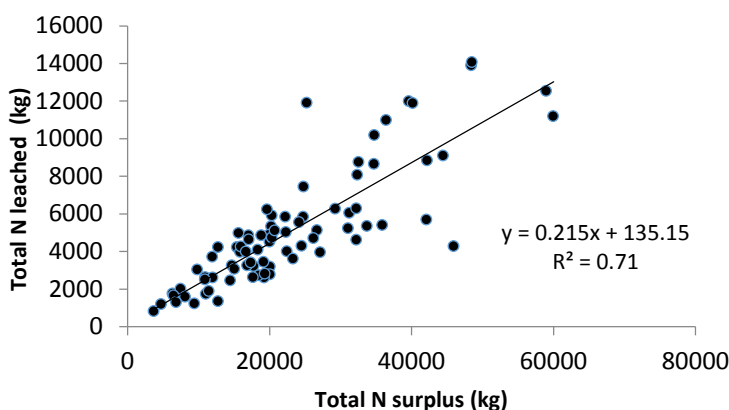


Figure 5a: Plot showing a linear relationship between milking platforms total kg/yr predicted N leaching and N surplus for 82 farms.

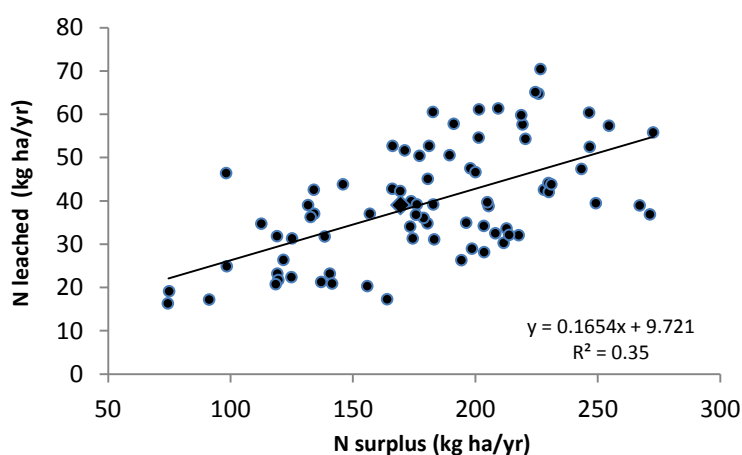


Figure 5b: Plot showing a linear relationship between milking platforms kg ha/yr predicted N leaching and N surplus for 82 farms.

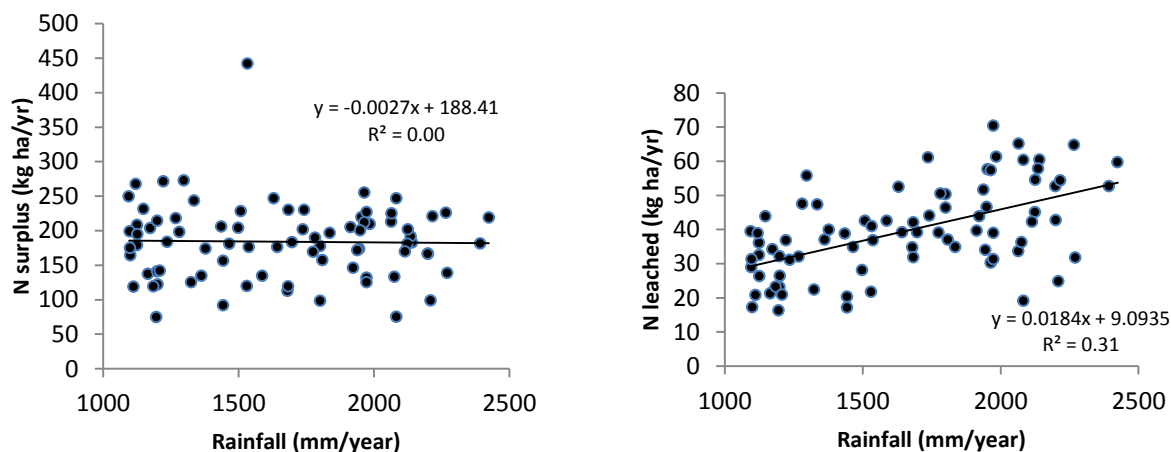
The unexpected difference in the predicted N leaching and N surplus between total kg/yr and kg ha/yr (Figs. 5a and 5b) prompted an exploration of why there was such a difference: It was found to lie in the estimates of N surplus used. A random sample of 31 farms from the 82 farms used showed no significant difference in the N leached (kg/ha/yr) ($p = 0.670$) but a significant difference in N surplus (kg/ha/yr) ($p = 0.001$), between Overseer's whole farm estimate and the nutrient management block estimate (Table 26). Some difference was expected in predicted N leached because in the derived estimate from the nutrient management blocks effective farm area was used but this would not account for the significant N surplus differences (Table 26).

Table 26: Comparisons between mean whole farm N leaching and N surplus (kg/ha/yr) from a random sample of 31 farms, as predicted by Overseer®.

Mean whole farm N leaching (kg/ha/yr) ¹	Mean effective farm area N leaching (kg/ha/yr) derived from individual nutrient management blocks ²	Mean whole farm N surplus (kg/ha/yr) ³	Mean effective farm area farm N surplus (kg/ha/yr) derived from individual nutrient management blocks ⁴
33.58 (s.e. 2.136)	34.90 (s.e. 2.247)	121.389 (s.e. 8.185)	163.065 (s.e. 9.431)
<i>p</i> = 0.670		<i>p</i> = 0.001	

NB: The first N leaching estimate¹ is from the Overseer® Scenario Report, Nitrogen Overview output report. The second estimate² is derived from Overseer® Scenario Report, Nitrogen output report of Total N lost for each nutrient management block. The first N surplus estimate³ is from the Overseer® Scenario Report, Nitrogen Overview output report. The second estimate⁴ is derived from Overseer® Scenario Report, Nitrogen output report of Total N lost for each nutrient management block.

Rainfall (annual median) had a weak relationship with milking platform predicted N leaching (kg N/ha/yr) ($R^2 = 0.31$) and no relationship to N surplus (Figures 6a and 6b).

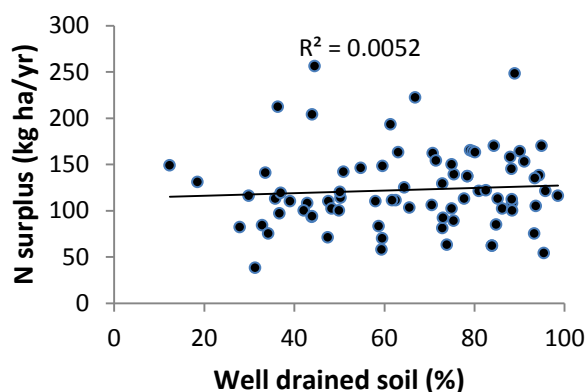
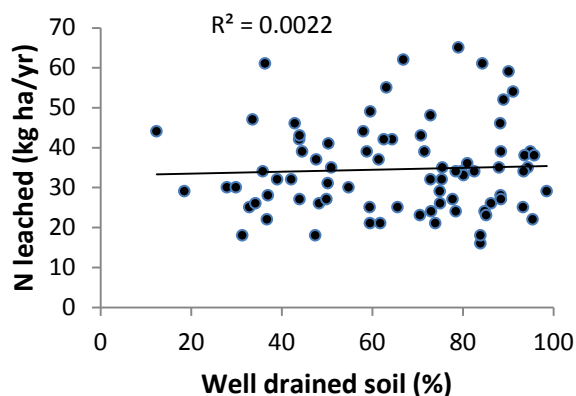


Figures 6a and 6b: Plot showing the relationship with rainfall and all milking platforms predicted N leaching (kg N/ha/yr) and N surplus (kg N/ha/yr) for 82 farms.

However, in Overseer® Version 6, N loss is estimated using drainage and not rainfall as the main hydraulic driver, unlike previous versions. In general, at individual farm scale, the higher the rainfall the more likely that drainage volumes will also be higher which, with all things being equal, should lead to higher N loss (Table 15). Then again, a number of factors will potentially affect any correlation: Timing of N fertiliser use, productivity, and number of cows present on farm from autumn through to winter, all influencing the amount of N surplus to plant uptake. Soils with poor drainage characteristics where greater denitrification will occur will also confound any correlation. Eventually too, within any one drainage season, there will be little or no available at risk N left in the soil.

This lack of correlation was also evident when predicted N leaching and N surplus were plotted against percentage of well drained soil (Figures 7a and 7b).

It was decided not to include these two variables (rainfall and well drained soils) further in the analysis as understanding the influence of different farm management practices was more important. That is, if change is necessary, farmers and others can relate to farm management practices which can be modified whereas not so with rainfall and soil drainage characteristics.



Figures 7a and 7b: Percentage of well drained soil against predicted N leaching and N surplus (kg N/ha/yr).

A multivariate statistical analysis was used to explore the best combination of selected farm management factors determining farm predicted N surplus and N leaching. For both variables we used the estimates from the Overseer® Scenario Report, Nitrogen Overview output report. For the analysis, we used a nonparametric regression method known as Generalised Additive Models (GAMs) by using a statistical package known as MOPED (Modelling Patterns in Environmental Data, version 3.1) developed by Jowett Consulting (copyright: Ian Jowett 2001-05). Nonparametric regression relaxes the usual assumption of linearity and uncovers structure between the independent variables and dependent variable that might otherwise be missed. The best combination of factors were selected based on lowest AIC (Akaike information criterion) value and a P (probability factor) value < 0.05. While the lowest AIC value was used as the indication of model strength, P value (< 0.05) was used for statistical significance of the model.

N applied, imported feed, and stocking rate, explained about 76% of the variation in farm N surplus (Table 27, and Figure 8). This result shows that almost 60% of the variation in N surplus data is explained by N applied. While this relationship is non-linear, we also found a positive linear relationship ($R^2 = 0.53$) between N applied and N surplus (Figure 8). Only about 60% of N is taken up in plant herbage and the rest is distributed between below ground root matter and soil micro-organisms (Dr Ants Roberts pers.com.) and therefore there is some uncontrollable loss. However it could mean too much N is being applied at times and at the wrong times in the wrong places causing direct rather than indirect losses.

Beukes et. al (2012) inferred that farm N leaching can be reduced by increasing the N conversion efficiency "...through lower replacement rates (16 versus 22%), lower stocked (<3.0 cows/ha) high genetic merit cows (30L milk/day at peak or 2.6 kg MS/day)) milked for longer (277 versus 240 days), feeding effluent irrigated, home-grown, low protein supplements to cows on high protein, grass-clover pastures to dilute N concentration in the diet, ... standing off cows for part of the day and using lower N fertilizer rates (50-70 kg/ha/yr)...".

Whilst with respect to Overseer® definitions of N surplus and N conversion efficiency are similar but not the same, the context Beukes (2012) used the term was as L milk/kg farm-gate N surplus. Our use of N surplus is more aligned to Beukes than the Overseer definition of N conversion efficiency and therefore we believe similar farm practices as they describe could be advanced in the Mangatainoka catchment to reduce N leaching.

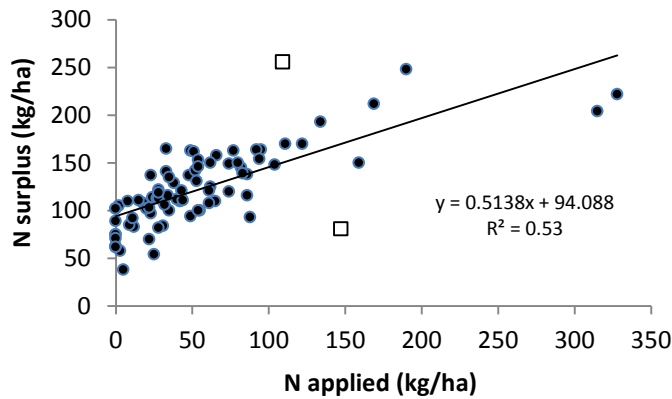


Figure 8: Plot showing the linear relationship between N surplus and N applied. The open squares on the plot represent the outliers responsible for reducing the strength of this relationship

The blank squares in figures 8 & 11 were considered as possible outliers as they may have had an undue influence on the results, however, as this report is based on a catchment scale no analysis on an individual farm basis was carried out.

The two Fonterra factory farms are not highlighted in either Figures 8 & 11 but are at the extreme end of the plots for N applied, N surplus and N leached. These farms are irrigated with waste water from the Pahiatua dairy factory which has an N concentration of 61 g/m³. Both farms have annually applied levels of N over 310 kg/ha.

Table 27: Best possible combination of variables (up to 4) determining predicted N surplus.

Independent variables	R ²	P	AIC
N applied	0.59	<0.001	446.84
N applied + Imported feed	0.72	<0.001	311.01
N applied + Imported feed + Stock rate	0.76	<0.001	271.15

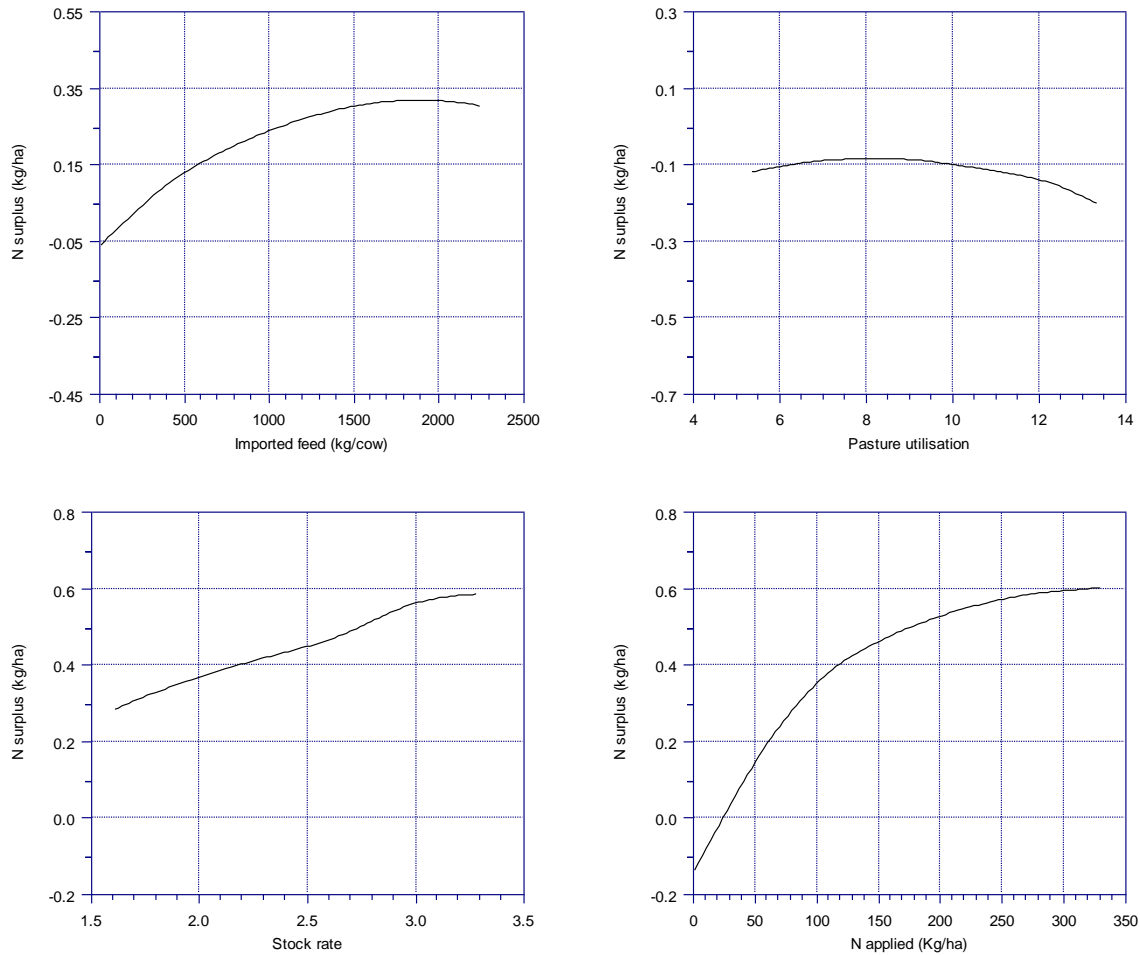


Figure 9: Plots displaying the best result of the GAM analysis and relative influence of the individual factors on farm predicted N surplus (kg N/ha/yr)

The graphical representation of our GAM analysis show that N applied and imported feed are both important variables in explaining the amount of N surplus and that this relationship becomes asymptotic at about 280 kg N/ha and 1,700 kg/cow respectively (Figure 9).

N applied, stock rate, imported feed, and cropping area was found to explain more than 60% of the variation in predicted N leaching (Table 28).

Table 28: Best possible combination of variables (up to 4) determining predicted N leaching

Independent variables	R ²	P	AIC
N applied	0.32	<0.001	185.17
N applied + Cropping area	0.47	<0.001	153.94
N applied + Cropping area + Stock rate	0.56	<0.001	136.2
N applied + Cropping area + Stock rate + Imported feed	0.64	<0.001	120.4

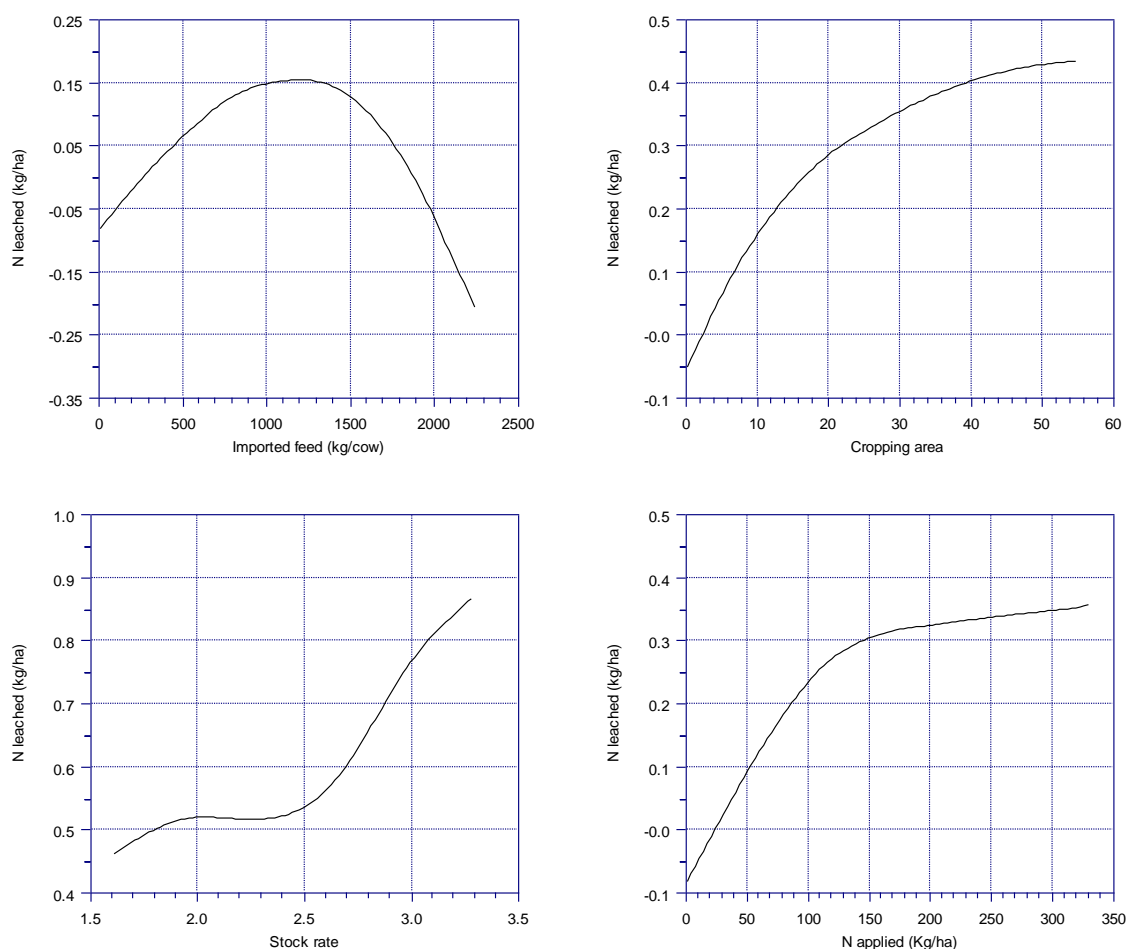


Figure 10: Plots displaying the best result of the GAM analysis and relative influence of the individual factors on predicted N leaching (kg N/ha/yr)

The graphical representation of the GAM analysis shows a unimodal relationship between imported feed and N leached, with decreasing leaching beyond 1000-1100 kg/cow (Figure 10). This can be attributed to certain farms using high amounts of imported feed but leaching less nitrogen. This is likely due to the use of herd homes, extensive use of feed pads, or the relatively low N fertiliser use on some of the system 5 farms. On the other hand N applied, stock rate, and cropping area continue to have positive relationships with predicted N leaching and most notably there is a strong increase in predicted N leaching at a stocking rate >2.5 cows/ha. There is also a tendency for an asymptotic relationship with N applied at about 150 kg ha/yr.

N applied has a weak ($R^2 = 0.27$) linear relationship with N leaching (Figure 11) as opposed to its relationship with N surplus. This can be attributed to some farms in the catchment with low inputs of N applied but high amount of N leaching and conversely, a few farms with high amounts of N applied but with relatively low N leaching.

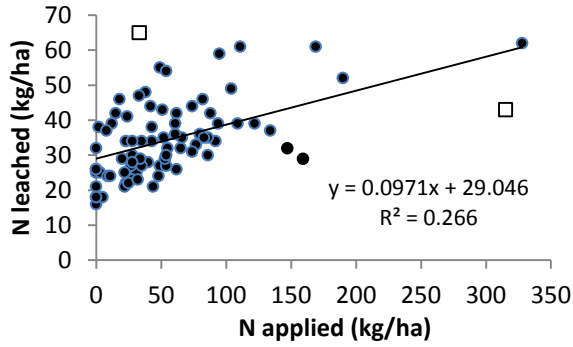


Figure 11: Plot showing the linear relationship between predicted N leaching and N applied. The open squares on the plot represent the outliers responsible for reducing the strength of this relationship

Stocking rate had a high correlation to MS/ha ($R^2 = 0.74$; $p < 0.001$). The combination of imported feed and N-applied was weakly correlated to MS/ha ($R^2 = 0.35$; $p < 0.001$). However N-applied and imported feed only increased the explained variation in MS/ha by 1% to 76% and therefore stocking rate was clearly the main driving factor behind farm milk production.

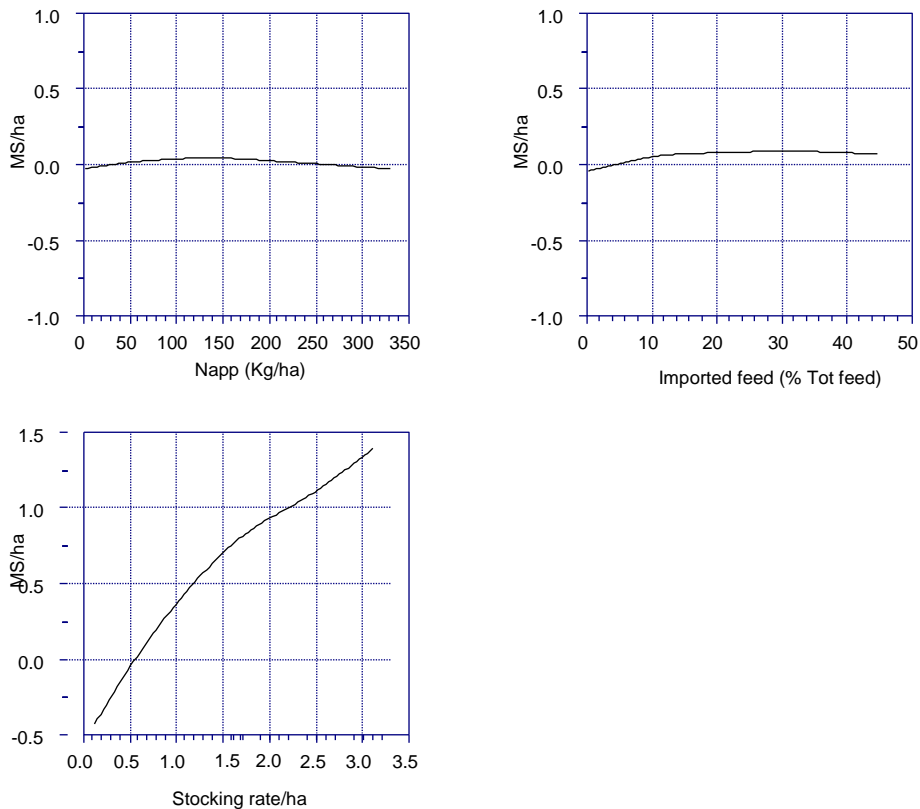


Figure 12: Plots showing GAM analysis of the influence of the individual predictor variables on Milk solid/ha

Overall, our analysis shows N applied, stock rate and imported feed are the main farm inputs that drive the variation in predicted farm N surplus. These factors along with the cropping area also explain more than half the predicted N leached. N applied has a stronger relationship with predicted N surplus than N leached.

18 Summary

As a part of the Manawatu Freshwater Clean-up Fund project, 83 of 88 dairy farms in the Mangatainoka catchment engaged in the EFP project. The completion of the eighty-three EFPs involved documentation of individual farm data, at a point in time across the entire catchment. This data allowed for accurate Overseer® modelling to be completed and individual farm N leaching losses to be calculated as well as a N leaching load from dairy farms on a whole catchment basis. In addition to the EFPs completed in the Mangatainoka catchment, a further 15 were also completed in the Tiraumea and Pohangina catchments.

Farmer uptake was high for the voluntary project, which led to an increased level of understanding regarding their responsibilities under One Plan and their ability to remain farming. The project has also provided for further understanding around nutrient management and losses for rural professionals, scientists, and farmers in general particularly at a catchment scale.

The project has revealed a wealth of information which this report summarises and to a limited extent, analyses to promote discussion on key farm practices that influence N leaching. Importantly, it reinforces the need for enhancing awareness of nutrient cycling on farm, and the impact high farm N surplus' have leading to nitrogen becoming a contaminant in surface waters.

At catchment scale, farm management practices appeared to have the greatest influence on N leaching regardless of rainfall or soil type. Reducing N surplus, and therefore N leaching, can be achieved via a range of farm management practice changes as suggested in the results and by Beukes et al. (2012).

The project led to a robust and complete Environmental Farm Plan being completed for each individual farm. A key component in achieving that has been establishing the processes and protocols for the various parties to work together. The completion of these EFPs has subsequently provided guidance to the process to move these farms, as well as other dairy farms requiring existing land use consent, smoothly through the consenting process. As a next step to the project, DairyNZ have partnered with farmers, Horizons Regional Council, and rural professionals to fund the preparation of the Nutrient Management Plan component of the consent application through a pilot project for the first 50 farms requiring existing land use consent.

19 References

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- The PET dataset (based on Penman method) is the similar dataset as the one in the OVERSEER® climate tool.

20 Appendix 1

Members of Steering Group

Dorothee Durpoix - Ministry for the Environment

Emma Bonner - Ministry for the Environment

Mike Scarsbrook - DairyNZ

Kevin Argyle - DairyNZ (replaced by James Muwunganirwa)

Ants Roberts - Ravensdown

Jeff Morton - Ballance Agri-Nutrients

Jim Galloway – Federated Farmers

Richard Murfitt - Federated Farmers

Jon Roygard - Horizons Regional Council

Peter Taylor - Horizons Regional Council

Derek Ryan - Horizons Regional Council

21 Appendix 2

Members of Action Team

Peter Taylor - Horizons Regional Council

Derek Ryan - Horizons Regional Council

Jeff Morton - Ballance Agri-Nutrients

Caroline Tatere - Ballance Agri-Nutrients

Bec Meyer - Ravensdown

Lachie Campbell – Ravensdown

Stephanie Sloan - Ravensdown

John Stantiall - Consultant

Lachie Grant - Consultant

Doug Benn - Consultant

