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Literature Survey Of Nitrogen And Phosphorus Loss From Land To Water In The Waikato Region

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Report for Waikato Regional Council

June 2011

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1. Executive Summary

This report provides a summary of published literature on nitrogen (N) and phosphorus (P) losses from land to water that was carried out in the Waikato region or of relevance to it. It was based on a literature search of science publication databases, selected publications not available to web searches and AgResearch reports. An end-note library of references is provided with the report. In addition, a summary is provided of relevant on-going research projects and programmes such as from the Ministry of Science and Innovation (MSI), MAF Sustainable Farming Fund (SFF), University of Waikato and PhD studies.

Research was grouped according to Sources and Pathways, and Mitigations. Studies on key N and P loss processes and sources were summarised, recognising the significant contribution of critical source areas, erosion and sediment losses, and animal excreta. A tabulated summary of individual research papers, their objectives, key findings and the magnitude of reduction of N and P losses from management or mitigation practices are presented. These covered effluent management, retired areas (wetlands, riparian management, fencing waterways, filter strips), fertiliser management (fertiliser use, fertiliser form, optimal soil P), nitrogen inhibitors, animal related issues (pugging, stock management, restricted grazing), land management (irrigation, sorbents, pasture, races, retention dams) and crop use (crop management, supplementary feeds).

Areas where further research is required are defined. These are:

Phosphorus:

Research is required on defining critical source areas (CSAs) on farms and catchments; this is ongoing in a new large MSI programme. Better knowledge of sediment and P losses in Waikato hill country is desirable as is a better understanding of benefits of mitigations to reduce these losses.

Nitrogen:

Knowledge of attenuation of N from below the root zone to surface waters in different soils in the Waikato is required and this could be addressed in part in a new MSI programme. While research has identified the significance of urine-N leaching in winter, recent research indicates that summer and autumn losses may have been underestimated. Better knowledge of this is needed as this has implications for the use of mitigations and their timing.

Winter and summer forage cropping is increasing and more data is required to predict N leaching from these crops and the effectiveness of mitigation practices.

In view of the relatively high N fertiliser use, information on the reduction of N leaching from reduced strategic N use is warranted in conjunction with effects on production and economics.

Phosphorus, Nitrogen and Systems Research

N and P losses to waterways from farm dairy effluent (FDE) can be significant on poorly drained soils but there is limited data on this in the Waikato region and on the benefits of management and mitigation practices.

A number of mitigations have had moderate evaluation using lysimeter and small plot trials but limited testing in grazing systems. More whole system research is needed to evaluate optimisation of mitigations. This would increase adoption by farmers, particularly if it is associated with wider evaluation of economic implications and other environmental emissions (e.g. greenhouse gases).

2. Introduction

Nitrogen (N) and phosphorus (P) loss from agricultural land in the Waikato region has long been recognised as a potential threat to lake and river ecosystems. Studies for the Waikato Regional Council (WRC) have previously estimated that N and P losses from land have increased over time with intensification of land use and conversion of land from plantation forestry to pastoral agriculture. Therefore, reducing N and P losses from agriculture in future would be desirable. If this is to be achieved it is important to understand the processes that lead to nutrient losses and potential effects of management or mitigation practices. Similarly, it is important to be aware of areas where research knowledge is poor. This report is a summary of published and current research on N and P loss processes and mitigation opportunities by reputable institutions, such as universities and Crown Research Institutes (CRIs) applicable to the Waikato region. Included is:

- Research on loss of N to groundwater and surface waterways in the Waikato and Bay of Plenty (BOP) regions
- Research on loss of P to groundwater, streams, rivers and lakes in New Zealand
- Comment on research limitations and areas where more research is required

However, this literature survey is not exhaustive. It is possible that some published and ongoing research may not have been found despite best efforts.

3. Methods

This project included a search of both published literature and research currently in progress.

3.1 Published Research

Scientific literature databases searched were:

- Biosis
- CAB Abstracts
- Scopus

Searches were limited to research published from 1990 to the present day.

Searches were undertaken using a range of keywords in various combinations. Keywords included:

- Nitrogen
- Phosphorus
- Leaching
- Runoff
- Loss
- Process
- Pathway
- Zealand
- Waikato
- Taupo
- Pukekohe
- Coromandel
- Hauraki
- King Country
- Bay of Plenty

These searches included selected authors of known reputation in the area of nutrient loss to water-bodies. These were:

- David Hamilton
- Stewart Ledgard
- Richard McDowell
- Ross Monaghan
- Louis Schipper
- Mark Shepherd
- Christine Smith
- Roland Stenger

Searches of selected publications were undertaken where it was known they were unlikely to be available in on-line journal databases. The main one of these was:

- Proceedings of the Workshop of the Fertiliser and Lime Research Centre (Massey University)

In addition, published articles were included from bibliographies of reports written by AgResearch.

Relevant publications were grouped by topic and are listed with title, reference, study objective, location and findings in Appendix 9.1. Findings relevant to each topic have been summarised.

An end-note library of references, and where possible, abstracts have been compiled. However, it is not exhaustive. References not found using scientific literature databases are not in the library. These include references found in the Proceedings of the Workshop of the Fertiliser and Lime Research Centre (Massey University) and those found in bibliographies of reports written by AgResearch.

3.2 Ongoing Research

On-line searches were undertaken to identify background information of current research projects. Websites of the following funding agencies were searched:

- Foundation for Research Science and Technology (FRST)
- Ministry of Science and Innovation (MSI)
- MAF Sustainable Farming Fund (SFF)

Local research organisations known to be working in this research area were contacted for additional information, including:

- University of Waikato
- Lincoln Ventures

A brief summary of the objectives of ongoing research programmes and contact details are listed with contact details of the programme leader. This includes several studies being undertaken by PhD candidates at the University of Waikato.

4. Existing Research Knowledge Relevant to the Waikato Region

A substantial body of literature and research describes nitrogen (N) and phosphorus (P) sources and pathways from agricultural land to water-bodies and the effectiveness of mitigation strategies to reduce discharge of N and P to waterways. These are summarised in the following sections and in Appendix 9.1 under relevant sub-headings.

4.1 Sources and Pathways

Critical Source Areas

Identification of critical source areas (CSAs) is a useful strategy to define the main contributors to P losses and in particular for mitigation of P losses. This involves targeting high risk areas such as lanes, gateways, troughs, effluent ponds and barns, etc. Of the six references identified, only one reported work undertaken in the Waikato. Different approaches were discussed. Empirical approaches are useful for indentifying CSAs but research on more process based approaches may improve understanding and predictions in future.

N and P Processes

Ten papers were identified covering processes underpinning N loss to waterways. These processes included soil erosion, urine deposition and denitrification, They concluded that processes must be considered in relation to the whole farm system.

Animal treading can enhance gaseous N losses by denitrification. However, N cycling via animal excreta, particularly urine, is the major determinant of N losses. Urine deposition increases pasture yield for 2 – 3 harvests, increases plant N and K concentrations and induces a prolonged reduction of N fixation by clover.

Eight papers considered P loss processes. Erosion from landslides can represent a significant localised contributor to nutrient loss but losses of nutrients, particularly P associated with sediment movement in overland flow induced by animal treading are of more general importance. In coarse low anion storage capacity pumice soils, P leaching may be a significant P loss process.

4.2 Effluent Management

Effluent management focused on farm dairy effluent (FDE) management but there were also studies on municipal sewage and domestic waste application to soil. N and P were equally studied. Research focused on the impacts of effluent, sewage and or domestic waste on risk of N and P losses. Findings suggested that increasing application rates and long term loading above agronomic requirements increases N and P build up in the soil and the associated risk of N and P losses. Risk of loss increases in soils of sloping land and artificial/impeded drainage. Management of FDE (e.g. depth, rate and timing of application) is critical on these soils to minimise losses.

4.3 Retired Areas

Wetlands

Research on wetlands in the Waikato and BOP regions focused on: 1) quantifying the area required for a wetland to be effective at removing N and P; 2) P processes within wetlands; 3) evaluation of the use of P sorbents in wetlands; 4) evaluation of the effectiveness of constructed wetlands and watercress at removing N and P; 5) floating wetlands.

The conclusions were that wetlands can be very effective at removing N and P from water but must be constructed well and bypass flow minimised. Effective constructive wetlands were estimated to require 2 -5% of a catchment area. In the Taupo area natural wetlands occupying 5% of a catchment removed 11-19% of N in runoff. Diversion of water through a water-cress bed was estimated to remove 33% of N at low flows and 16% at high flows. The use of sorbents added to wetlands can aid P removal.

Riparian Management

Research on riparian management has been widespread throughout the New Zealand. The studies outlined the effectiveness of various riparian systems at removing N and P from overland flow. Up to 95% of nitrate-N entering the riparian zone can be removed although long term studies show that the effectiveness of some riparian systems can decrease over time. The effectiveness of P removal can be variable and riparian protection and ongoing management of riparian areas is recommended.

Fencing Waterways

The only study located in the Waikato focusing on fencing of waterways found that the provision of water troughs did not deter cattle from accessing waterways. Other studies undertaken in Otago and Southland focused on deer wallows as hot-spots for P loss and management recommendations to reduce impacts on stream water quality.

Filter Strips

Four studies were undertaken looking at pasture filter strips and addition of P sorbents in the Waikato and BOP regions with the main focus on P. Reduced flow weighted N & P loss was observed from riparian strips receiving channelized runoff from pasture. Alum / polyacrylamide application increased retention by up to 40% but effectiveness diminished on drying out.

4.4 Fertiliser Management

Fertiliser Use

There are a small range of relevant studies undertaken in the Waikato and BOP regions on N fertiliser use.

Two studies focused on cropping systems in the Pukekohe region. These studies investigated the effects of differing land uses (dairy, winter greens, winter potatoes), timing of cropping (winter v summer crops) and N fertiliser use on N losses. These studies and others with forage crops for grazing all showed high rates of N leaching associated with the effects of soil cultivation as well as loss arising from use of high N fertiliser rates.

The remainder of the studies focused on grazed pastoral systems. These studies covered N leaching potential in new and existing farm systems, winter application on N in hill country, impacts of the rate of N application in dairy farmlets on N leaching and groundwater contamination, and a review on the state of knowledge relating to fertiliser advice to identify areas to improve N fertiliser recommendations for pasture.

Research generally showed increased risk of direct leaching of fertiliser-N applied in winter and overall, an exponential increase in N leaching associated with increasing animal N inputs.

Fertiliser Form

No studies were found in the Waikato or BOP regions relating to impacts of fertiliser form on N loss and only one on impacts of fertiliser form on P loss. However, several South Island studies were found relating to P loss. All of these studies concluded that soluble P fertilisers (e.g. Superphosphate) pose a greater risk of P loss than slowly available P fertilisers (e.g. RPR). However with good management and appropriate mitigation strategies the differences in P loss can be minimised. Mitigation strategies included avoiding application when overland flow is likely.

Optimal Soil Test P

Only one study was found specifically relating to the Waikato. This was a survey on soil quality including Olsen P status and highlighted high soil P levels under cropping and dairying. Other studies in the South Island and the Hawkes Bay region focused mainly on the impacts of soil P status on P loss. These studies covered a range of soils and showed that P loss was lower from high retentive volcanic soils and that as Olsen P soil test increases then the risk of soil P loss increases also. They illustrated the benefit of not exceeding the optimum soil P status for plant growth to reduce P losses.

4.5 Inhibitors

Several studies have been undertaken on the effectiveness of Inhibitors on reducing N losses.

The urease inhibitor Agrotain can reduce ammonia losses from urea fertiliser or urine by over 60%.

Research on nitrification inhibitors covered a range of areas including effectiveness of DCD in reducing leaching losses, the effectiveness of liquid versus granular forms, timing of applications to obtain the best benefit (i.e. critical period), direct application to ruminants, impacts of soil type and rainfall and use on annual forage crops. Findings indicated that two applications are optimal with an autumn and winter application, and that a reduction in N loss of up to 60% can be achieved. One study of a dairy grazing system near Rotorua on pumice soils showed an average reduction in N leaching of 20%.

4.6 Animal Related Issues

Pugging

There have been several studies conducted in the Waikato looking at pugging and these showed increased N loss by denitrification. However, only one study in the Waikato and several in the lower South Island examined the impacts of pugging on P loss. These indicated that N and P losses increase with increased pugging and that sediment bound P is a major source of P loss. Mitigation strategies to reduce N and P loss due to pugging are to restrict or avoid grazing when pastures are liable to pugging damage.

Stock Management

Fifteen studies located in the Waikato region focused on N and five addressed P. N leaching losses were lower from sheep and deer grazing, than from cattle grazing under similar intake systems.

Grazing can also reduce infiltration rate in soil and increase runoff and nutrient loads to waterways post-grazing. Over-grazing damages soil. Nutrient loss generally increases with increased stocking rate, particularly when grazing forage crops.

Use of wintering pads/stand-off pads can reduce nitrate leaching by up to 50%. Urinations on paddock are reduced as excreta N from the pad is captured and applied more evenly to pasture (preferably at a time of low risk of loss).

Stocking rate should be considered with other factors such as strategic destocking when assessing environmental impacts. Increased stocking rates and N inputs are generally associated with reduced N efficiency and increased N losses.

Restricted Grazing or Controlled duration grazing

Two studies relating to restricted grazing in the Waikato and BOP regions showed reduced N leaching by 30-50%. Several other studies occurred in the Manawatu and the lower South Island. The general conclusion was that using restricted grazing practices during winter (and in autumn in mole drained soils) can decrease N and P losses by up to 50%, but that pasture growth may decline, possibly due to less excreta deposition.

4.7 Land Management

Irrigation

Only one study was found addressing N loss in relation to irrigation using Taupo soil. It concluded that leaching is more related to pasture use efficiency than to annual drainage. Three other South Island studies focused on P loss. Losses as dissolved reactive phosphorus (DRP) were small compared to Total P and the major loss pathway is particulate P, much of which is in organic form. Irrigation increased utilisation of P but increased P movement to depth in the soil profile. To reduce P losses, irrigation scheduling should be managed to reduce overland flow.

N and P Sorbents

Several studies were found focusing on the use of P sorbents to reduce P loss to waterways. Three studies were conducted in each of the Waikato and BOP regions. The studies covered a wide range of methods of use and types of P sorbent use including P socks, backfilling mole and tile drains, and incorporation in water bodies. The range of P sorbents studied included alum, tephra and various industrial by-products, e.g. slag. Some industrial by-products were found to be toxic to plants. The general consensus was that P sorbents can be very successful at removing P from overland flow and streams but that good management is critical.

One study investigated the use of wood chip filter as an N sorbent and concluded that to be effective a filter 1.2% – 2.4% of the catchment area would be required.

Pasture Species

One study investigated the effect of pasture species on N uptake and leaching. Grasses with larger roots systems are associated with increased interception and reduced N losses. Research and development of new cultivars is ongoing.

Races and Lanes

Studies in the South Island associated races, laneways and crossings with increased loss of P to waterways.

Retention Dams and Drains

Best management practice specifications are available for small retention dams to retain P. Drains may act as either a sink or a source of N & P depending on conditions and/or management. One study showed that up to 55% of DRP may be removed over a distance of 150 metres.

4.8 Cropping and Feeds

Cropping (Forage crop management and Arable / horticulture)

Five relevant references were found relating to cropping in the region.

Three references focused on the impacts of crop rotation on N loss and two on impacts of DCD. The use of cover crops was also studied. Potatoes, Maize and forage crops were studied.

Findings centred on the importance of the use of cover crops within the rotation and their role in N uptake. Deep rooting crops such as Maize show potential to reduce N losses. DCD studies showed promise in reducing N losses from fodder crops. Other findings showed that annual cropping had a higher N loss risk than perennial crops.

N leaching losses from dairying was typically lower than Winter Green crops which were in turn less than winter potatoes. Timing of cultivation can have significant impacts on N leaching with high risk from autumn and winter cultivations.

No studies on P loss were found.

Supplementary Feed

Three studies in the Waikato region addressed the effect of dietary management and supplementary feed on N loss efficiency and N losses. Within the farm boundary maize supplementation has been observed to improve N loss efficiency but this may be reversed when the N loss from the maize production area is included in the farm system.

5. Research at Whatawhata

During the 1990's and 2000's there was extensive catchment research carried out at Whatawhata Research Station (175°05'E, 37°49'S) on hill country about 18 km west of Hamilton (initially led by Dr Bruce Thorrold now at DairyNZ and subsequently by Dr Mike Dodd AgResearch). This research was initially undertaken in partnership with NIWA (Dr John Quinn) and utilised artificial rainfall. These experimental studies included a range of detailed small plot studies and farm catchment scale studies. The small plot studies included the use of artificial rainfall intensity treatments and initially focused on erosion (sediment) losses but were extended to include the effect of soil P status (Olsen P) and fertiliser form (high soluble v less soluble P and S fertilisers) on N and P losses. Much of this research was never published but used to underpin ongoing studies. Additionally, artificial rainfall was used in studies to assess sediment losses from pugged soils. Some N and P measurements were also made but ceased early into the research. Much of this work was also never published.

NIWA staff were also involved in some catchment scale studies. Water samples from differing catchments (native bush, pasture, pine forest, and combinations of the three) were taken regularly over several years, both manually and with automatic samplers. These studies focused on the impacts of the different catchments on stream water quality. We understand that some sediment, faecal microbes, and some nutrient analyses were also made but only some have been published by Dr Mike Dodd.

A series of three papers were written (see Appendix 9.3) on work conducted at Whatawhata Research centre. These were titled:

Improving the economic and environmental performance of a New Zealand hill country farm catchment:

1. Goal development and assessment of current performance
2. Forecasting and planning land-use change and
3. Short-term outcomes of land-use change

The first paper details the process of characterising the current state of the case study catchment (i.e. collecting data on key indicators chosen by the catchment management group to assess business viability and ecosystem health).

The second paper of a the multi-stakeholder, integrated catchment management project at the Whatawhata Research Centre explored land use and management change options to improve the economic and environmental performance of the case study hill land catchment farm.

The third paper looked at implementing land use management changes to improve economic and environmental performance of the Mangaotama case study catchment farm. Marked improvements were observed in the key environmental and economic performance indicators with optimal land use change.

Additionally a report was written for MAF reviewing the results, outputs and outcomes of recent rural catchment based research in New Zealand. Eighteen catchments were reviewed including Whatawhata.

Full references for the above articles are listed in the Appendix 9.3.

6. Ongoing Research of Relevance in the Waikato Region

Work underway in the Waikato region focusing on reducing N and P loss to water-bodies is being led by CRIs, universities and other groups focused on specific sectors.

Table 1 summarises lead organisations co-ordinating existing research programmes and studies in the Waikato region.

Table 1: Lead organisations undertaking research investigating loss of N and P to water-bodies in the Waikato region.

Crown Research Institutes	**Universities**	**Other Organisations**
AgResearch	Lincoln University	DairyNZ
Plant and Food	Waikato University	Foundation for Arable Res.
Environmental Science and Research (ESR)		Horticulture NZ
Landcare Research		Lincoln Ventures
NIWA		Potato Production Group
		Standoff Facility User Group
		Taupo Lake Care

The scope and focus of research programmes is diverse. A summary of ongoing research listing for each programme, the title, lead organisation and objectives is included in Appendix 9.2. There are programmes focusing on improving measurement of N leaching and others more focused on addressing the environmental impacts. Mitigation methods are under development mindful of the need to achieve acceptable soil and water quality standards. Some studies are focused on single catchments, e.g. Taupo, Rerewhakaaitu, Rotorua. The scope of research programmes varies. Some of the smaller studies are focusing on topics such as:

- Grazing management
- Effectiveness of winter cover crops
- End of drain treatment methods
- Nitrification inhibitors
- Tactical application of nutrients

MSI programmes are underway to improve the understanding of P loss processes in space and time so mitigations methods can be developed in a framework that will ensure delivery to farmers to encourage and monitor adoption in the context of environmental, economic, social and cultural drivers. Several SFF studies are measuring the physical and financial performance of farming systems relative to environmental impacts.

Information is being summarised and used to develop industry lead guidelines and codes of practice. The Farm Dairy Effluent (FDE) Code of Practice was released earlier this year. Design guidelines for stand-off facilities are to be developed soon.

7. Gaps in Knowledge and Research

Overall the amount of research completed or in progress found was relatively widespread. However, there were several gaps in specific areas of research found that could need addressing. In general areas of fertiliser use, stocking strategy, stock management and supplementary feeds had moderate amounts of research on N loss but little on P losses. There was a distinct lack of work on N and P in the Waikato region for CSAs, erosion, fencing of waterways, fertiliser form, filter strips, irrigation, P loss processes, optimal soil P, N and P sorbents, pasture species, races and lanes and P retention dams. Cropping, effluent management, N inhibitors, N loss processes, urine deposition and riparian management had a moderate amount of research but this was limited in some specific areas. However, there was a significant amount or research in the South Island on several areas of interest. Table 2 provides a summary of research gaps in the Waikato region.

Although there are a number of gaps in the research identified, there has been a moderate level of applied research undertaken in the Waikato region. Some of the ongoing research is focusing on areas which may help to reduce these gaps.

Table 2: Extent of research that has been carried out in the Waikato region.

Area of interest	N research	P research	Comments
Sources and Pathways			
Critical source areas	None	Poor	None on N. Only one on P in the Waikato region but several in the South Island.
N Loss processes	Moderate	n/a	Moderate coverage
P Loss processes	n/a	Poor	Only one reference in the Waikato region.
Erosion	None	None	Two in South Island only
Urine deposition	Good	None	Four references in the region on N but none relating to P
Effluent Management			
FDE management	Moderate	Poor	No research on poorly drained, peat soils and those with hump and hollow drainage systems
Municipal and dairy factory effluent management	Good	Moderate	Moderate coverage in the Waikato region
Retired Areas			
Wetlands	Moderate-High	Good	Good coverage of the region for N but lesser coverage for P

Table 2 (cont.): Extent of research that has been carried out in the Waikato region.

Area of interest	N research	P research	Comments
Retired Areas (continued)			
Riparian management	Good	Poor	Good coverage of the region for N but poor coverage for P
Fencing waterways	None	Poor	Main focus was on deer in the South Island, with only one reference in the Waikato region
Filter strips	Poor	Moderate	Four relevant references found
Fertiliser Management			
Fertiliser use	Moderate	Poor	Moderate research on N losses but little on effects of reducing N use. Only one reference on P found
Fertiliser form	None	Poor	None focusing on N. Several studies on P in South Island but only one on P in the Waikato region.
Optimal soil test P	n/a	Poor	Some South Island references
Inhibitors			
Inhibitors	Moderate	n/a	Moderate number of plot trials conducted on nitrification inhibitors but little on grazed systems.
Stock Management			
Pugging	Poor	Poor	Several on P in South Island
Stock management	Moderate	Poor	Good research on N in region but a poor coverage focusing on P
Restricted grazing	Poor	None	Mainly Manawatu
Land Management			
Irrigation	Poor	None	Only one N reference in Taupo. Three in South Island
N and P sorbents	Poor	Poor	Several in South Island
Pasture species	Poor	None	Only two references found
Races and lanes	None	None	South Island on P only
Retention dams	None	Poor	P only. None specified as in the Waikato region.
Cropping and Feeds			
Cropping	Good	none	Moderate coverage of N although limited for forage crops. The only references relating to P were outside the Waikato region.
Supplementary feeds	Good	None	Four references only

8. General recommendations for future research

8.1 Phosphorus

Research is required on defining CSAs on farms and catchments; this is ongoing in a new large MSI programme. Better knowledge of sediment and P losses in Waikato hill country is desirable as is a better understanding of benefits of mitigations to reduce these losses.

8.2 Nitrogen

Knowledge of attenuation of N from below the root zone to surface waters in different soils in the Waikato is required and this could be addressed in part in a new MSI programme. While research has identified the significance of urine-N leaching in winter, recent research indicates that summer and autumn losses may have been underestimated. Better knowledge of this is needed as this has implications for the use of mitigations and their timing.

Winter and summer forage cropping is increasing and more data is required to predict N leaching from these crops and the effectiveness of mitigation practices.

In view of the relatively high N fertiliser use, information on the reduction of N leaching from reduced strategic N use is warranted in conjunction with effects on production and economics.

8.3 Phosphorus, nitrogen and systems research

N and P losses to waterways from FDE can be significant on poorly drained soils but there is limited data on this in the Waikato region and on the benefits of management and mitigation practices.

A number of mitigations have had moderate evaluation using lysimeter and small plot trials but limited testing in grazing systems. More whole system research is needed to evaluate optimisation of mitigations. This would increase adoption by farmers, particularly if it is associated with wider evaluation of economic implications and other environmental emissions (e.g. greenhouse gases).

9. Appendices

9.1 Published Research

Sources and Processes

Topic No.	Topics
1	Critical source areas
2	N loss processes
3	P loss processes
4	Erosion
5	Urine deposition

Mitigation and Management

Topic No.	Topics
6	Effluent management
	Retired areas
7	Wetlands
8	Riparian management
9	Fencing waterways
10	Filter strips
	Fertiliser Management
11	Fertiliser use
12	Fertiliser form
13	Optimal soil test P
14	Inhibitors
	Animal Related Issues
15	Pugging
16	Stock management
17	Restricted grazing
	Land management
18	Irrigation
19	N & P sorbents
20	Pasture species
21	Races and Lanes
22	Retention dams
	Cropping and Feeds
23	Forage crop / Arable
24	Suppl feed

WRC literature survey - N & P loss from land to water

Published Papers - Critical source areas

Id	Title	Author (Year)	Reference	Objective / Study aim	Findings	Location	N/P	Topic
D080	Sources of sediment and phosphorus in stream flow of a highly productive dairy farmed catchment.	McDowell, R. W. and R. J. Wilcock (2007).	Journal of Environmental Quality 36(2): 540-548.	Quantify P loss to a stream in a dairy catchment	Modelled P losses to establish P sources: topsoil by overland flow - maybe lanes. Riparian protection and management of soil P recommended	SI	P	Critical source areas Riparian management Races Optimal soil test P
D082	Identifying and linking source areas of flow and P transport in dairy-grazed headwater catchments, North Island, New Zealand.	Muller, K., M. S. Srinivasan, et al. (2010).	Hydrological Processes 24(25): 3689-3705.	Study of P sources and flows in a dairy grazed Waikato catchment	P transport not limited to runoff. Effluent ponds significant source. Shallow groundwater flows are important	Waikato	P	Critical source areas Effluent management
E03	Integrated assessment of phosphorus in the Lake Hayes catchment, South Island, New Zealand.	Caruso, B. S. (2000).	Journal of Hydrology 229(3-4): 168-189.	Illustrates an integrated water-shed approach for assessment of P in a catchment	Considerable uncertainty in results. Identified potential P sources. Useful for pollution assessment	SI	P	Critical source areas
E15	Approaches for quantifying and managing diffuse phosphorus exports at the farm/small catchment scale.	McDowell, R. W., D. Nash, et al. (2009).	Journal of Environmental Quality 38(5): 1968-1980.	Investigate two approaches for quantifying and managing P losses either at the small catchment scale or farm scale.	Deterministic cost benefit analysis was compared with a knowledge integraton process using Baysien networks. Both models were selective in what was included. Both produced working models.	New Zealand and Australia	P	Critical source areas
E22	Hydrological approaches to the delineation of critical-source areas of runoff. (Special issue: New Zealand agricultural research in the twenty-first century. Celebrating 50 years of publication.).	Srinivasan, M. S. and R. W. McDowell (2007).	New Zealand Journal of Agricultural Research 50(2): 249-265.	Study of methods to identify areas and sources of P critical to runoff (critical source areas)	Advantages and limitations of approaches discusses. Emprically based approaches are easier to use. Reduced losses are economically achievable.	Otago	P	Critical source areas
E23	Identifying critical source areas for water quality: 1. Mapping and validating transport areas in three headwater catchments in Otago, New Zealand.	Srinivasan, M. S. and R. W. McDowell (2009).	Journal of Hydrology 379(1-2): 54-67.	Validation / assessment of methods for identification of CSAs.	Process based approaches are more applicable - more promising for future development. Other approaches dependent on input data which is more difficult to obtain.	Otago	P	Critical source areas

Id	Title	Author (Year)	Reference	Objective / Study aim	Findings	Location	N/P	Topic
G50	Identifying critical source areas for water quality: 2. Validating the approach for phosphorus and sediment losses in grazed headwater catchments.	McDowell RW, Srinivasan MS (2009)	Journal of Hydrology 379:68-80	Identifcation of critical source areas	A simpler approach to P mitigation would be to target high risk areas such as lanes, gateways, troughs and barns	Otago	P	Critical source areas

Id	Title	Author (Year)	Reference	Objective / Study aim	Findings	Location	N/P	Topic
A03	Denitrification capacity in the vadose zone at three sites in the Lake Taupo catchment, New Zealand.	Barkle, G., T. Clough, et al. (2007).	Australian Journal of Soil Research 45(2): 91-99.	Study nutrient transformations in the zone between soil and growndwater	There is evidence of denitrification in the lower vadose zone. Variable.	Taupo	N	N loss processes
A31	Predicting groundwater nitrate concentrations in a region of mixed agricultural land use: a comparison of three approaches.	McLay, C. D. A., R. Dragten, et al. (2001).	Environmental Pollution 115(2): 191-204.	To detemine if shallow nitrate groundwater concentrations can be predicted using landuse information and topsoil properties	Three approaches investigated. All judged unsuitable. On a wider scale nitrate contaminaton in the region reflects intensive agricultural practices. Site specific factors may affect shallow groundwaters	Waikato	N	N loss processes Modelling
A44	Low nitrate contamination of shallow groundwater in spite of intensive dairying: the effect of reducing conditions in the vadose zone-aquifer continuum.	Stenger, R., G. Barkle, et al. (2008).	Journal of Hydrology, New Zealand 47(1): 1-24.	Investigate whether or not substantial nitrate reduction occurs below the root zone.	Nitrate reduction caused by soil heterotrophs and autotrophs is widespread. This is not accounted for by models estimating losses to groundwaters.	Toenepi, Waikato	N	N loss processes
B01	Fate of the 15N-labelled faeces fraction of dairy farm effluent (DFE) irrigated onto soils under different water regimes.	Barkle, G. F., R. Stenger, et al. (2001).	Nutrient Cycling in Agroecosystems 59(1): 85-93.	Study of movement of N in the faecal fraction of FDE after irrigation onto soil under wet and dry regimes	Approximately: 10% remains near surface, 10% uptake by plants, 38% in soil organic fraction, <2% inorganic / microbial fraction	Waikato	N	N loss processes
B05	Fate of 15N labelled urine on four soil types.	Clough, T. J., S. F. Ledgard, et al. (1998).	Plant and Soil 199(2): 195-203.	Determine the effect of soil type on fate of urinary N	Soil type affected the timing and form of inorganic N leaching. Macropore flow contributed to leaching of urea in some soils.	Waikato	N	N loss processes
B11	Nitrogen concentration in the urine of cattle, sheep and deer grazing a common ryegrass/cocksfoot/white clover pasture.	Hoogendoorn, C. J., K. Betteridge, et al. (2010).	New Zealand Journal of Agricultural Research 53(3): 235-243.	Determine urine N conc. in female sheep, beef and deer over time.	Urine N concentration change rapidly within a few days (3). Differerences between species significant but inconsistent.	Taupo	N	N loss processes

Id	Title	Author (Year)	Reference	Objective / Study aim	Findings	Location	N/P	Topic
B23	Influence of time of application on the utilization of nitrogen fertilizer by asparagus, estimated using 15N.	Ledgard, S. F., J. A. Douglas, et al. (1992).	Plant and Soil 147(1): 41-47.	Determine the effect of N fertiliser on asparagus production	12% response to fertiliser only in the first of three years. No significant effect observed due to rate or timing.	Waikato	N	N loss processes Fertiliser use
B57	Animal treading stimulates denitrification in soil under pasture.	Menneer, J. C., S. Ledgard, et al. (2005).	Soil Biology and Biochemistry 37(9): 1625-1629.	Study of the effects of treading wet soil on denitrification	Treading reduces soil aeration, reduces plant growth. This with the resultant increase in NH4+ and NO3- stimulates denitrification	Waikato	N	Stock management Pugging N loss processes
I41	Denitrification rates on amended dairy pasture plots: Can in situ denitrification be manipulated to control N loss? .	Bryan Stevenson, L Schipper, A McGill, J Ryburn and D Clark, (2009).	In: Nutrient management in a rapidly changing world. (Eds L.D. Currie and C.L. Lindsay). Occasional Report No. 22. Fertilizer and Lime Research Centre, Massey University, Palmerston North, New Zealand.	Investigate ammendment of soil as a means to control denitrification and reduce N leaching	Some changes observed but not on an annual basis. Propose to focus on controlling denitrification during periods of peak denitrification activity	Waikato	N	N loss processes
J01	Denitrification and Availability of Carbon and Nitrogen in a Well-drained Pasture Soil Amended with Particulate Organic Carbon.	Stevenson, B. A., L. A. Schipper et al, (2011).	Journal of Environmental Quality 40(3): 923-930	Investigate use of particulate organic carbon to increase denitrification	Manipulation of denitrification rate may be possible. Difficult to measure effectiveness owing to temporal nature of process dependent on nitrate and moisture content.	Waikato	N	N loss processes
J10	Nitrogen leaching from sheep, cattle and deer-grazed pastures in the Lake Taupo catchment in New Zealand.	Hoogendoorn C J, Betteridge K, Ledgard S F, Costall D A, Park Z A and Theobald P W (2011).	Animal Production Science 51: 416-425.	Quantify leaching losses of sheep, beef and deer grazing under similar systems	N leaching losses were lower from sheep and deer grazing, than from cattle grazing under similar intake systems.	Taupo	N	N loss processes

Id	Title	Author (Year)	Reference	Objective / Study aim	Findings	Location	N/P	Topic
A17	Effects of sheep grazing episodes on sediment and nutrient loss in overland flow.	Elliott, A. H. and W. T. Carlson (2004).	Australian Journal of Soil Research 42(2): 213-220.	Investigate the effect of sheep grazing on nutrient runoff on hill-country	Particulate nutrients correlated to % bare ground. Grazing reduces infiltration rate, increases runoff and increases loads post-grazing	Whatawhata	P	P loss processes Stock management
A54	Phosphorus leaching from pastures can be an environmental risk and even a significant fertiliser expense.	Redding, M. R., A. Ghani, et al. (2006).	Proceedings of the New Zealand Grassland Association 68: 293-296.	Does significant P leaching occur under normal pastoral farming systems?	Yes. Some Rotorua soils of low ASC have enriched P conc. to a depth of 1.5 m indicative of P leaching. Alternative management strategies need to be developed.	Rotorua	P	P loss processes
D022	Contaminant losses in overland flow from cattle, deer and sheep dung.	McDowell, R. W. (2006).	Water Air & Soil Pollution 174(1-4): 211-222.	Determine risk of losses arising from overland flow for up to 30 days following depostion of dung.	Risks: DRP > TP > NH4-N with NO3-N & SS losses negligble. Most risk accounted for in first few days.	Invermay, SI	P	P loss processes
E11	Phosphorus in humped and hollowed soils of the Inchbonnie catchment, West Coast, New Zealand: II. Accounting for losses by different pathways.	McDowell, R. W. (2008).	New Zealand Journal of Agricultural Research 51(3): 307-316.	Study of P loss processes from dairy pasture to Lake Brunner a region of high rainfall.	Amount and form of P loss measured.Significant processes identified. Mitigation management practices discussed.	SI	P	P loss processes Optimal soil test P Fertiliser form
E16	Particulate phosphorus transport within stream flow of an agricultural catchment.	McDowell, R. W. and R. J. Wilcock (2004).	Journal of Environmental Quality 33(6): 2111-2121.	Identification of key P loss pathways from intensively grazed Southland dairy pasture	Stream conc of TP and DRP high in summer / autumn. Loads highest in winter. Source: topsoil. Route: tile drains > overland flow. Mitigation: reduce Olsen P.	Southland, SI	P	P loss processes
E20	Phosphorus exchangeability and leaching losses from two grassland soils.	Sinaj, S., C. Stamm, et al. (2002).	Journal of Environmental Quality 31(1): 319-330.	Study of P loss processes in soils under flood irrigation and impact of preferential flow	High fixing capacity of sub-soil was able to fix P. There are risks in assessing P loss on the basis of P mobility in the topsoil alone.	Canterbury, SI	P	P loss processes

Id	Title	Author (Year)	Reference	Objective / Study aim	Findings	Location	N/P	Topic
G37	Connecting phosphorus loss from land to surface water quality.	McDowell RW, Biggs BJF, Sharpley AN, Nguyen L (2004)	Chemistry and Ecology (London). 20:1-40	Review of mechanisms of P transfer from landscape to surface waters	Potential P loss mitigations discussed	Not available - Best guess SI.	P	P loss processes
G48	Sources of phosphorus lost from a grazed pasture soil receiving simulated rainfall.	McDowell RW, Nash DM, Robertson F (2007)	Journal of Environmental Quality 36:1281-1288.	A study of sources of P lost from grazed pasture	DRP accounted for majority of P lost. Sources: treading / dung > treading > pasture plants / soil > pasture plants	Southland, SI	P	P loss processes

Id	Title	Author (Year)	Reference	Objective / Study aim	Findings	Location	N/P	Topic
D015	Phosphorus export from an agricultural watershed: Linking source and transport mechanisms.	McDowell, R., A. Sharpley, et al. (2001).	Journal of Environmental Quality 30(5): 1587-1595.	Identify factors affecting streamflow DRP & TP in an agricultural catchment	Factors: Erosion, soil P conc. And channel sediment P sorption	SI	P	Erosion Optimal soil test P
E04	Effects of landslides on contaminant sources and transport in steep pastoral hill country.	Caruso, B. S. and E. Jensen (2001).	Journal of Hydrology New Zealand 39(2): 127-154.	Investigation of movement of contaminants mediated by landslide	Landslide affects nutrient movement directly.	Lake Tutira, Hawkes Bay	N&P	Erosion

Id	Title	Author (Year)	Reference	Objective / Study aim	Findings	Location	N/P	Topic
A41	A stochastic model of urinary nitrogen and water flow in grassland soil in New Zealand.	Shorten, P. R. and A. B. Pleasants (2007).	Agriculture, Ecosystems & Environment 120(2/4): 145-152.	Model the variability of urine patch N leaching in Taupo	N leaching in winter greater than in summer. Model predicted that 38, 61, 71% of N in single, double and triple urine patches leached during winter.	Taupo	N	Urine deposition Modelling
B41	Effects of cow urine and its major constituents on pasture properties (ryegrass).	Ledgard, S. F., K. W. Steele, et al. (1982).	New Zealand Journal of Agricultural Research 25(1): 61-68.	Effects of cow urine on pasture	Yield increased for 2 - 3 harvests. Plant N and K increased. Clover growth and N fixation reduced.	Waikato	N	Urine deposition
B54	The effect of a single application of cow urine on annual N2 fixation under varying simulated grazing intensity, as measured by four 15N isotope techniques.	Menneer, J. C., S. Ledgard, et al. (2003).	Plant and Soil 254(2): 469-480.	Study effects of dairy cow urine on nitrogen fixation in legume/ryegrass pastures	Urine has a prolonged effect reducing N fixation. Defoliation intensity may be a potential tool for enhancing N fixation.	Waikato	N	Urine deposition
B64	Application of carbon additives to reduce nitrogen leaching from cattle urine patches on pasture.	Shepherd, M., J. Menneer, et al. (2010).	New Zealand Journal of Agricultural Research 53(3): 263-280.	Evaluation of use of sawdust / sucrose to decrease leaching of N from newly deposited urine patches	Sawdust ineffective. Risk of yield loss and large C applications may limit practical application.	Waikato	N	Urine deposition

Id	Title	Author (Year)	Reference	Objective / Study aim	Findings	Location	N/P	Topic
A07	Wastewater denitrification using carbonaceous beds.	Brice, R., S. Cameron, et al. (2008).	Water 35(7): 96-101.	Evaluation of inexpensive technology for wastewater denitrication discussed	Performance judged successful	Taupo, Northland, Auckland	N	Effluent management
A42	Changes in soil properties after application of dairy factory effluent to New Zealand volcanic ash and pumice soils.	Sparling, G. P., L. A. Schipper, et al. (2001).	Australian Journal of Soil Research 39(3): 505-518.	Investigate changes in soil properties following application of dairy factory effluent to Waikato soils	High N application rate. Soil quality indicators improved. N cycling increased - N leaching a concern	Waikato	N	Effluent management
A52	Nitrate leaching from a free-draining volcanic soil irrigated with municipal sewage effluent in New Zealand.	Magesan, G. N., C. D. A. McLay, et al. (1998).	Agriculture Ecosystems & Environment 70(2-3): 181-187.	Measure N leaching from municipal sewage irrigated soil near Rotorua	Approx 50% of nitrate readily leached beyond topsoil. Nitrate conc. depend on application rate. Large N loads in irrigated catchment waterbodies observed in winter. Viability questioned.	Rotorua	N	Effluent management
D002	Land application of domestic effluent onto four soil types: Plant uptake and nutrient leaching.	Barton, L., L. A. Schipper, et al. (2005).	Journal of Environmental Quality 34(2): 635-643.	Study of leaching losses from four soils treated with domestic wastewaters	Applying effluent increased plant uptake of N and P. N & P leached predominently organic. Greater N & P leaching from gley soils due to preferential flow.	Four sites - not specified	N&P	Effluent management
D008	Irrigation of an allophanic soil with dairy factory effluent for 22 years: Responses of nutrient storage and soil biota.	Degens, B. P., L. A. Schipper, et al. (2000).	Australian Journal of Soil Research 38(1): 25-35.	Effects of long term application (22 yrs) of dairy factory effluent on allophanic soil	Increased Total N at depths 0.1 - 0.5 m. 8% of N applied in soil (0 - 0.75 m). Increased Total P and Olsen P at all depths. Potential for further P storage.	Rotorua Whakatane	N&P	Effluent management
D082	Identifying and linking source areas of flow and P transport in dairy-grazed headwater catchments, North Island, New Zealand.	Muller, K., M. S. Srinivasan, et al. (2010).	Hydrological Processes 24(25): 3689-3705.	Study of P sources and flows in a dairy grazed Waikato catchment	P transport not limited to runoff. Effluent ponds significant source. Shallow groundwater flows are important	Waikato	P	Critical source areas Effluent management

Id	Title	Author (Year)	Reference	Objective / Study aim	Findings	Location	N/P	Topic
D100	Nutrient leaching and changes in soil characteristics of four contrasting soils irrigated with secondary-treated municipal wastewater for four years.	Sparling, G. P., L. Barton, et al. (2006).	Australian Journal of Soil Research 44(2): 107-116.	Investigate changes in chemical, biochemical and physical characteristics of soils arising from long-term wastewater treatment	Allophanic and pumice soils preferred for effective treatment. Na is an issue. > 50% of N in organic form.	Waikato	N&P	Effluent management
G24	Land application for farm dairy effluent: development of a decision framework for matching management practice to soil and landscape risk.	Houlbrooke DJ, Monaghan RM (2010)	In Farming's future: minimising footprints and maximising margins (Ed L.D. Currie). Occasional report No. 23. Fertilizer and Lime Research Centre, Massey University, Palmerston North, New Zealand.	Description of a management tool to match management practices to soil and landscape risk factors	Risk is dependent on features such as sloping land, artificial drainage, poor infilration, impeded drainage. Addressed by tool to tailor specific BMP to manage risk to waterbodies	Not specified	P	Effluent management
I09	Farm dairy effluent: findings of recent research studies in the Waikato.	Longhurst, R D, O'Connor, M B, Roberts, A H C and Waller, J E, (1999).	In: Best soil management practices for production. (Eds L D Currie, M J Hedley, D J Horne and P Loganathan). Occasional report No. 12. Fertilizer and Lime Research Centre, Massey University, Palmerston North, New Zealand.	Report on studies in Waikato to obtain information from which BMP could be developed	With increasing herd size FDE N conc has increased. There is a large variation in N conc. N loss due to FDE lower than inorganic N fertilisers in a trial at a nearby site.	Waikato	N&P	Effluent management
I18	Does water and/or effluent irrigation increase nitrogen leaching from pumice soils under dairying?.	C P Burgess, G Barkle, P L Singleton, R Hill, R Stenger and T Fenton, (2002).	In: Dairy farm soil management. (Eds L D Currie and P Loganathan). Occasional report No. 15. Fertilizer and Lime Research Centre, Massey University, Palmerston North, New Zealand.	Quantify the effects of irrigation and FDE application on N & P losses from pumice soils	Leaching is more related to pasture N use efficiency than the annual volume of drainage. Nitrate loss: Eff > IrrEff > Irr = NonIrr	Taupo	N	Irrigation Effluent management
J02	Farm Dairy Effluent (FDE) Design Standards.	J. Powers, Borrie, N., (2011).	At: http://www.dairynz.co.nz/file/fileid/35547	Describe design standards for farm dairy effluent systems operating in New Zealand	-	New Zealand wide	N	Effluent management
J12	Matching farm dairy effluent storage requirements and management practices to soil and landscape features.	Houlbrooke, D.J.; Monaghan, R.M.; McLeod, M. (2010).	Report for Environment Waikato	Describe soil drainage mechanisms and provide a framework for development of minimum storage requirements and application practices in the Waikato	BMPs vary depending on soil type and topography. A framework is recommended for use in design of FDE systems to reduce risk of direct contamination of groundwaters. Research of peat soils & hump and hollow drainage systems is lacking	Waikato	N	Effluent management
J13	Nitrogen leaching from soil lysimeters irrigated with dairy shed effluent and having managed drainage.	Singleton, P.L.; McLay, C.D.A.; Barkle, G.F. (2001).	Australian Journal of Soil Research 39: 385-396	Quantify amounts and forms of N leached on FDE irrigation of a gley soil over a period of two years	Application of FDE affects amount and forms of N leached. Amount leached is approximately proportional. Organic N comprises a large proportion of N leached.	Waikato	N	Effluent management

Id	Title	Author (Year)	Reference	Objective / Study aim	Findings	Location	N/P	Topic
A40	How much runoff do riparian wetlands affect?	Rutherford, J. C., D. Schroer, et al. (2009).	New Zealand Journal of Marine and Freshwater Research 43(5): 1079-1094.	Used measurements from 6 wetlands to model performance over entire Taupo catchment	Riparian / valley wetlands are only 5% of the catchment but may attentuate N in 11-19% of runoff	Taupo	N	Wetlands Riparian management
E05	Treatment wetlands for removing phosphorus from agricultural drainage waters. Nutrient management in agricultural watersheds: a wetlands solution.	DeBusk, T. A., K. A. Grace, et al. (2005).	E. J. Dunne, K. R. Reddy and O. T. Carton (Eds.). Wageningen, Wageningen Academic Publishers: 167-178.	Discussion of P processes in wetlands. Pilot studies in several countries to evaluate techniques discussed	P cycling in wetlands is complex. Full scale use in practice yet to be proven.	International study - including NZ	P	Wetlands
G03	Substrate and filter materials to enhance phosphorus removal in constructed wetlands treating diffuse farm runoff: a review.	Ballantine DJ, Tanner CC (2010)	New Zealand Journal of Agricultural Research 53:71-95.	A review to evaluate the effectiveness of a range of P sorbing materials for use in wetlands	Recommend: Porous materials or materials enriched with Al or Fe such as melter slag	Not specified	P	Wetlands P sorbents
G20	Floating wetlands for stormwater treatment: removal of copper, zinc and fine particulates.	Headley TR, Tanner CC (2007)	Technical Publication, Auckland Regional Council, New Zealand	The effectiveness of floating wetlands for removing contaminants from stormwater	Removes 21-50% of DRP from artificial urban stormwater.	n/a - In lab study	P	Wetlands
G86	Nutrient capture by experimental watercress beds, Lake Rotorua. In: Farming's future: minimising footprints and maximising margins	Sukias J, McKergow L (2010)	(Currie LD, Christensen CL, Eds.), Occasional Report No. 23, Fertilizer and Lime Research Centre, Massey University, Palmerston North, New Zealand. p 142-151.	Evaluation of watercress as a method for removal of nutrients from agicultural runoff	Diversion of water through a watercress bed removed 33% of N at low flows and 16% at higher flows	Rotorua	N&P	Wetlands
G88	Plants as ecosystem engineers in subsurface-flow treatment wetlands.	Tanner CC (2001)	Water Science Technology 44:(11-12)9-17.	A review of the role of plant and their effect on removal of nutrients	In general net removal by plant is a relatively small proportion of total removal. Plants serve to enhance key nutrient transformation processes	n/a - Review	P	Wetlands

Id	Title	Author (Year)	Reference	Objective / Study aim	Findings	Location	N/P	Topic
G90	Nutrient removal by a constructed wetland treating subsurface drainage from grazed dairy pasture.	Tanner CC, Nguyen ML, Sukias JPS (2005)	Agriculture Ecosystems and Environment 105:145-162	Evaluation of the performance of a constructed wetland draining dairy pasture	Approx twice the amount of DRP and TP exiting the wetland than is entering in the first year. Amounts similar in 2nd year. May be due to establishment effects.	Waikato	P	Wetlands
I14	Nitrogen removal by a seepage wetland intercepting surface and subsurface flows from a dairy catchment in waikato.	M L Nguyen, N Eynon-Richards and J Barnett, (2002).	In: Dairy farm soil management. (Eds L D Currie and P Loganathan). Occasional report No. 15. Fertilizer and Lime Research Centre, Massey University, Palmerston North, New Zealand.	Quantify the N removal performance of a seepage wetland in a dairy catchment in the Waikato	The wetland reduced incoming nitrate by 70 - 95% except when outflows exceeded inflow and/or nitrate inflow was not adequately intercepted. The wetland may be a source of NH4+, DON and PN.	Waikato	N	Wetlands
I16	Last ditch effort to reduce nutrient export from drained dairy pastures using constructed wetlands.	C C Tanner, M L Nguyen and J P S Sukias, (2002).	In: Dairy farm soil management. (Eds L D Currie and P Loganathan). Occasional report No. 15. Fertilizer and Lime Research Centre, Massey University, Palmerston North, New Zealand.	Quantify the N & P removal performance of a constructed wetlands in the Waikato and Northland	Drainage flows highly pulsed. In the Waikato: Conc of nitrate & TN reduced. NH4+ & DRP increased. Mass balance indicated substantial removal of DRP and all forms of N.	Waikato	N&P	Wetlands
I22	Export of nitrogen in subsurface drainage from irrigated and rain-fed dairy pastures and its attenuation in constructed wetlands.	Chris Tanner, M L Nguyen and J P S Sukias, (2005).	In: Developments in fertiliser application technologies and nutrient management. (Eds L.D. Currie and J.A. Hanly). Occasional Report No. 18. Fertilizer and Lime Research Centre, Massey University, Palmerston North, New Zealand.	Quantify constructed wetland removal performance for wetlands receiving drainage from irrigated and rain-fed dairy pastures	Moderate reductions for total N. Performance dependent on variation in seasonal loading and establishment/maturation factors	Northland and Waikato	N	Wetlands
I27	Dairy farm drainage nitrate attenuation wetlands and filters.	James Sukias, C Tanner and L McKergow, (2006).	In: Implementing sustainable nutrient management strategies in agriculture. (Eds L.D. Currie and J.A. Hanly). Occasional Report No. 19. Fertilizer and Lime Research Centre, Massey University, Palmerston North, New Zealand.	Compare the effectiveness of constructed wetlands and wood chip filters for removal of nitrate	To be effective constructed wetlands should be 2-5% of catchment area; woodchip filters 1.2-2.4% of catchment area.	Waikato	N	Wetlands N sorbents
I48	Nutrient capture by experimental watercress beds, Lake Rotorua.	James Sukias and L McKergow, (2010).	In: Farming's future: Minimising footprints and maximising margins. (Eds L.D. Currie and C.L. Christensen). Occasional Report No. 23. Fertilizer and Lime Research Centre, Massey University, Palmerston North, New Zealand.	Investigate the effectiveness of Watercress as a measure to reduce stream N & P.	Watercress dies back from Jun to Sep. Removal of N and P effective in summer during periods of low flow. Not effective at high flow. Yet to be developed to farm scale	Rotorua	N&P	Wetlands
I55	Surface flow constructed wetlands as a drainage management tool – Long term performance.	James Sukias and C Tanner, (2011).	In: Adding to the knowledge base for the nutrient manager. (Eds L.D. Currie and C L. Christensen). http://flrc.massey.ac.nz/publications.html. Occasional Report No. 24. Fertilizer and Lime Research Centre, Massey University, Palmerston North, New Zealand.	Quantify long-term drain yields and nutrient removals of constructed wetlands	Removal of Total N ranged from 18 - 43% of annual influent load. Annual flow proportional total P increased by up to 115%	Waikato	N&P	Wetlands

Id	Title	Author (Year)	Reference	Objective / Study aim	Findings	Location	N/P	Topic
I56	Floating treatment wetlands: A new tool for nutrient management in lakes and waterways?.	Chris C Tanner, J P S Sukias, J Park, C Yates and T Headley, (2011).	In: Adding to the knowledge base for the nutrient manager. (Eds L.D. Currie and C L. Christensen). http://flrc.massey.ac.nz/publications.html. Occasional Report No. 24. Fertilizer and Lime Research Centre, Massey University, Palmerston North, New Zealand.	Floating treatment wetland described. Performance in experimental tanks is discussed		Waikato	N&P	Wetlands

Id	Title	Author (Year)	Reference	Objective / Study aim	Findings	Location	N/P	Topic
A02	Phosphorus of soils in riparian and non-riparian wetland and buffer strips in the Waikato area, New Zealand.	Aye, T. M., M. L. Nguyen, et al. (2006).	New Zealand Journal of Agricultural Research 49(3): 349-358.	Investigation of P release processes in riparian buffer strips	Soils with high Olsen P may have high P loss as subsurface flow	Waikato	P	Optimal soil test P Riparian management
A13	Effects of riparian set-aside on soil characteristics in an agricultural landscape: implications for nutrient transport and retention.	Cooper, A. B., C. M. Smith, et al. (1995).	Agriculture, Ecosystems & Environment 55(1): 61-67.	Effectiveness of a riparian scrub, set-aside and pasture in terms of nutrient transport	Riparian set-aside delivers runoff with low sediment and nitrate but high in dissolved P	Taupo	N	Riparian management
A22	Nutrient and vegetation changes in a retired pasture stream: recent monitoring in the context of a long-term dataset.	Howard-Williams, C. and S. Pickmere (1999).	Science for Conservation: 41.	Long-term monitoring of changes in retired stream	Permanent grassland resistant to invasion - assisted plantings required. % of nutrients removed has decreased.	Taupo	N&P	Riparian management
A23	Long-term nutrient and vegetation changes in a retired pasture stream: monitoring programme and vegetation survey 1999-2003, updating data from 1976.	Howard-Williams, C. and S. Pickmere (2005).	Science for Conservation. Wellington, Department of Conservation: 32.	Long-term monitoring of changes in retired stream	Riparian biodiversity increasing at 3%/year. % of nutrients removed increasing. Intensification and urban development indicate further change is inevitable	Taupo	N&P	Riparian management
A39	Influences of leaf toughness and nitrogen content on in-stream processing and nutrient uptake by litter in a Waikato, New Zealand, pasture stream and streamside channels.	Quinn, J. M., G. P. Burrell, et al. (2000).	New Zealand Journal of Marine & Freshwater Research 34(2): 253-271.	Improve basis for selection of plants for riparian buffers	Highly retentive streams require wide variety of plants / leaf types. Soft N-rich leaves may be OK for streams frequently flushing litter downstream.	Waikato	N	Riparian management
A40	How much runoff do riparian wetlands affect?	Rutherford, J. C., D. Schroer, et al. (2009).	New Zealand Journal of Marine and Freshwater Research 43(5): 1079-1094.	Used measurements from 6 wetlands to model performance over entire Taupo catchment	Riparian / valley wetlands are only 5% of the catchment but may attentuate N in 11-19% of runoff	Taupo	N	Wetlands Riparian management

Id	Title	Author (Year)	Reference	Objective / Study aim	Findings	Location	N/P	Topic
A55	Watershed riparian management and its benefits to a eutrophic lake.	Williamson, R. B., C. M. Smith, et al. (1996).	Journal of Water Resources Planning and Management 122(1): 24-32.	Model benefits to eutrophic Lake Rotorua of implementing diffuse source controls	Estimate controls will reduce watershed total P loads by 20%. Will assist in shifting lake status towards mesotrophic.	Rotorua	N	Riparian management
C02	Riparian pasture retirement effects on sediment phosphorus and nitrogen in channellised surface runoff from pastures.	Smith, C.M. (1989).	New Zealand Journal of Marine and Freshwater Research 23(1): 139-146	Evaluation of effectiveness of riparian pasture retirement on steep slopes by assessment of channellised runoff - 22 month study	Riparian pasture retirement effectively reduces surface runoff and pollutant loads in the short-term. Long-term effects not assessed.	Waikato	N&P	Riparian management
D080	Sources of sediment and phosphorus in stream flow of a highly productive dairy farmed catchment.	McDowell, R. W. and R. J. Wilcock (2007).	Journal of Environmental Quality 36(2): 540-548.	Quantify P loss to a stream in a dairy catchment	Modelled P losses to establish P sources: topsoil by overland flow - maybe lanes. Riparian protection and management of soil P recommended	SI	P	Critical source areas Riparian management Races Optimal soil test P
I15	Effects of riparian vegetation on nitrate removal processes.	F Matheson, M L Nguyen, B Cooper and T Burt, (2002).	In: Dairy farm soil management. (Eds L D Currie and P Loganathan). Occasional report No. 15. Fertilizer and Lime Research Centre, Massey University, Palmerston North, New Zealand.	Short term study on the effectiveness of bare soil and wetland plants on nitrate removal processes	Dentrification was the predominant N removal process irrespective of harvesting (62%); less so for bare soil (29%).	Not specified	N	Riparian management
I23	Field experiments to determine the transformations of nitrogen within a lake taupo subcatchment.	Rob Collins, J Sukias, G Barkle and R Stenger, (2005).	In: Developments in fertiliser application technologies and nutrient management. (Eds L.D. Currie and J.A. Hanly). Occasional Report No. 18. Fertilizer and Lime Research Centre, Massey University, Palmerston North, New Zealand.	Overview of program to describe N transformations and pathways in wetlands, vadose zone and stream network of a Taupo subcatchment	Nitrate removal up to 95% can occur within riparian wetlands. Subsurface NH4+ may diminish relative importance of nitrate loss. Denitrification greater in topsoil and uppeer vadose zone.	Waikato	N	Riparian management
J03	Improving the economic and environmental performance of a New Zealand hill country farm catchment: 3. Short term outcomes of land use change.	Dodd, M.B.; Quinn, J.M.; Thorrold, B.S.; Parminter, T.G.; Wedderburn, M.E. (2008).	New Zealand Journal of Agricultural Research 53: 155-169.	Report improvement of environmental performance indicators on implementing land use changes to improve farm economic performance.	Reforestation and riparian zone development were undertaken with intensification of the remainder of the farm. Improving indicators were sediment (76%) and phosphorus (62%).	Whatawhata	P	Riparian management Stock management

Id	Title	Author (Year)	Reference	Objective / Study aim	Findings	Location	N/P	Topic
D024	Water quality in headwater catchments with deer wallows.	McDowell, R. W. (2007).	Journal of Environmental Quality 36(5): 1377-1382.	Determine the contribution of N & P loads arising from deer wallows	Median concentrations in excess of recommended guidelines for lowland water quality and contact recreation. Recommend deer wallows be fenced off.	Invermay & Balclutha, SI	P	Fencing waterways
D030	The use of safe wallows to improve water quality in deer farmed catchments.	McDowell, R. W. (2009).	New Zealand Journal of Agricultural Research 52(1): 81-90.	How to manage deer wallows to mitigate contaminant loss to surface waters?	Fencing off old wallow with riparian planting and use of a 'safe' wallow reduced loads by 90%. P & SS losses reduced. Mitigation recommended.	Balclutha, SI	P	Fencing waterways
E10	Phosphorus and sediment loss in a catchment with winter forage grazing of cropland by dairy cattle.	McDowell, R. W. (2006).	Journal of Environmental Quality 35(2): 575-583.	Study of the effects of winter forage grazing of dairy cattle on P loss processes	Compared to clearing up of stream banks P losses on moderately sloping land were minimal. SS load increased by 75%	Balclutha, SI	P	Stock management Fencing waterways
G02	The influence of season and providing a water trough on stream use by beef cattle grazing hill-country in New Zealand.	Bagshaw C, Thorrold B, Davison M, Duncan IJH, Matthews LR (2008)	Applied Animal Behaviour Science 109:155-166.	A study of the behaviour of beef cattle with respect to access to streams when supplied with trough water	The provision of water troughs do not effectively deter beef cattle from accessing streams in hill country. No change in use of streams observed	Whatawhata, Waikato	P	Fencing waterways
G35	Water quality of a stream recently fenced-off from deer.	McDowell RW (2008)	New Zealand Journal of Agricultural Research 51:291-298	Study effects of fencing off a stream and wallow on stream water quality	P loading in stream decreases up to 90% on exclusion of deer. DRP not significantly affected.	Invermay, SI	P	Fencing waterways
G45	Monitoring the impact of farm practices on water quality in the Otago and Southland deer focus farms.	McDowell RW, McGrouther N, Morgan G, Srinivasan MS, Stevens DR, Johnson M, Copland R (2006)	Proceedings of the New Zealand Grassland Association 68:183-188	Quantify the effect of selected strategies in terms of improving soil and water quality on deer focus farms	Sediment trap reduces TP concentrations by 10%. Fencing off improved water quality	Otago & Southland, SI	P	Retention dams Fencing waterways

WRC literature survey - N & P loss from land to water

Published Papers - Filter strips

Id	Title	Author (Year)	Reference	Objective / Study aim	Findings	Location	N/P	Topic
G53	Landscape grass filter strips in the Rotorua Lakes catchment.	McKergow L, Taylor A, Stace C, Costley K, Timpany G, Paterson J (2007)	In: Designing Sustainable Farms: Critical Aspects of Soil and Water Management (Currie LD, Tayes LJ Eds.), Occasional Report No. 20, Fertilizer and Lime Research Centre, Massey University, Palmerston North, New Zealand, pp. 322-330.	Measure effectiveness of hillslope grass filter strips in the Rotorua catchment	Trapping of nutrients is variable. Concentrations and loads of SS and TP in inflowing runoff are reduced by more than 40%	Rotorua	P	Filter strips
G67	Enhancing the P trapping of pasture filter strips: successes and pitfalls in the use of water supply residue and polyacrylamide.	Redding MR, Welten B, Kear M (2008)	European Journal of Soil Science 59:257-264.	Study of methods for improving performance of pasture filter strips	Use of alum and polyacrylamide increases P retention by up to 40%. Effectivenes is dimished by drying.	Ruakura, Waikato	P	Filter strips
G80	Riparian pasture retirement effects on sediment, phosphorus, and nitrogen in channelised surface run-off from pastures.	Smith CM (1989)	New Zealand Journal of Marine Freshwater Research 23:139-146.	Study how effective riparian strips are for reduction of P runoff from pasture	Reduction in flow-weighted N and P observed.	Tauwhare, Waikato	P	Filter strips
I57	Implementing on-farm P mitigations in Rerewhaakitu catchment .	Bob Longhurst, M Hawke, B Parker and S Balvert, (2009).	In: Nutrient management in a rapidly changing world. (Eds L.D. Currie and C.L. Lindsay). Occasional Report No. 22. Fertilizer and Lime Research Centre, Massey University, Palmerston North, New Zealand.	Development of methods / strategies on a catchment scale to assist farmers minimise the environmental impact of farming on a lake	Identifcation of critical source areas and implementation of mitigation measures such as filter strips, sediment traps and P-sorbents	Rerewhakaaitu	N&P	P sorbents Filter strips

Id	Title	Author (Year)	Reference	Objective / Study aim	Findings	Location	N/P	Topic
A04	Nitrate leaching and productivity of some farming options in the Lake Taupo catchment.	Betteridge, K., C. J. Hoogendoorn, et al. (2007).	Proceedings of the New Zealand Grassland Association 69: 123-129.	Investigate N leaching potential of new and existing farm systems in Taupo catchment	N-fertilised annual crops associated with high N leaching	Taupo	N	Fertiliser use
A09	The effect of situational variability in climate and soil, choice of animal type and N fertilisation level on nitrogen leaching from pastoral farming systems around Lake Taupo, New Zealand.	Bryant, J. R., V. O. Snow, et al.	Agricultural Systems.	Effects of climate, soil type, fertliliser and stock types on N leaching as determined by the EcoMod model	Fert N has propensity to leach. Weather variation between year and soil type has marked influence. N leaching depends on urine deposition	Taupo	N	Fertiliser use
A14	Potential for nitrate leaching from different land uses in the Pukekohe area.	Crush, J. R., S. N. Cathcart, et al. (1997).	Proceedings of the New Zealand Grassland Association 59: 55-58.	N leaching modelled from different land-uses in Pukekohe area	Land use options ranked. Winter crops have higher N surplus than summer crops. Practices increasing leaching were: high N fert, prolonged history of cultivation, no cover crops	Pukekohe	N	Arable / hort Fertiliser use
A18	Winter nitrate leaching losses from three land uses in the Pukekohe area of New Zealand.	Francis, G. S., L. A. Trimmer, et al. (2003).	New Zealand Journal of Agricultural Research 46(3): 215-224.	Compare nitrate leaching losses from three different land-uses (dairy, winter potatoes, winter greens)	Dairy < Winter greens < Winter potatoes. Drivers: Pre-winter N fert and mineralisation of residues	Pukekohe	N	Arable / hort Fertiliser use
A29	Effect of fertiliser rate and type on the yield and nitrogen balance of a Pukekohe potato crop.	Martin, R. J., M. D. Craighead, et al. (2001).	Agronomy New Zealand 31: 71-80.	Effects of rate and form of N fert applied to potato crop	Form of N fertiliser had no effect. Foliar fertilisers had not effect. Inhibitor reduced leaching by 30% with increased soil-NH4 at harvest and increased uptake by cover crop. Increased N application increased N leaching.	Waikato	N	Fertiliser use
A38	Pasture production gains from strategic winter nitrogen applications on a North Island sheep and beef hill country farm.	Puha, M. R., W. M. King, et al. (2008).	Proceedings of the New Zealand Grassland Association 70: 117-121.	Explore winter application of N fertiliser in Waikato hill-country to improve production	Response aspect dependent. Leachate N concentration depended on aspect and slope - less consistent for steep northerly slopes	Waikato	N	Fertiliser use

Id	Title	Author (Year)	Reference	Objective / Study aim	Findings	Location	N/P	Topic
B22	Environmental impacts of different nitrogen inputs on dairy farms and implications for the Resource Management Act of New Zealand.	Ledgard, S. F., J. R. Crush, et al. (1998).	Environmental Pollution 102(SUPPL. 1): 515-519.	Determine N inputs and losses from a Hamilton farmlet receiving fertiliser at rates from 0 - 400 kg N/ha/yr.	Nitrate leaching up to 152 kg N/ha/yr with nitrate conc increasing with N application. NZ data is compared with European farm data. RMA implications discussed.	Waikato	N	Fertiliser use
B23	Influence of time of application on the utilization of nitrogen fertilizer by asparagus, estimated using 15N.	Ledgard, S. F., J. A. Douglas, et al. (1992).	Plant and Soil 147(1): 41-47.	Determine the effect of N fertiliser on asparagus production	12% response to fertiliser only in the first of three years. No significant effect observed due to rate or timing.	Waikato	N	N loss processes Fertiliser use
B30	Nitrogen inputs and losses from clover/grass pastures grazed by dairy cows, as affected by nitrogen fertilizer application.	Ledgard, S. F., J. W. Penno, et al. (1999).	Journal of Agricultural Science 132(2): 215-225.	Study N flows within a Waikato dairy farmlet affected by N fertiliser and imported maize silage	Maize supplementation improved N efficiency and reduced N losses compared to application of N fert. Application of N fertiliser is associated with reduced N fixation. 0N farmlet most N efficient with milk production 83% of 400N farmlet	Waikato	N	Suppl feeds Fertiliser use
B36	Nitrogen inputs and losses from New Zealand dairy farmlets, as affected by nitrogen fertilizer application: Year one.	Ledgard, S. F., M. S. Sprosen, et al. (1996).	Plant and Soil 181(1): 65-69.	Study N flows within a Waikato dairy farmlet affected by N fertiliser (year 1 only)	Increased N fert associated with: 1) increased grass growth and lower drainage. 2) Increased nitrate conc in 400N leachate. 3) reduced N fixation in 400N treatment.	Waikato	N	Fertiliser use
H04	Effect of regular irrigation with dairy farm effluent on soil organic matter and soil microbial biomass.	Barkle, G. F., R. Stenger, et al. (2000).	Australian Journal of Soil Research 38(6): 1087-1097.	Study of DFE irrigation over several years on SOM and microbial biomass	For sustainable use without N leaching gradually increasing mineralisation from increased SOM should be considered when applying N fertiliser	Waikato	N	Fertiliser use
I03	Impact of rate of nitrogen fertiliser application on nitrate leaching from grazed dairy pastures .	Ledgard, S F, Sprosen, M S and Brier, G J, (1996).	In: Recent developments in understanding chemical movement in soils: Significance in relation to water quality and efficiency of fertiliser use. (Eds L D Currie and P Loganathan). Occasional report No. 9. Fertilizer and Lime Research Centre, Massey University, Palmerston North, New	Impacts of rate of N fertiliser application on N leaching	Nitrate N leaching varies with N fertiliser application; NH4+ remains consistently low. 400N of fertliser has a marked effect on N leached double that of the 200N applied.	Waikato	N	Fertiliser use
I06	Groundwater nitrate levels under grazed dairy pastures receiving different rates of nitrogen fertiliser.	Ledgard, S F, Selvarajah, N, Jenkinson, D and Sprosen, M S, (1996).	In: Recent developments in understanding chemical movement in soils: Significance in relation to water quality and efficiency of fertiliser use. (Eds L D Currie and P Loganathan). Occasional report No. 9. Fertilizer and Lime Research Centre, Massey University, Palmerston North, New	The effect of amount of N fertiliser applied on groundwater water nitrate levels under grazed dairy pastures	200 N farmlet leaches slightly more that the 0 N farmlet. Leaching from the 400 N farmlets were greater with N conc in drainage well in excess of 11.3 mg/L (drinking guidelines)	Waikato	N	Fertiliser use

Id	Title	Author (Year)	Reference	Objective / Study aim	Findings	Location	N/P	Topic
I35	Management strategies to minimise nitrate leaching from arable crops.	Glyn Francis, S Thomas, H Barlow, F Tabley, R N Gillespie and R F Zyskowski, (2007).	In: Designing sustainable farms: Critical aspects of soil and water management. (Eds L.D. Currie and L.J. Yates). Occasional Report No. 20. Fertilizer and Lime Research Centre, Massey University, Palmerston North, New Zealand.	Measure irrigation and fertiliser management effects on annual losses from crop rotations	N losses varied widely depending on fertiliser rate applied, irrigation, winter rainfall and crops grown.	Canterbury, SI	N	Fertiliser use
I54	Nitrogen fertiliser advice –what progress can we make?.	Mark A Shepherd and G M Lucci, (2011).	In: Adding to the knowledge base for the nutrient manager. (Eds L.D. Currie and C L. Christensen). http://flrc.massey.ac.nz/publications.html. Occasional Report No. 24. Fertilizer and Lime Research Centre, Massey University, Palmerston North, New Zealand.	Review the state of knowledge relating to fertiliser advice and identify areas of possible improvement in N fertliser recommendations for pasture	Focus areas: 1) Better synthesis and use of existing knowledge. 2) Decision support tools. 3) Environmental farm monitoring for decision support. 4) Focus on critical periods	NZ wide including Waikato	N	Fertiliser use

Id	Title	Author (Year)	Reference	Objective / Study aim	Findings	Location	N/P	Topic
D046	Phosphorus fertilizer form affects phosphorus loss to waterways: a paired catchment study.	McDowell, R. W., R. P. Littlejohn, et al. (2010).	Soil Use & Management 26(3): 365-373.	A paired sheep grazed catchment study to determine differences in P losses to waterways arising from P fertiliser form.	Where appropriate climatic and soil conditions exist RPR can be used to reduce P losses to streams	SI	P	Fertiliser form
D049	Potential phosphorus losses in overland flow from pastoral soils receiving long-term applications of either superphosphate or reactive phosphate rock.	McDowell, R. W., R. M. Monaghan, et al. (2003).	New Zealand Journal of Agricultural Research 46(4): 329-337.	Study the effect of long term application of superphosphate or RPR on P loss by overland flow.	Soluble P fertilisers present incidental risk of greater P loss. If good management practice is observed the differences between RPR and superphosphate use is minimal	SI	P	Fertiliser form
E11	Phosphorus in humped and hollowed soils of the Inchbonnie catchment, West Coast, New Zealand: II. Accounting for losses by different pathways.	McDowell, R. W. (2008).	New Zealand Journal of Agricultural Research 51(3): 307-316.	Study of P loss processes from dairy pasture to Lake Brunner a region of high rainfall.	Amount and form of P loss measured.Significant processes identified. Mitigation management practices discussed.	SI	P	P loss processes Optimal soil test P Fertiliser form
G36	Evaluation of two management options to improve the water quality of Lake Brunner, New Zealand.	McDowell RW (2010)	New Zealand Journal of Agricultural Research 53:59-69.	Evaluation of two management options to improve lake water quality	Use of RPR instead of superphosphate decreases P losses. Use of alum on west coast pastures ineffective. May have been washed off	SI	P	Fertiliser form P sorbents
G38	Alternative fertilisers and management to decrease incidental phosphorus loss.	McDowell RW, Catto W (2005)	Environmental Chemistry Letters 2:169-174	Study the potential of P loss from souble P fertilisers from time of application and model potential losses throughout the year	Availability of fertiliser sourced P to surface runoff is directly related to the fertliser's water soluble P concentration. Application of soluble P fert when overland flow is unlikely or application of slow release P fertilisers is recommended	Glenmaru & Invermay, SI	P	Fertiliser form
G79	The long-term effectiveness of reactive phosphate rock as a phosphate fertiliser for New Zealand pastures.	Sinclair A, Dyson CB, Shannon PW (1990)	Proceedings of the New Zealand Grassland Association 51:101-104.	Reported results from several NZ field trials comparing PR with TSP	RPR is recommended where rainfall is > 800mm and soil pH less than 6.0. There is a lag time of effectiveness of about four years.	NZ wide including Waikato	P	Fertiliser form

Id	Title	Author (Year)	Reference	Objective / Study aim	Findings	Location	N/P	Topic
I11	Potential losses of phosphorus and nitrogen in runoff and drainage from pastoral soils applied with superphosphate and reactive phosphate rock.	M L Nguyen, B F Quin and J P S Sukias, (2002).	In: Dairy farm soil management. (Eds L D Currie and P Loganathan). Occasional report No. 15. Fertilizer and Lime Research Centre, Massey University, Palmerston North, New Zealand.	Investigate the effect of SSP and RPR on potential losses of P in runoff and drainage from pastures with long term P application history	SSP is more susceptible to losses of DRP and PP in simulated runoff than RPR.	Waikato	P	Fertiliser form

Id	Title	Author (Year)	Reference	Objective / Study aim	Findings	Location	N/P	Topic
A02	Phosphorus of soils in riparian and non-riparian wetland and buffer strips in the Waikato area, New Zealand.	Aye, T. M., M. L. Nguyen, et al. (2006).	New Zealand Journal of Agricultural Research 49(3): 349-358.	Investigation of P release processes in riparian buffer strips	Soils with high Olsen P may have high P loss as subsurface flow	Waikato	P	Optimal soil test P Riparian management
D015	Phosphorus export from an agricultural watershed: Linking source and transport mechanisms.	McDowell, R., A. Sharpley, et al. (2001).	Journal of Environmental Quality 30(5): 1587-1595.	Identify factors affecting streamflow DRP & TP in an agricultural catchment	Factors: Erosion, soil P conc. And channel sediment P sorption	SI	P	Erosion Optimal soil test P
D033	Estimating phosphorus loss from New Zealand grassland soils.	McDowell, R. W. and L. M. Condron (2004).	New Zealand Journal of Agricultural Research 47(2): 137-145.	Model P loss from grasslands soils using measured soil chemical properties	Surface P runoff losses are greater for soils of high Olsen P and low ASC	SI	P	Optimal soil test P
D050	Soil phosphorus concentrations to minimise potential P loss to surface waters in Southland.	McDowell, R. W., R. M. Monaghan, et al. (2003).	New Zealand Journal of Agricultural Research 46(3): 239-253.	Determine P losses from several Southland soils over a range of soil Olsen P concentrations	Manure or fert applic increased Olsen P and P in overland flow. P loss dominated by pedological origin. Olsen P values inducing P loss > 0.02 mg/L (env limit) in overland flow ranged from 5 - 51.	SI	P	Optimal soil test P
D080	Sources of sediment and phosphorus in stream flow of a highly productive dairy farmed catchment.	McDowell, R. W. and R. J. Wilcock (2007).	Journal of Environmental Quality 36(2): 540-548.	Quantify P loss to a stream in a dairy catchment	Modelled P losses to establish P sources: topsoil by overland flow - maybe lanes. Riparian protection and management of soil P recommended	SI	P	Critical source areas Riparian management Races Optimal soil test P
D099	Soil quality monitoring in New Zealand: trends and issues arising from a broad-scale survey.	Sparling, G. and L. Schipper (2004).	Agriculture Ecosystems & Environment 104(3): 545-552.	Survey of soil quality throughout NZ	80% soil properties within acceptable range. Compaction widespread. C depleted under cropping. Excess P under cropping and dairy.	Not specified NZ wide review	N&P	Optimal soil test P

Id	Title	Author (Year)	Reference	Objective / Study aim	Findings	Location	N/P	Topic
E11	Phosphorus in humped and hollowed soils of the Inchbonnie catchment, West Coast, New Zealand: II. Accounting for losses by different pathways.	McDowell, R. W. (2008).	New Zealand Journal of Agricultural Research 51(3): 307-316.	Study of P loss processes from dairy pasture to Lake Brunner a region of high rainfall.	Amount and form of P loss measured.Significant processes identified. Mitigation management practices discussed.	SI	P	P loss processes Optimal soil test P Fertiliser form
G16	Measurement and modelling of runoff and phosphate movement from seasonally dry hill-country pastures.	Gillingham AG, Gray MG (2006)	New Zealand Journal of Agricultural Research 49:233-245.	Model the movement of P in dry hill country pasture	P loss from soil by overland flow is directly related to soil P concentration	Hawkes Bay	P	Optimal soil test P

WRC literature survey - N & P loss from land to water

Published Papers - Inhibitors

Id	Title	Author (Year)	Reference	Objective / Study aim	Findings	Location	N/P	Topic
A11	Reducing nitrate leaching losses from a Taupo pumice soil using a nitrification inhibitor eco-n.	Cameron, K. C., H. J. Di, et al. (2007).	Proceedings of the New Zealand Grassland Association 69: 131-135.	Evaluatiion of eco-N effectiveness in Taupo catchment	Eco-N reduced nitrate leaching by 23 to 32% (mean: 27%)	Taupo	N	Inhibitors
A33	Soil N process inhibitors alter nitrogen leaching dynamics in a pumice soil.	Menneer, J. C., S. Ledgard, et al. (2008).	Australian Journal of Soil Research 46(4): 323-331.	Investigate the effect of soil N process inhibitors on the fate of urine-N in pumice soil	DCD & 4-MP reduce leaching by 59%. Agrotain reduced NH3 emissions by 64% increasing medium term leaching losses. Agrotain-DCD exacerbated N losses.	Taupo	N	Inhibitors
A43	Effect of rate and form of dicyandiamide application on nitrate leaching and pasture production from a volcanic ash soil in the Waikato.	Sprosen, M. S., S. F. Ledgard, et al. (2009).	New Zealand Journal of Agricultural Research 52(1): 47-55.	Examine effects of granular and liquid application of DCD	DCD in both liquid and granular forms proved effective in reducing N leaching from urine.	Waikato	N	Inhibitors
A46	Reducing NH3, N2O and NO3- -N losses from a pasture soil with urease or nitrification inhibitors and elemental S-amended nitrogenous fertilizers.	Zaman, M., M. L. Nguyen, et al. (2008).	Biology and Fertility of Soils 44(5): 693-705.	Reduction of pasture N losses using urease / nitrification inhibitors	Using both Agrotain and DCD together will potentially reduce N losses.	Ruakura, Waikato	N	Inhibitors
A53	Effect of timing and formulation of dicyandiamide (DCD) application on nitrate leaching and pasture production in a Bay of Plenty pastoral soil.	Menneer, J. C., M. S. Sprosen, et al. (2008).	New Zealand Journal of Agricultural Research 51(3): 377-385.	Investigate effects of timing and formulation of DCD application on nitrate leaching	Form (liquid versus granular) has no effect. For greatest benefit both autumn and winter applications are recommended.	Bay of Plenty	N	Inhibitors
B28	A novel concept to reduce nitrogen losses from grazed pastures by administering soil nitrogen process inhibitors to ruminant animals: A study with sheep.	Ledgard, S. F., J. C. Menneer, et al. (2008).	Agriculture, Ecosystems and Environment 125(1-4): 148-158.	Investigate reduction of N losses by direct administraton of DCD to ruminants (sheep).	Direct administration of N process inhibitors to grazing ruminents has potential to reduce N losses from urine patches.	Not specified	N	Inhibitors

Id	Title	Author (Year)	Reference	Objective / Study aim	Findings	Location	N/P	Topic
I40	Farmers taking control of their future: research into minimising nitrogen and phosphorus from pasture land into Rotorua lakes.	Stewart Ledgard, A Ghani, M Redding, M Sprosen, S Balvert and D Smeaton, (2008).	In: Carbon and nutrient management in agriculture. (Eds L.D. Currie and L.J. Yates). Occasional Report No. 21. Fertilizer and Lime Research Centre, Massey University, Palmerston North, New Zealand.	Summary of research undertaken to develop pratical mitigations for N and P losses to Rotorua lakes	DCD application reduced N losses 15 - 25% and nil winter grazing, 34 - 42% Hay bale filter dams did not reduce P losses due to their rapid degradation	Rotorua	N	Inhibitors Restricted grazing
I42	Effectiveness of dicyandiamide in reducing nitrogen leaching losses from two contrasting soil types under two rainfall regimes – A lysimeter study .	Mark Shepherd, B Welten and S Ledgard, (2009).	In: Nutrient management in a rapidly changing world. (Eds L.D. Currie and C.L. Lindsay). Occasional Report No. 22. Fertilizer and Lime Research Centre, Massey University, Palmerston North, New Zealand.	Effectiveness of DCD in relation to soil type and rainfall	Effectiveness varied from 34-54% reducing with increasing rainfall. More effective on Horotiu soils than Waikare clays	Waikato	N	Inhibitors
I43	Winter grazing of a forage crop; effects on nitrate leaching .	Mark Shepherd, M Sprosen, S Ledgard and D Smeaton, (2009).	In: Nutrient management in a rapidly changing world. (Eds L.D. Currie and C.L. Lindsay). Occasional Report No. 22. Fertilizer and Lime Research Centre, Massey University, Palmerston North, New Zealand.	Quantify nitrate losses following grazing of a winter forage crop and measure the effect of DCD application	The risk of leaching N when winter grazing forage crops is high. 52% of leaching attributable to forage crop and winter fallow. DCD reduced total N leaching by up to 24%	Taupo	N	Inhibitors Forage crop management
I49	Mitigating nitrate leaching in dairy systems – which periods of urine deposition should we be targeting?.	Mark Shepherd, P Phillips, V Snow and C Glassey, (2010).	In: Farming's future: Minimising footprints and maximising margins. (Eds L.D. Currie and C.L. Christensen). Occasional Report No. 23. Fertilizer and Lime Research Centre, Massey University, Palmerston North, New Zealand.	Determine the critical period for DCD application to pasture	Urine deposited in March poses as great or greater a risk of leaching than urine deposited in May or June. Need to extend this work to additional soil types and climates	Waikato	N	Inhibitors
I52	Targeting DCD at critical source areas as a nitrogen loss mitigation strategy.	Keith Betteridge, F Li, D Costall, A Roberts, W Catto, A Richardson and J Gates, (2011).	In: Adding to the knowledge base for the nutrient manager. (Eds L.D. Currie and C L. Christensen). http://flrc.massey.ac.nz/publications.html. Occasional Report No. 24. Fertilizer and Lime Research Centre, Massey University, Palmerston North, New Zealand.	Determine the effectiveness of DCD on two farms in the Taupo catchment and identify campsites on hill paddocks	N loss greater on strip grazed pastures. DCD reduced N leaching. Both nitrate and NH4+ leached down the profile. GPS tracking of cows did not identify obvious campsites	Taupo	N	Inhibitors Forage crop management
I53	The challenge of late summer urine patches in the Waikato region.	Mark Shepherd, P Phillips and V Snow, (2011).	In: Adding to the knowledge base for the nutrient manager. (Eds L.D. Currie and C L. Christensen). http://flrc.massey.ac.nz/publications.html. Occasional Report No. 24. Fertilizer and Lime Research Centre, Massey University, Palmerston North, New Zealand.	Determine the critical period for DCD application to pasture - include info on the interaction of timing & rate of urine N application	There is a significant contribution to N leaching arising from urine deposited in Feb/Mar and by extrapolation before this.	Waikato	N	Inhibitors

Id	Title	Author (Year)	Reference	Objective / Study aim	Findings	Location	N/P	Topic
B57	Animal treading stimulates denitrification in soil under pasture.	Menneer, J. C., S. Ledgard, et al. (2005).	Soil Biology and Biochemistry 37(9): 1625-1629.	Study of the effects of treading wet soil on denitrification	Treading reduces soil aeration, reduces plant growth. This with the resultant increase in NH4+ and NO3- stimulates denitrification	Waikato	N	Stock management Pugging N loss processes
C01	Impact of cattle treading on hill land: 2. Soil physical properties and contaminant runoff.	Nguyen, M.L., G.W. Sheath et al. (1998).	New Zealand Journal of Agricultural Research 41(2): 279-290	Investigation of the effects of a 2-3 winter treading event on soil physical properties and nutrient runoff in hill-country	More N, P and sediment observed in runoff following simulated rainfall. These effects disappeared within 6 months.	Whatawhata, Waikato	N&P	Pugging
D006	Do aggregation, treading, and dung deposition affect phosphorus and suspended sediment losses in surface runoff?	Cournane, F. C., R. W. McDowell, et al. (2010).	Australian Journal of Soil Research 48(8): 705-712.	Effects of aggregation, dung and treading on P loss by surface runoff..	Losses: Dung > Treading. Pallic / Gley soils more vulnerable than Melanic / Brown soils. P load greater in light low density aggregates	SI	P	Pugging
D007	Effects of cattle treading and soil moisture on phosphorus and sediment losses in surface runoff from pasture.	Cournane, F. C., R. W. McDowell, et al. (2010).	New Zealand Journal of Agricultural Research 53(4): 365-376.	Study how treading affects the loss of P and SS in surface runoff for four soils	DRP greater in runoff following drier conditions but less likely. PP losses with treading of more concern. Care is required under wet winter-spring conditions	SI	P	Pugging
D038	Effects of deer grazing and fence-line pacing on water and soil quality.	McDowell, R. W., J. J. Drewry, et al. (2004).	Soil Use & Management 20(3): 302-307.	Study of the effects of red deer grazing and fence line pacing on N & P loss to surface waters.	N unlikely to have a significant impact compared to P. Management strategies required to mitigate P losses.	SI	N&P	Pugging
D056	Water and soil quality in an Otago deer farm.	McDowell, R. W. and R. J. Paton (2004).	Proceedings of the New Zealand Grassland Association 66: 187-193.	Study of the impacts to soil and water arising from fence-line pacing and wallowing by deer.	In other than dry years (rainfall < 20% normal) mitigations targeting fence-line pacing and wallowing are required to protect soil and surface water quality.	SI	N	Pugging

Id	Title	Author (Year)	Reference	Objective / Study aim	Findings	Location	N/P	Topic
G40	Cattle treading and phosphorus and sediment loss in overland flow from grazed cropland.	McDowell RW, Drewry JJ, Muirhead RW, Paton RJ (2003c)	Australian Journal of Soil Research 41:1521-1532.	Study of overland P loss from grazed cropland	Treading increased overland flow. Grazing increased TP loss by 250% attributed to dung and soil disturbance. Wintering stock on forage crops increases P loss especially in particulate form	SI	P	Pugging
G41	Restricting cattle treading to decrease phosphorus and sediment loss in overland flow from grazed cropland.	McDowell RW, Drewry JJ, Muirhead RW, Paton RJ (2005)	Australian Journal of Soil Research. 43:61-66.	Study the effects of restricted grazing of forage brassica crops on soil properties and P loss	Restricted grazing during winter is beneficial for minimizing contaminant loss	SI	P	Pugging

WRC literature survey - N & P loss from land to water

Published Papers - Stock management

Id	Title	Author (Year)	Reference	Objective / Study aim	Findings	Location	N/P	Topic
A04	Nitrate leaching and productivity of some farming options in the Lake Taupo catchment.	Betteridge, K., C. J. Hoogendoorn, et al. (2007).	Proceedings of the New Zealand Grassland Association 69: 123-129.	Investigate N leaching potential of new and existing farm systems in Taupo catchment	Strategic destocking over winter can greatly reduce N leaching.	Taupo	N	Stock management
A05	Reduced nitrate leaching from livestock in a large lake catchment in New Zealand.	Betteridge, K., S. F. Ledgard, et al. (2005).	Precision livestock farming '05. S. Cox (Ed.). Wageningen, Wageningen Academic Publishers: 49-56.	Investigate nitrate leaching potential of cropping and drystock farm systems in Taupo catchment	All year grazing has greater leaching losses that those of no winter grazing systems	Taupo	N	Stock management
A08	Simulation of mitigation strategies to reduce nitrogen leaching from grazed pasture.	Bryant, J. R., C. J. Hoogendoorn, et al. (2007).	Proceedings of the New Zealand Grassland Association 69: 145-151.	N mitigation strategies modelled at the paddock level using EcoMod for a farm in Lake Taupo catchment	Recomendations: graze steers not heifers, use salt diuretic, use DCD. Needs to be scaled up to farm level	Taupo	N	Stock management
A15	Effects of dairying on water quality of lowland streams in Westland and Waikato.	Davies-Colley, R. J. and J. W. Nagels (2002).	Proceedings of the New Zealand Grassland Association 64: 107-114.	Survey of water quality of eight lowland streams	Area specific discharge correlates with land-use. Nutrient concentration is dependent on water flow.	Westland, Waikato	N&P	Stock management
A17	Effects of sheep grazing episodes on sediment and nutrient loss in overland flow.	Elliott, A. H. and W. T. Carlson (2004).	Australian Journal of Soil Research 42(2): 213-220.	Investigate the effect of sheep grazing on nutrient runoff on hill-country	Particulate nutrients correlated to % bare ground. Grazing reduces infiltration rate, increases runoff and increases loads post-grazing	Whatawhata	P	P loss processes Stock management
A19	Land use impacts on nutrient export in the Central Volcanic Plateau, North Island. (Special issue: Land use impacts).	Hamilton, D. (2004).	New Zealand Journal of Forestry 49(4): 27-31.	Review of the effects of land-use change from forestry (Rotorua, Taupo)	Discuss age of stream inflows, mitigation options	Taupo, Rotorua	N&P	Stock management

Id	Title	Author (Year)	Reference	Objective / Study aim	Findings	Location	N/P	Topic
A20	Soil C and N sequestration and fertility development under land recently converted from plantation forest to pastoral farming.	Hedley, C. B., B. H. Kusumo, et al. (2009).	New Zealand Journal of Agricultural Research 52(4): 443-453.	Development of pasture following conversion from forestry	In first the five years N accumulated at 0.45 t/ha/year to 150 mm depth. Implies immobilisation of N into organic matter.	Taupo, Rotorua	N	Stock management
A28	Control of pollutants using stand-off pads containing different natural materials.	Luo, J., A. Donnison, et al. (2006).	Proceedings of the New Zealand Grassland Association 68: 315-320.	Investigate standoff pad materials for retention of N	Bark and sawdust pads retained about 60% of deposited excreta N	In laboratory	N	Stock management
B18	Nitrogen cycling in low input legume-based agriculture, with emphasis on legume/grass pastures.	Ledgard, S. F. (2001).	Plant and Soil 228(1): 43-59.	Discuss N flows with respect to legume based N fixation.	Dietary management and stock management, methods for improving N efficiency in legume based farming systems are discussed.	Not specified - Review	N	Suppl feeds Stock management
B57	Animal treading stimulates denitrification in soil under pasture.	Menneer, J. C., S. Ledgard, et al. (2005).	Soil Biology and Biochemistry 37(9): 1625-1629.	Study of the effects of treading wet soil on denitrification	Treading reduces soil aeration, reduces plant growth. This with the resultant increase in NH4+ and NO3- stimulates denitrification	Waikato	N	Stock management Pugging N loss processes
D076	Potential waterway contamination associated with wintering deer on pastures and forage crops.	McDowell, R. W. and D. R. Stevens (2008).	New Zealand Journal of Agricultural Research 51(3): 287-290.	Determine P losses arising from winter grazing of pasture and forage crops	Contaminant concentrations increased with grazing, the more so when grazing forage crops. DRP similar for pasture and forage crops. In general contaminants exceeded national guidelines for lowland water quality	SI	P	Stock management
E10	Phosphorus and sediment loss in a catchment with winter forage grazing of cropland by dairy cattle.	McDowell, R. W. (2006).	Journal of Environmental Quality 35(2): 575-583.	Study of the effects of winter forage grazing of dairy cattle on P loss processes	Compared to clearing up of stream banks P losses on moderately sloping land were minimal. SS load increased by 75%	Balclutha, SI	P	Stock management Fencing waterways
I13	Effect of stocking rate on leaching of nitrate and associated nutrients.	M S Sprosen, S F Ledgard, S B Lindsey and K A Macdonald, (2002).	In: Dairy farm soil management. (Eds L D Currie and P Loganathan). Occasional report No. 15. Fertilizer and Lime Research Centre, Massey University, Palmerston North, New Zealand.	Study the effect of stocking rate on N leaching losses	Stocking rate may be a poor indicator on N leaching. Where cows are dried of and culls removed earlier reduced pasture intake and reduced fewer N deposits may influence the amount of N leached more than stocking rate.	Waikato	N	Stock management

Id	Title	Author (Year)	Reference	Objective / Study aim	Findings	Location	N/P	Topic
I19	Nitrogen flows and losses in dairy farms in New Zealand and the UK: effects of grazing management.	D R Chadwick, S F Ledgard and L Brown, (2002).	In: Dairy farm soil management. (Eds L D Currie and P Loganathan). Occasional report No. 15. Fertilizer and Lime Research Centre, Massey University, Palmerston North, New Zealand.	A comparison of NZ and UK housing-grazing management and consequential N losses	The greater use of off-wintering pads in NZ has potential to reduce nitrate leaching losses as excreta-N is returned more evenly to pastures	NZ and UK - Review	N	Stock management
I20	Nitrate leaching in grazing systems and management strategies to reduce losses.	Stewart F Ledgard and J C Menneer (Invited presentation) (2005).	In: Developments in fertiliser application technologies and nutrient management. (Eds L.D. Currie and J.A. Hanly). Occasional Report No. 18. Fertilizer and Lime Research Centre, Massey University, Palmerston North, New Zealand.	Review of mitigation measures to reduce nitrate leaching from grazed pastures	Grazing-off / feedpad reduces nitrate leaching by up to 60%. Stock type: cows > deer = sheep. Fertiliser has minimal effect unless excessive or untimely. Other strategies to be evaluated include inhibitors, low-N-feeds. Requires whole system approach.	Review - NZ wide including the Waikato	N	Stock management
I25	Nitrogen leaching and whole-system efficiency as affected by dairy intensification and mitigation practices in the resource efficient dairying trial.	Stewart Ledgard, M Sprosen, A Judge, S Lindsey, R Jensen and D Clark, (2006).	In: Implementing sustainable nutrient management strategies in agriculture. (Eds L.D. Currie and J.A. Hanly). Occasional Report No. 19. Fertilizer and Lime Research Centre, Massey University, Palmerston North, New Zealand.	Evaluate the environmental consequences of more intensive dairy farming	N fert (170 kg N/ha) with increased stocking rate increased milk production by 20%; doubled nitrate loss. Using maize silage reduced losses kg NO3-N / kg MS; include land to grow maize and whole system efficiency is reduced	Waikato	N	Suppl feeds Stock management Restricted grazing
I47	Using loafing pads to capture urine from dairy cows in late lactation whilst maintaining pasture intake, milk production and animal welfare .	Chris Glassey, C E F Clark, K L M McLeod, P Gregorini, D A Costall, K Betteridge and J G Jago, (2010).	In: Farming's future: Minimising footprints and maximising margins. (Eds L.D. Currie and C.L. Christensen). Occasional Report No. 23. Fertilizer and Lime Research Centre, Massey University, Palmerston North, New Zealand.	Investigate the effect on urination events of 16 hr removal of cows from pasture to a standoff pad	Urinations on pasture and laneways was reduced from 85% (control) to 50 - 56% when restricted grazing	Waikato	N	Stock management
J03	Improving the economic and environmental performance of a New Zealand hill country farm catchment: 3. Short term outcomes of land use change.	Dodd, M.B.; Quinn, J.M.; Thorrold, B.S.; Parminter, T.G.; Wedderburn, M.E. (2008).	New Zealand Journal of Agricultural Research 53: 155-169.	Report improvement of environmental performance indicators on implementing land use changes to improve farm economic performance.	Reforestation and riparian zone development were undertaken with intensification of the remainder of the farm. Improving indicators were sediment (76%) and phosphorus (62%).	Whatawhata	P	Riparian management Stock management

WRC literature survey - N & P loss from land to water

Published Papers - Restricted grazing

Id	Title	Author (Year)	Reference	Objective / Study aim	Findings	Location	N/P	Topic
B07	An analysis of environmental and economic implications of nil and restricted grazing systems designed to reduce nitrate leaching from New Zealand dairy farms. I. Nitrogen losses.	De Klein, C. A. M. and S. F. Ledgard (2001).	New Zealand Journal of Agricultural Research 44(2-3): 201-215.	Examine effects of nil and restricted grazing on N flows and losses	Restricted grazing may be beneficial in reducing nitrate leaching losses. Nil grazing systems have higher losses arising from gaseous N loss.	NZ wide review	N	Restricted grazing
D037	Restricting the grazing time of cattle to decrease phosphorus, sediment and E-coli losses in overland flow from cropland.	McDowell, R. W., J. J. Drewry, et al. (2005).	Australian Journal of Soil Research 43(1): 61-66.	Study of the effects of restricted grazing of brassica crops on soil physical properties and P loss by overland flow.	Restricted grazing of forage crops in winter was beneficial for reducing contaminant loss.	SI	P	Restricted grazing Forage crop management
D041	Phosphorus, nitrogen and sediment losses from irrigated cropland and pasture grazed by cattle and sheep.	McDowell, R. W. and D. J. Houlbrooke (2008).	Proceedings of the New Zealand Grassland Association 70: 77-83.	Determine N & P losses arising during grazing of irrigated forage plots by sheep and beef.	P loss due to irrigation events: 30% cattle, < 20% sheep N & P losses: cattle > sheep Urine patch > Non urine patch areas Focus: Reduce irrigation induced overland flow, adopt restricted grazing with stand-off pad	North Otago, SI	N&P	Irrigation Restricted grazing Forage crop management
I25	Nitrogen leaching and whole-system efficiency as affected by dairy intensification and mitigation practices in the resource efficient dairying trial.	Stewart Ledgard, M Sprosen, A Judge, S Lindsey, R Jensen and D Clark, (2006).	In: Implementing sustainable nutrient management strategies in agriculture. (Eds L.D. Currie and J.A. Hanly). Occasional Report No. 19. Fertilizer and Lime Research Centre, Massey University, Palmerston North, New Zealand.	Evaluate the environmental consequences of more intensive dairy farming	N fert (170 kg N/ha) with increased stocking rate increased milk production by 20%; doubled nitrate loss. Using maize silage reduced losses kg NO3-N / kg MS; include land to grow maize and whole system efficiency is reduced	Waikato	N	Suppl feeds Stock management Restricted grazing
I40	Farmers taking control of their future: research into minimising nitrogen and phosphorus from pasture land into Rotorua lakes.	Stewart Ledgard, A Ghani, M Redding, M Sprosen, S Balvert and D Smeaton, (2008).	In: Carbon and nutrient management in agriculture. (Eds L.D. Currie and L.J. Yates). Occasional Report No. 21. Fertilizer and Lime Research Centre, Massey University, Palmerston North, New Zealand.	Summary of research undertaken to develop pratical mitigations for N and P losses to Rotorua lakes	DCD application reduced N losses 15 - 25% and nil winter grazing, 34 - 42% Hay bale filter dams did not reduce P losses due to their rapid degradation	Rotorua	N	Inhibitors Restricted grazing
I45	Controlling nitrogen and phosphorus loss from dairy farms using restricted grazing practices .	Christine Lindsay, J A Hanly, M J Hedley, D J Horne, P J Schreurs and H B Toes, (2009).	In: Nutrient management in a rapidly changing world. (Eds L.D. Currie and C.L. Lindsay). Occasional Report No. 22. Fertilizer and Lime Research Centre, Massey University, Palmerston North, New Zealand.	A study quantifying the differences between normal and restricted grazing on mole tile dairy grazed paddocks	Drainage N concentrations decreased throughout the drainage season. Soil N at the beginning of the drainage season influences N loss more than three spring grazings during the drainage season.	Manawatu	N	Restricted grazing

Id	Title	Author (Year)	Reference	Objective / Study aim	Findings	Location	N/P	Topic
I46	Using duration-controlled grazing to reduce nitrate-N leaching from dairy farms .	Christine L Christensen, J A Hanly, M J Hedley and D J Horne, (2010).	In: Farming's future: Minimising footprints and maximising margins. (Eds L.D. Currie and C.L. Christensen). Occasional Report No. 23. Fertilizer and Lime Research Centre, Massey University, Palmerston North, New Zealand.	A study quantifying the differences between normal and restricted grazing on mole tile dairy grazed paddocks	Duration controlled grazing reduces N losses - Differences are more evident early in the drainage season consistent with reduced urine-N deposits in summer and autumn	Manawatu	N	Restricted grazing
I59	Nitrate leaching and pasture accumulation during two years of duration-controlled grazing in the Manawatu.	Christine Christensen, M J Hedley, J A Hanly and D J Horne, (2011).	In: Adding to the knowledge base for the nutrient manager. (Eds L.D. Currie and C L. Christensen). http://flrc.massey.ac.nz/publications.html. Occasional Report No. 24. Fertilizer and Lime Research Centre, Massey University, Palmerston North, New Zealand.	A study quantifying the differences between normal and restricted grazing on mole tile dairy grazed paddocks	Restricted grazing achieved over two seasons a 50% reduction in leaching. However in year two reduced pasture accumulation was observed possibly due to less excreta deposits	Manawatu	N	Restricted grazing

WRC literature survey - N & P loss from land to water

Published Papers - Irrigation

Id	Title	Author (Year)	Reference	Objective / Study aim	Findings	Location	N/P	Topic
D004	Influence of long-term irrigation on the distribution and availability of soil phosphorus under permanent pasture.	Condron, L. M., S. Sinaj, et al. (2006).	Australian Journal of Soil Research 44(2): 127-133.	Study of influence of long term irrigation on the distribution of P in soil profile	Improved utilisation of applied fertiliser P. Caused increased movement of P to depth in the soil profile	Winchmore, SI	P	Irrigation
D041	Phosphorus, nitrogen and sediment losses from irrigated cropland and pasture grazed by cattle and sheep.	McDowell, R. W. and D. J. Houlbrooke (2008).	Proceedings of the New Zealand Grassland Association 70: 77-83.	Determine N & P losses arising during grazing of irrigated forage plots by sheep and beef.	P loss due to irrigation events: 30% cattle, < 20% sheep N & P losses: cattle > sheep Urine patch > Non urine patch areas Focus: Reduce irrigation induced overland flow, adopt restricted grazing with stand-off pad	North Otago, SI	N&P	Irrigation Restricted grazing Forage crop management
I12	Amounts and forms of phosphorus in leachate from a grassland soil.	L M Condron, G S Toor, H J Di, K C Cameron and T Hendry, (2002).	In: Dairy farm soil management. (Eds L D Currie and P Loganathan). Occasional report No. 15. Fertilizer and Lime Research Centre, Massey University, Palmerston North, New Zealand.	Quantify forms of P lost by leaching from a grassland soil under flood irrigation over three years	Losses of DRP very small compared to total P. Losses were greatest from soil that received dairy shed effluent. Most P in particulate and dissolved forms thought to be predominantly organic	Canterbury, SI	P	Irrigation
I18	Does water and/or effluent irrigation increase nitrogen leaching from pumice soils under dairying?.	C P Burgess, G Barkle, P L Singleton, R Hill, R Stenger and T Fenton, (2002).	In: Dairy farm soil management. (Eds L D Currie and P Loganathan). Occasional report No. 15. Fertilizer and Lime Research Centre, Massey University, Palmerston North, New Zealand.	Quantify the effects of irrigation and FDE application on N & P losses from pumice soils	Leaching is more related to pasture N use efficiency than the annual volume of drainage. Nitrate loss: Eff > IrrEff > Irr = NonIrr	Taupo	N	Irrigation Effluent management

Id	Title	Author (Year)	Reference	Objective / Study aim	Findings	Location	N/P	Topic
D020	The effectiveness of industrial by-products to stop phosphorous loss from a Pallic soil.	McDowell, R. W. (2004).	Australian Journal of Soil Research 42(7): 755-761.	Investigation of industrial by-products as P sorbing agents in a pallic soil	Some were toxic to plants. None leached heavy metals. Melter slag and bottom ash considered effective	SI	P	P sorbents
D021	The effectiveness of coal fly-ash to decrease phosphorus loss from grassland soils.	McDowell, R. W. (2005).	Australian Journal of Soil Research 43(7): 853-860.	Investigate the suitability of using fly ash as a P sorbing agent for a range of soil types	Fly ash has a liming effect - induced C & P mineralisation. Inorganic P increased in labile fractions for 4 of the 6 soils. Not recommended for pastoral soils.	Huntly, Waikato	P	P sorbents
D087	Nitrogen transformation in a denitrification layer irrigated with dairy factory effluent.	Schipper, L. A. and A. McGill (2008).	Water Research 42(10-11): 2457-2464.	Description of a treatment system designed to operate when constrained by land area	Bypass flow an issue rendering thicker denitrification layers ineffective. Not practical for large scale use	Waikato	N	N sorbents
D090	Denitrifying bioreactors-An approach for reducing nitrate loads to receiving waters.	Schipper, L. A., W. D. Robertson, et al. (2010).	Ecological Engineering 36(11, Sp. Iss. SI): 1532-1543.	Measure effectiveness of a range of bioreactors for reducing nitrate losses to water bodies.	Bioreactors can be a cost effective means of reducing nitrate discharge to water bodies and are complementary to other agricultural management practices aimed at reducing nitrate losses.	Waikato	N	N sorbents
G03	Substrate and filter materials to enhance phosphorus removal in constructed wetlands treating diffuse farm runoff: a review.	Ballantine DJ, Tanner CC (2010)	New Zealand Journal of Agricultural Research 53:71-95.	A review to evaluate the effectiveness of a range of P sorbing materials for use in wetlands	Recommend: Porous materials or materials enriched with Al or Fe such as melter slag	Not specified	P	Wetlands P sorbents
G18	Evaluation of tephra for removing phosphorus from dairy farm drainage waters.	Hanly JA, Hedley MJ, Horne DJ (2008)	Australian Journal of Soil Research 46:542-551.	Effectiveness of tephra for prevention of P loss from tile-drained land	Reduced P loss in winter of 45% compared to a standard mole and pipe drainage system	Balclutha, SI	P	P sorbents

Id	Title	Author (Year)	Reference	Objective / Study aim	Findings	Location	N/P	Topic
G34	The effectiveness of industrial by-products to stop phosphorus loss from a Pallic soil.	McDowell RW (2004)	Australian Journal of Soil Research 42:755-761.	A survey of P sorbing industrial waste suitable for removing P from a pallic soil	Steel melter slag recommended - non toxic, neutral pH	SI	P	P sorbents
G36	Evaluation of two management options to improve the water quality of Lake Brunner, New Zealand.	McDowell RW (2010)	New Zealand Journal of Agricultural Research 53:59-69.	Evaluation of two management options to improve lake water quality	Use of RPR instead of superphosphate decreases P losses. Use of alum on west coast pastures ineffective. May have been washed off	SI	P	Fertiliser form P sorbents
G42	Assessment of a technique to remove phosphorus from streamflow.	McDowell RW, Hawke M, McIntosh JJ (2007)	New Zealand Journal of Agricultural Research 50:503-510.	Evaluation of P socks containing steel melter slag for removal of P from a stream	Effective removal strategy at low flows but ineffective at high flows > 20 L/sec. More expensive than alum dosing. More cost effective strategy would be to use steel melter slag to prevent P loss to waterways from critical areas	Rerewhakaaitu	P	P sorbents
G43	Management options to decrease phosphorus and sediment losses from irrigated cropland grazed by cattle and sheep.	McDowell RW, Houlbrooke DJ (2009)	Soil Use and Management 25:224-233.	Study of overland P loss from grazed cropland and management options	P loss greater from forage cropland than pasture. Irrigation management important as losses depend on soil moisture status. Restricted grazing and application of alum reduces P losses	SI	P	P sorbents Forage crop management
G49	Treatment of drainage water with industrial by-products to prevent phosphorus loss from tile-drained land.	McDowell RW, Sharpley AN, Bourke B (2008)	Journal of Environmental Quality 37:1575-1582.	Effectiveness of selective industrial by-products for prevention of P loss from tile-drained land	Backfilling mole-tile drains with slag reduced P loss.	SI	P	P sorbents
G65	Low-dose alum application trialled as a management tool for internal nutrient loads in Lake Okaro, New Zealand.	Paul WJ, Hamilton DP, Gibbs MM (2008)	New Zealand Journal of Marine Freshwater Research 42:207-217.	Evaluation of alum application for reduction of internal nutrient loads in Lake Okaro.	Not successful due to dose rate, timing, P species conc. and the pH of the water column at time of application	Rotorua	P	P sorbents
I27	Dairy farm drainage nitrate attenuation wetlands and filters.	James Sukias, C Tanner and L McKergow, (2006).	In: Implementing sustainable nutrient management strategies in agriculture. (Eds L.D. Currie and J.A. Hanly). Occasional Report No. 19. Fertilizer and Lime Research Centre, Massey University, Palmerston North, New Zealand.	Compare the effectiveness of constructed wetlands and wood chip filters for removal of nitrate	To be effective constructed wetlands should be 2-5% of catchment area; woodchip filters 1.2-2.4% of catchment area.	Waikato	N	Wetlands N sorbents

Id	Title	Author (Year)	Reference	Objective / Study aim	Findings	Location	N/P	Topic
I57	Implementing on-farm P mitigations in Rerewhaakitu catchment .	Bob Longhurst, M Hawke, B Parker and S Balvert, (2009).	In: Nutrient management in a rapidly changing world. (Eds L.D. Currie and C.L. Lindsay). Occasional Report No. 22. Fertilizer and Lime Research Centre, Massey University, Palmerston North, New Zealand.	Development of methods / strategies on a catchment scale to assist farmers minimise the environmental impact of farming on a lake	Identifcation of critical source areas and implementation of mitigation measures such as filter strips, sediment traps and P-sorbents	Rerewhakaaitu	N&P	P sorbents Filter strips

Id	Title	Author (Year)	Reference	Objective / Study aim	Findings	Location	N/P	Topic
A37	Influence of different forage grasses on nitrate capture and leaching loss from a pumice soil.	Popay, A. J. and J. R. Crush (2010).	Grass and Forage Science 65(1): 28-37.	Determine effect of forage grasses on N updake and leaching loss	Endophyte had no effect on uptake or leaching. High aerial DM, large root systems extending below 20cm increase N interception and reduce leaching loss	Not specified	N	Pasture species

WRC literature survey - N & P loss from land to water

Published Papers - Races

Id	Title	Author (Year)	Reference	Objective / Study aim	Findings	Location	N/P	Topic
D012	Potential phosphorus and sediment loads from sources within a dairy farmed catchment.	Lucci, G. M., R. W. McDowell, et al. (2010).	Soil Use & Management 26(1): 44-52.	Determine P loads from sources withn a dairy farmed catchment	P loss: trough > crossing > gateway > pasture. Causal factors predicting P load identified: Olsen P, % bare ground, % saturation	SI	P	Races Optimal soil test P
D080	Sources of sediment and phosphorus in stream flow of a highly productive dairy farmed catchment.	McDowell, R. W. and R. J. Wilcock (2007).	Journal of Environmental Quality 36(2): 540-548.	Quantify P loss to a stream in a dairy catchment	Modelled P losses to establish P sources: topsoil by overland flow - maybe lanes. Riparian protection and management of soil P recommended	SI	P	Critical source areas Riparian management Races Optimal soil test P

Id	Title	Author (Year)	Reference	Objective / Study aim	Findings	Location	N/P	Topic
G27	In-channel coarse sediment trap: Best management practice.	Hudson HR (2002)	Environmental Management Associates Ltd, Ministry of Agriculture and Forestry.	Description of BMP for design and operation of an in channel course sediment trap	-	Not specified	P	Retention dams
G45	Monitoring the impact of farm practices on water quality in the Otago and Southland deer focus farms.	McDowell RW, McGrouther N, Morgan G, Srinivasan MS, Stevens DR, Johnson M, Copland R (2006)	Proceedings of the New Zealand Grassland Association 68:183-188	Quantify the effect of selected strategies in terms of improving soil and water quality on deer focus farms	Sediment trap reduces TP concentrations by 10%. Fencing off improved water quality	Otago & Southland, SI	P	Retention dams Fencing waterways
G63	Ecological function of drainage ditches in attenuating ammonium and phosphate pollutants from dairy farms.	Nguyen ML, Sukias JPS, Nagels JW, Reeves P (2002)	In: Dairy farm soil management (Currie LD, Loganathan P Eds.), Occasional Report No. 15, Fertilizer and Lime Research Centre, Massey University, Palmerston North, New Zealand.	Study of the function of drainage ditches in attenuation of ammonium and phosphate	P in solution when introduced to the drain was reduced by 56% over a distance of 150m	Not specified	P	Retention dams

Id	Title	Author (Year)	Reference	Objective / Study aim	Findings	Location	N/P	Topic
A05	Reduced nitrate leaching from livestock in a large lake catchment in New Zealand.	Betteridge, K., S. F. Ledgard, et al. (2005).	Precision livestock farming '05. S. Cox (Ed.). Wageningen, Wageningen Academic Publishers: 49-56.	Investigate nitrate leaching potential of cropping and drystock farm systems in Taupo catchment	Nitrate leaching from annual cropping > perennial cropping.	Taupo	N	Forage crop management
A36	Effect of early season leaching on the amount and distribution of soil mineral nitrogen under a maize grain crop in Waikato.	Pearson, A. and L. Reynolds (2007).	Agronomy New Zealand 37: 29-36.	Determine extent of in-season N leaching from Waikato maize crops	N movement restricted to maize rooting zone. Following harvest in absence of crop uptake leaching will occur.	Waikato	N	Forage crop management
D037	Restricting the grazing time of cattle to decrease phosphorus, sediment and E-coli losses in overland flow from cropland.	McDowell, R. W., J. J. Drewry, et al. (2005).	Australian Journal of Soil Research 43(1): 61-66.	Study of the effects of restricted grazing of brassica crops on soil physical properties and P loss by overland flow.	Restricted grazing of forage crops in winter was beneficial for reducing contaminant loss.	SI	P	Restricted grazing Forage crop management
D041	Phosphorus, nitrogen and sediment losses from irrigated cropland and pasture grazed by cattle and sheep.	McDowell, R. W. and D. J. Houlbrooke (2008).	Proceedings of the New Zealand Grassland Association 70: 77-83.	Determine N & P losses arising during grazing of irrigated forage plots by sheep and beef.	P loss due to irrigation events: 30% cattle, < 20% sheep N & P losses: cattle > sheep Urine patch > Non urine patch areas Focus: Reduce irrigation induced overland flow, adopt restricted grazing with stand-off pad	North Otago, SI	N&P	Irrigation Restricted grazing Forage crop management
G43	Management options to decrease phosphorus and sediment losses from irrigated cropland grazed by cattle and sheep.	McDowell RW, Houlbrooke DJ (2009)	Soil Use and Management 25:224-233.	Study of overland P loss from grazed cropland and management options	P loss greater from forage cropland than pasture. Irrigation management important as losses depend on soil moisture status. Restricted grazing and application of alum reduces P losses	SI	P	P sorbents Forage crop management
I37	Winter cover crops affect soil mineral N levels and nitrate leaching.	Scott Shaw and A Pearson, (2008).	In: Carbon and nutrient management in agriculture. (Eds L.D. Currie and L.J. Yates). Occasional Report No. 21. Fertilizer and Lime Research Centre, Massey University, Palmerston North, New Zealand.	Investigate the effect of cover crops of maize production and N losses	Soil mineral N at the start of winter and the choice of cover crop have a direct effect on winter leaching and the mineral N available at the end of winter	Hastings Otorohanga	N	Forage crop management

Id	Title	Author (Year)	Reference	Objective / Study aim	Findings	Location	N/P	Topic
I39	Potential for maize to recycle leached soil nitrate.	Jeff Reid and S R Shaw, (2008).	In: Carbon and nutrient management in agriculture. (Eds L.D. Currie and L.J. Yates). Occasional Report No. 21. Fertilizer and Lime Research Centre, Massey University, Palmerston North, New Zealand.	Establish if maize can recover N previously leached to the subsoil	Maize crops show substantial potential. However to do this without compromising production will require sophisticated tools.	Not relevant - In lab modelling	N	Forage crop management
I43	Winter grazing of a forage crop; effects on nitrate leaching .	Mark Shepherd, M Sprosen, S Ledgard and D Smeaton, (2009).	In: Nutrient management in a rapidly changing world. (Eds L.D. Currie and C.L. Lindsay). Occasional Report No. 22. Fertilizer and Lime Research Centre, Massey University, Palmerston North, New Zealand.	Quantify nitrate losses following grazing of a winter forage crop and measure the effect of DCD application	The risk of leaching N when winter grazing forage crops is high. 52% of leaching attributable to forage crop and winter fallow. DCD reduced total N leaching by up to 24%	Taupo	N	Inhibitors Forage crop management
I52	Targeting DCD at critical source areas as a nitrogen loss mitigation strategy.	Keith Betteridge, F Li, D Costall, A Roberts, W Catto, A Richardson and J Gates, (2011).	In: Adding to the knowledge base for the nutrient manager. (Eds L.D. Currie and C L. Christensen). http://flrc.massey.ac.nz/publications.html. Occasional Report No. 24. Fertilizer and Lime Research Centre, Massey University, Palmerston North, New Zealand.	Determine the effectiveness of DCD on two farms in the Taupo catchment and identify campsites on hill paddocks	N loss greater on strip grazed pastures. DCD reduced N leaching. Both nitrate and NH4+ leached down the profile. GPS tracking of cows did not identify obvious campsites	Taupo	N	Inhibitors Forage crop management

Id	Title	Author (Year)	Reference	Objective / Study aim	Findings	Location	N/P	Topic
A14	Potential for nitrate leaching from different land uses in the Pukekohe area.	Crush, J. R., S. N. Cathcart, et al. (1997).	Proceedings of the New Zealand Grassland Association 59: 55-58.	N leaching modelled from different land-uses in Pukekohe area	Land use options ranked. Winter crops have higher N surplus than summer crops. Practices increasing leaching were: high N fert, prolonged history of cultivation, no cover crops	Pukekohe	N	Arable / hort Fertiliser use
A18	Winter nitrate leaching losses from three land uses in the Pukekohe area of New Zealand.	Francis, G. S., L. A. Trimmer, et al. (2003).	New Zealand Journal of Agricultural Research 46(3): 215-224.	Compare nitrate leaching losses from three different land-uses (dairy, winter potatoes, winter greens)	Dairy < Winter greens < Winter potatoes. Drivers: Pre-winter N fert and mineralisation of residues	Pukekohe	N	Arable / hort Fertiliser use

Id	Title	Author (Year)	Reference	Objective / Study aim	Findings	Location	N/P	Topic
B18	Nitrogen cycling in low input legume-based agriculture, with emphasis on legume/grass pastures.	Ledgard, S. F. (2001).	Plant and Soil 228(1): 43-59.	Discuss N flows with respect to legume based N fixation.	Dietary management and stock management, methods for improving N efficiency in legume based farming systems are discussed.	Not specified - Review	N	Suppl feeds Stock management
B30	Nitrogen inputs and losses from clover/grass pastures grazed by dairy cows, as affected by nitrogen fertilizer application.	Ledgard, S. F., J. W. Penno, et al. (1999).	Journal of Agricultural Science 132(2): 215-225.	Study N flows within a Waikato dairy farmlet affected by N fertiliser and imported maize silage	Maize supplementation improved N efficiency and reduced N losses compared to application of N fert. Application of N fertiliser is associated with reduced N fixation. 0N farmlet most N efficient with milk production 83% of 400N farmlet	Waikato	N	Suppl feeds Fertiliser use
I25	Nitrogen leaching and whole-system efficiency as affected by dairy intensification and mitigation practices in the resource efficient dairying trial.	Stewart Ledgard, M Sprosen, A Judge, S Lindsey, R Jensen and D Clark, (2006).	In: Implementing sustainable nutrient management strategies in agriculture. (Eds L.D. Currie and J.A. Hanly). Occasional Report No. 19. Fertilizer and Lime Research Centre, Massey University, Palmerston North, New Zealand.	Evaluate the environmental consequences of more intensive dairy farming	N fert (170 kg N/ha) with increased stocking rate increased milk production by 20%; doubled nitrate loss. Using maize silage reduced losses kg NO3-N / kg MS; include land to grow maize and whole system efficiency is reduced	Waikato	N	Suppl feeds Stock management Restricted grazing

9.2 Ongoing Research

WRC literature survey - N & P loss from land to water
New and Ongoing Research

Id	Use	Title	Contact Person	Lead Organisation	Project Objective	Comment / Reference
F01	Y	SFF: Nitrogen management for environment accountability	Sonia Whiteman	Horticulture New Zealand	Development of simple robust system(s) for measurement of nitrogen leaching in arable and horticultural production systems	
F02	Y	SFF: Targeted nitrogen mitigation	Jocelyn Reeve	Taupo Lake Care	Develop nitrogen leaching mitigation methods to sustain livestock farming within the Lake Taupo Catchment using targeted DCD application	
F03	Y	SFF: Grazing strategies and standoff use to minimise nitrogen dervied emissions from dairy farms	Jenny Jago	Stand-off Facility User Group	Develop alternative grazing and herd management strategies to reduce urine deposits on farmland and consequential N leaching	
F04	Y	SFF: Autumn winter drainage and N leaching under a cover crop following an irrigated potato crop	Monty Spencer	Potato Product Group, Horticulture New Zealand	Measure how effective a winter cover crop is at retaining and recycling the remaining nitrogen following an irrigated potato crop	
F08	Y	FRST: Redesigning nitrogen management	Hong J. Di	Lincoln University	Develop new nitrification inhibitor technology to reduce leaching from New Zealand dairy farms	
F09	Y	FRST: Delivering environmental solutions for sustainable productivity outcomes for NZ pastoral industries	Cecile de Klein	AgResearch	Provide farmer-friendly tools for measurement and mitigation of N and P losses to waterways. Develop frameworks for monitoring, adoption of BMPs with consideration for environmental, economic, social and cultural impacts	Recently updated for second round - under review.

Id	Use	Title	Contact Person	Lead Organisation	Project Objective	Comment / Reference
F11	Y	FRST: Clean water, productive land	Richard McDowell	AgResearch	Understand spatial and temporal variability of contaminant loss to efficiently develop practical tools and BMPs to assist managers, industry and regulators achieve acceptable water quality targets	
F12	Y	FRST: Aquatic rehabilitation	John Quinn	NIWA	Maintain / improve biological integrity of threatened ecosystems and species (managed or not managed) in spite of cumulative effects of threats and impacts on indigenous ecosystems and processes.	http://www.niwa.co.nz/our-science/freshwater/research-projects/all/restoration-of-aquatic-ecosystems#null
F13	Y	FRST: Management of cumulative effects of stressor on aquatic ecosystem	Malcolm Green	NIWA	No info to hand	
F14	Y	FRST: Framework for interoperable freshwater models	Sandy Elliot		No info to hand	
F15	Y	THESIS: A study of the options to achieve water quality restoration goals in the Rotorua lakes.	Jonathan Abel	Waikato University	Study nutrient sources and pathways in the Lake Rotorua catchment to provide stakeholders and policy makers with a better understanding of how to control diffuse pollution of water-bodies.	
F16	Y	THESIS: Remediation measures to mitigate sediment and nutrient inputs from agricultural catchments to Waikato lakes	Rebecca Eivers	Waikato University	Investigate end of drain treatment systems to develop a toolbox of effective mitigations to reduce sediment and nutrient loads to lakes	

Id	Use	Title	Contact Person	Lead Organisation	Project Objective	Comment / Reference
F17	Y	OBI: Lake ecosystem restoration	Bruce Clarkson	Waikato University	Restore indigenous lake biodiversity by development and proven application of new technologies to effectively manage harmful algal blooms and pest fish	http://www.mfe.govt.nz/environmental-reporting/about/partnerships/forum-2010-05-11/craig-cary.pdf http://www.lernz.co.nz/
F18	Y	SFF: Winter Forage Crops vs pasture: Managing environmental risk	Mark Shepherd	AgResearch	Management of winter forage crops to minimise N leaching while mantaining feed supply	
F19	Y	SFF: A farmer led approach to developing a catchment plan to improve water quality	Bob Parker Ian Power	Fruition Horticulture AgResearch	Demonstrate and test how a positive and cooperative approach can achieve water quality targets while allowing profitable farming to continue.	
F20	Y	THESIS: Nitrate removal potential and hydraulic performance of carbon media for denitrification reactors	Stewart Cameron	Waikato University	Study flow of effluent through denitrification beds to determine nitrate removal using a range of carbon substrates	
F21	Y	THESIS: Nitrification Inhibitors	Brendon Welton	Waikato University	Study delivery and effectiveness of nitrification inhibitors in the field on ash and pumice soils	
F22	Y	THESIS: not known	Glen Treweek	Waikato University	Study N leaching and pasture uptake from pumice soils irrigated with municipal effluent	

Id	Use	Title	Contact Person	Lead Organisation	Project Objective	Comment / Reference
F23	Y	SFF: Preparing for river co-management: Considering different farm system's financial and environmental performance	Alison Dewes	AgResearch	Quantification of the physical and financial performance of a range of farm systems in relation to environmental impacts	
F24	Y	SFF: Uncovered stand-off facility design and management	Chris Glassey	DairyNZ	Develop guidelines for uncovered stand-off facility design and management to improve system profitability and environmental sustainability	
F25	Y	SFF: Meeting nutrient loss targets on dairy farms in the Lake Rotorua catchment	Tanira Kingi	AgResearch	On a model farm quantify the effectiveness of key management actions that demonstrate cost effective options for achieving change on individual farms and build capability among farmers to adopt technology and implement change	
F26	Y	SFF: Optimising Nutrient Use In the Piako-Waihou catchment	Nick Pool	Foundation for Arable Research	Investigate methods and technology to reduce nutrient loading in the Waihou and Piako catchments by improvement of tactical application of nutrients, in particular N & P.	
F27	Y	Groundwater assimilative capacity programme.	Murray Close Roland Stenger	Environmental Science and Research Lincoln Ventures	Study the ability of the sub-surface environment to assimilate N and P	

9.3 Whatawhata Research

WRC Literature Survey - N & P Loss to Waterbodies

Published Papers

Id	Use	Title	Author (Year)	Reference
K01	Y	Improving the economic and environmental performance of a New Zealand hill country farm catchment: 1. Goal development and assessment of current performance.	Dodd, M.B.; Thorrold, B.S.; Quinn, J.M.; Parminter, T.G.; Wedderburn, M.E. (2008).	New Zealand Journal of Agricultural Research 51: 127-141.
K02	Y	Improving the economic and environmental performance of a New Zealand hill country farm catchment: 2. Forcasting and planning land-use change.	Dodd, M.B.; Quinn, J.M.; Thorrold, B.S.; Parminter, T.G.; Wedderburn, M.E. (2008).	New Zealand Journal of Agricultural Research 51: 143-153.
K03	Y	Improving the economic and environmental performance of a New Zealand hill country farm catchment: 3. Short term outcomes of land use change.	Dodd, M.B.; Quinn, J.M.; Thorrold, B.S.; Parminter, T.G.; Wedderburn, M.E. (2008).	New Zealand Journal of Agricultural Research 53: 155-169.
K04	Y	Transformation towards agricultural sustainability in New Zealand hill country pastoral landscapes.	Dodd, M.B.; Wedderburn, M.E.; Parminter, T.G.; Thorrold, B.S.; Quinn, J.M. (2008).	Agricultural Systems 98: 95-107.
K05	Y	Review of recent rural catchment-based research in New Zealand.	Dodd, M.B.; Wilcox, B.; Parminter, T. (2009).	Report for MAF Policy