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Dairy farming grazing management practices in the Waikato region

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Te Kaunihera ā Rohe o Waikato

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Executive summary

Nutrient management is a focus for the Waikato Regional Council due to its role in managing the region's water quality. Nutrients from the land seep into groundwater, flow into waterways and lead to reduced water quality. Monitoring shows that nutrient concentrations in waterways are increasing across intensively farmed areas in the region.

Related to the issue of increased nutrients in waterways, soil compaction and excessive fertility in the region's soils are common issues. Stocking pressure can lead to pugging of soils. Pugging results in compaction of the pore spaces in the soil so that water logging can occur leading to nutrients and bacteria running off into waterways. Excessive fertility results when more fertiliser is added to soils than plants can use. This extra fertiliser can leach into waterways or get washed off with soil particles when it rains (Environment Waikato, 2008). These processes mean that there is strong connection between farmers' grazing management practices and nutrient management.

The purpose of this research is to understand the grazing management decisions of dairy farmers' in the Waikato region, and relate that to nutrient management issues to give a picture of how nutrient management practices are, or could be, incorporated into the various farm contexts. The focus of the research is on the winter practices that help or exacerbate nutrient management. A companion report focuses on beef and sheep farming.

Asking farmers why they choose certain practices over others, or why they may have made changes to their farm system, can provide insight into the likelihood of the adoption of practices. It can help identify areas of the farm system where farmers are already exercising recommended practices. It can also indicate potential barriers or obstacles associated with certain practices, which could impede the adoption of new practices.

In all, 36 farmers participated in the research through in-depth interviews. Interviews were undertaken in the main dairying areas of the region. A quarter of those interviewed ran grass-based production systems, while the remaining farmers imported varying amounts of feed ranging from 10-35 percent. Herd sizes ranges from 70 to 3900 cows with a median of 470. Soils, climate, rainfall and topography varied, which lead to variation in grazing management practices.

This report presents the recommended nutrient management practices available to farmers and the actual grazing management practices of farmers from the interviews. Grazing rotation, fertiliser application, stocking rates, wintering off and standing off practices, feed systems (including the use of grown supplements) are covered in the report.

The table below draws together the recommended practices with the farm practice to see where practices are currently undertaken and where potential exists for practice change and where barriers exist to adoption. The report contains more detail, including verbatim comments from the participant farmers to illustrate how and why these practices are integrated into their respective farm systems.

Table 1 Summary of farm practices for nutrient management

Recommended Management Practice	Summary of practices and potential barriers to uptake
Nutrient Budget Nutrient Budgets assist farmers to identify where savings can be made and monitor the amount of nutrient leaching occurring from their system	Uptake amongst farmers was high due to the recent push by Fonterra and the fertiliser industry. Findings from this research indicate that many farmers prefer to use a combination of soil test results, recommendations from trusted farm consultants/advisors and their own experience to determine their fertiliser regime rather than follow a nutrient budget exclusively. Farmers also liked to retain the flexibility to alter their practices in response to seasonal conditions throughout the year. In general, farmers viewed nutrient budgets as a helpful tool, even if only used as a general guide, and some found that it had led to saving in fertiliser costs.
Nutrient Management Plan (NMP) A NMP provides farmers with a list of actions to mitigate nitrogen (N) and phosphorus (P) losses from their system	This study found a general lack of awareness about nutrient management plans, with only two farmers having a NMP. Among many farmers there was confusion as to what a NMP entailed, indicating a knowledge gap in regards to this intervention. In general, most farmers were applying amounts in excess of the 60kg of N/ha/yr threshold in the Waikato Regional Plan, which requires a NMP to be in place. This implies a knowledge gap in respect of the rule. The effectiveness of nutrient management plans depends on their successful implementation, and recommendations in a NMP may have significant impacts on a farm system. While NMP preparation may focus on a Nutrient Budget and some best management practices, a farm system based plan prepared by a farm consultant may cost in the order of $3,000 to $5,000. This is a significant cost given farmers are not aware of the advantages, if any, that a NMP offers them over a nutrient budget.
Fertiliser management - nitrogen management Nitrogen management practices include: avoiding applications in winter to reduce the risk of leaching, reducing N rates in line with the Nutrient Budget, using nitrification inhibitors	Many farmers avoided application of nitrogen fertiliser during the winter months because they want to ensure pasture uptake. Farmers are aware of the importance of temperature and moisture to get maximum value from their fertiliser. However, a few farmers did apply small dressings of nitrogen through the winter months, and these were seen as essential to promote pasture growth. The rising costs of N resulted in a reduction in the amount of N applied for a number of farmers. However, N was seen by a number of farmers as a cost effective and preferred way to provide feed. None of the farmers we interviewed were using nitrification inhibitors. Farmers were cautious, as there is limited research on the actual benefits in dollar terms. Nitrogen management was motivated by desire to ensure adequate pasture production; hence, farmers that use nitrogen are likely to resist any suggestions that they substantially reduce their nitrogen use though they may be willing to trial more efficient N technologies.
Fertiliser management – phosphate management Phosphorus adheres strongly to soil particles, which can be transported via overland flow to waterways. Management practices should avoid	Three quarters of the farmers had Olsen P levels on farm above the recommended optimum economic return levels of 20-30 for ash and sedimentary soils and 35-45 for pumice soils. Because of increased costs, a few farmers were withholding fertiliser applications and dropping or “mining” Olsen P levels. Some farmers were dropping their Olsen P levels as nutrient budgets become more of a management tool. However, many farmers viewed their Olsen P levels as ideal and were interested in

Recommended Management Practice	Summary of practices and potential barriers to uptake
pugging of soils, stock grazing on steeper slopes and near waterways and avoid soluble fertiliser P applications during high risk months, use slow release forms of phosphate fertiliser	maintaining them. Most farmers applied their main fertiliser either in split spring and autumn dressings or in spring. Uptake of slow release forms of phosphate fertiliser was low with none using these forms currently and only a few having trialled them in the past. Phosphorus management was strongly motivated by desire to maximise pasture production, hence farmers are likely to resist any suggestions that they substantially reduce their store of phosphorus in the soil.
Fertiliser management – effluent management Key recommendations to reduce the environmental impact of dairy effluent systems are to have adequate storage to get through wet periods, storm water diversion in place to divert rainwater entering storage, omit fertiliser N inputs on effluent blocks, increase application area to capture nutrients and decrease fertiliser inputs.	Almost three quarters of farms had travelling irrigator systems under the regional plan Permitted Activity Rule. Most systems had limited storage with many needing to irrigate daily. Some had holding tanks or ponds able to store effluent for up to 6 weeks, and some farmers stated they were aware of not applying in wet periods. Those with pond systems under a discharge consent had holding capacity of 3 months up to 5 years. Most farmers were aware of the benefits of using effluent to replace fertiliser and lower costs, and were modifying fertiliser application on effluent blocks. Some still applied fertiliser when they felt it was needed. Similarly, some farmers were in the process of extending application areas or had recently extended areas in order to lower costs. Effluent management was influenced by farm context and existing expensive infrastructure. This suggests farmers are unlikely to alter their effluent management in the short-term.
Wintering practices – wintering off, managing wet soils Reducing stocking pressure over winter by wintering off, that is sending a proportion of the herd to another location when the risk of N leaching is high, or by using stand off areas (stand off pads, feed pads, yards or herd homes) to reduce time spent on paddocks, alleviating soil compaction during the wetter months of winter when nitrogen leaching risk is highest are key strategies to reduce N loss.	This study shows that winter management practices are influenced by a number of interconnected factors such as soil structure and susceptibility to pugging, herd size, type of production (grass-based / imported feed) and land availability to manage wet pasture. Many farmers who were able to keep stock at home during the winter had a strong preference for this action because of the desire to control cow condition. The cost of wintering off is a major barrier for some farmers. Finding affordable grazing within the Waikato region was not always possible, bringing increased stock transport costs and for inspection visits. Other farmers noted that they had sufficient space to manage their stock on their farm. Therefore wintering off was seen as unnecessary with no added benefit to their management system. Technologies such as feedpads, stand off pads or herd homes can require considerable capital investment. Of note was the finding that some farmers felt their current practices were sufficient to manage wet soils and stand off infrastructure was considered unnecessary. Conversely, some farmers used their stand off infrastructure extensively through the winter. Wintering off was strongly influenced by farm context particularly the need to manage feed deficits, water logging and farm infrastructure. This suggests farmers are unlikely to modify their wintering practices.
Supplementary feed Imported low-N	This study found that the use of feed to supplement pasture deficits depends on whether there is enough space available to

Recommended Management Practice	Summary of practices and potential barriers to uptake
supplements can be used to overcome feed deficits instead of relying on N to boost pasture growth. Crops can support feed deficits, but concentrating large numbers of stock for long periods in cropped paddocks can result in pugging and compaction of soil, increased risk of, P and N loss from urine and dung and transport of faecal coliforms from dung, and damages the soil reducing long-term productivity.	grow supplementary feed, the cost of purchased feed and ability to feed out. Farmers noted that farm topography and soils affected their ability to feed out on paddocks. In terms of bought in feed, some farmers strongly expressed that the move to a higher input farm was not desirable because of increased costs and management. Other farmers maintained that N was the cheapest way to fill feed deficits and did not see a financial benefit to either buying in or growing feed. Turnips were commonly grown as a summer crop and were part of re-grassing programmes. Paddocks were typically grazed bare and then re-seeded. Supplementary feeding practices were strongly influenced by farm context particularly the capacity to grow supplementary feed, the cost of purchased feed and ability to feed out. This suggests farmers are unlikely to make major changes to their supplementary feeding practices to reduce nutrient emissions.
Riparian Management Riparian fencing can reduce the amount of P, sediment and microbes (such as faecal bacteria) entering the water by preventing stock from trampling banks and accessing waterways. Riparian planting further helps stabilise banks and block the movement of soil particles from land into waterways.	Many farmers reported fencing of waterways and drains. For most, this was done to stop stock wandering and damaging banks. Some mentioned they were aware of the benefits to water quality also. For some farmers, a barrier to uptake was the threat of recurrent flooding and damage to fencing. This was costly to repair so areas prone to flooding were purposely avoided. Few farmers mentioned that they had undertaken riparian planting. Those that had felt it made their property more attractive. A couple of farmers noted management of weeds in planted areas was of concern. This suggests farmers are unlikely to invest in riparian fencing to reduce nutrient emissions.

Summary and recommendations

Even though the environmental and economic benefits of a particular practice may appear to be well established, at the farm level there may still be sensible hesitation amongst farmers to adopt practices as the transition to a new practice may be of little or no benefit, involve significant costs, or present unwanted management issues.

This research has shown that there are a number of factors that farmers must consider (such as climate, soils and topography) when assessing new practices. Benefits may not be present for those farmers who in their opinion have sufficient management methods in place to get through winter months. There is some hesitation where there is insufficient information available about a particular practice, for example the use of nitrification inhibitors. For some farm contexts change in practices may simply be impractical, for example a shift from an effluent pond system to land application.

For these reasons, it is clear that 'a one size fits all' approach to nutrient management is not suitable and a more nuanced farm level approach is needed. In addition, for some wintering practices such as wintering off farmers will be very resistant to change while other practices (such as type of N or P applied) may be more easily changed.

It is clear from the table above that there are a number of wintering practices that are currently undertaken that align with the policy objective to reduce nutrient leaching, particularly during the winter risk period, and that these practices are generally adopted for the purpose of maintaining farm productivity through managing pasture and stock condition. In addition, from a policy perspective, some practices have been adopted but not necessarily in a manner that will achieve the policy objective, for example the extent of riparian management.

From the research findings, the following recommendations are made. That the Waikato Regional Council:

1. Continue to work closely with farm advisors/consultants to ensure consistency of messages around nutrient management tools and methods of disseminating information to farmers.

2. Work collaboratively with industry to promote the economic benefits of using a nutrient budget as a primary nutrient management tool.

3. Work to lift farmers' understanding of nutrient budgeting and interpretation of Overseer results to increase farmers' perception of the value-add of nutrient management to their business

4. Focus on the promotion of the purpose of Nutrient Management Plans and the associated regulations that require farmers to have a NMP in place. EW should focus on promoting the benefits to farmers of using a NMP.

5. Work towards increasing awareness, understanding and use of new technologies such as nitrification inhibitors and alternative low-N feed supplements by continuing to advocate for regional field trials, offering incentives and through promoting the economic and environmental benefits.

6. Work towards clarifying policies in relation to effluent storage. Continue to promote sound effluent management and application practices. Continue to advocate for industry support in regard to compliance with effluent regulations. Continue to advocate for improvements in the design of effluent systems to reduce failures.

7. Consider an investigation into the development of recommended grass residual lengths for the Waikato region (which considers the variance in soil type, rainfall, temperature etc) to limit nutrient losses through overland flow.

8. Continue to promote riparian management and address the gap between farm practice and effective nutrient mitigation through targeted communication about requirements and offering incentives.

9. Incorporate the variability in farm context in any voluntary nutrient management 'tool kits' promoted.

10. Promote research on nitrogen and phosphorus transport mechanisms to waterways, and in particular the risk periods for stock management and fertiliser application.

11. Recognise the variation in farm context in any regulatory framework put in place to promote nutrient management practices on farm.

1 Introduction

Waikato Regional Council has a statutory role to manage water quality and land use where it affects soil and water bodies. Water quality is consistently rated the highest environmental concern in surveys of the Waikato community. Sediment, microbial contamination and nutrients adversely affect water quality. Land use practices contribute these and other contaminants to water bodies, much of which comes from diffuse sources.

There is a clear trend towards greater concentration of nutrients in the region's waterways, making nutrients a focus for the Waikato Regional Council. Nutrients from the land seep into groundwater, or flow into streams, rivers and lakes. Increasing nutrient concentrations can lead to increased weed and algae growth (decreasing water clarity), low oxygen levels (affecting aquatic life) and can lead to toxic algal blooms (Environment Waikato, 2008). Moreover, declining waterway health can affect both the mauri of the waterway and its capacity to support traditional cultural activities (Ritchie, 2007).

Related to the issue of increased nutrients in waterways, there are also indications that soil compaction and excessive fertility in the region's soils are common problems. Excessive stocking pressure can lead to pugging of soils. Pugging results in compaction of the pore spaces in the soil so that water logging can occur leading to nutrients and bacteria running off into waterways. In general, as stocking rates increase on grazed pasture, more urine is deposited. This increases the potential for nitrogen to be leached below the root zone and enter ground and surface water (Waikato Regional Council 2008). Excessive soil fertility results when more fertiliser is added to soils than plants can use. This extra fertiliser can leach into waterways or get washed off with soil particles when it rains (Waikato Regional Council, 2008). Therefore, there is a strong connection between farmers' grazing management practices (such as stocking rate and management, fertiliser use, feed manipulation) and nutrient management.

In August 2007, the Waikato Regional Council commissioned a report to summarise current scientific understanding and gaps in knowledge about on-farm nutrient management practices, and to identify the effectiveness of on-farm practices in reducing nutrient losses from the farm system (Ritchie, 2007).

In that report Ritchie (2007) noted that while there are a range of nutrient management practices currently available for farmers to adopt, there are currently only a few practices that are easily adopted into a farm system that have both a positive impact on farm income and the environment. In addition, local climatic, soil and farm management variables influence the magnitude of environmental gain from implementing different practices (Ritchie, 2007). Both the extent to which farmers are adopting these practices, and the decision-making that influences their choice to adopt or reject a practice, are not known.

Because of these important information gaps, the council commissioned this report on the adoption of grazing management practices by dairy farmers in the Waikato region. In particular, this report provides an understanding of dairy farmers' decision-making around the adoption of a variety of practices within the context of their grazing management systems, and how these practices link to farm nutrient management. A companion study focuses on beef and sheep farmers.

The aim of this report is to assist policy makers and those in education and advisory roles about farm nutrient management by providing information about dairy farmer decision-making and current practices at the farm-scale to enable delivery of targeted advisory/education programmes and practical recommendations to determine effective policy options.

The findings in this report are based on interviews with 36 dairy farmers in the Waikato region. Interviews were conducted in a manner that enabled farmers to describe their farm systems, their grazing management routines and the decisions they made when undertaking, trialling, adopting or rejecting various practices. The interviews were not intended or designed to be an assessment of environmental best practice or to assess compliance with Council rules (for example those for dairy effluent management). However, where farmers had experience of non-compliance, they openly discussed incidents, and these were explored as part of understanding nutrient and grazing management practices.

The theoretical framework utilised to inform the design of this study and interpret the findings is the Kaine Framework (Kaine 2004); which is briefly outlined in section three of this report. The findings for each of the grazing management practices are presented with an emphasis on their role in nutrient management. The analysis of the interviews also includes using the Framework to segment farmers' wintering off and wet soil management practices, two important practices for nutrient management.

A discussion of the findings about grazing management practices in relation to nutrient management practices is given. An assessment about the likely adoption of each nutrient reduction practice is provided by taking account of the benefits and costs that farmers' decision-making revealed about each practice, and its integration with the farm system. This integration with the wider farm system and context is the focus rather than the 'ease of adoption', where ease is often framed as low barriers to implementation (such as cost).

2 Background

There are 3,500 dairy herds in the Waikato region, 30.5 per cent of the national total (Dairy NZ 2010). The region's dairy industry is traditionally characterised by pasture based non-irrigated activities. Recent trends in the industry include the amalgamation and/or corporatisation of farms, use of irrigation, increasing herd sizes and stocking rates, and the adoption of feed pad and herd home technologies by some farmers (Cameron, et al, 2008). The map below shows the distribution of dairy farming the region.

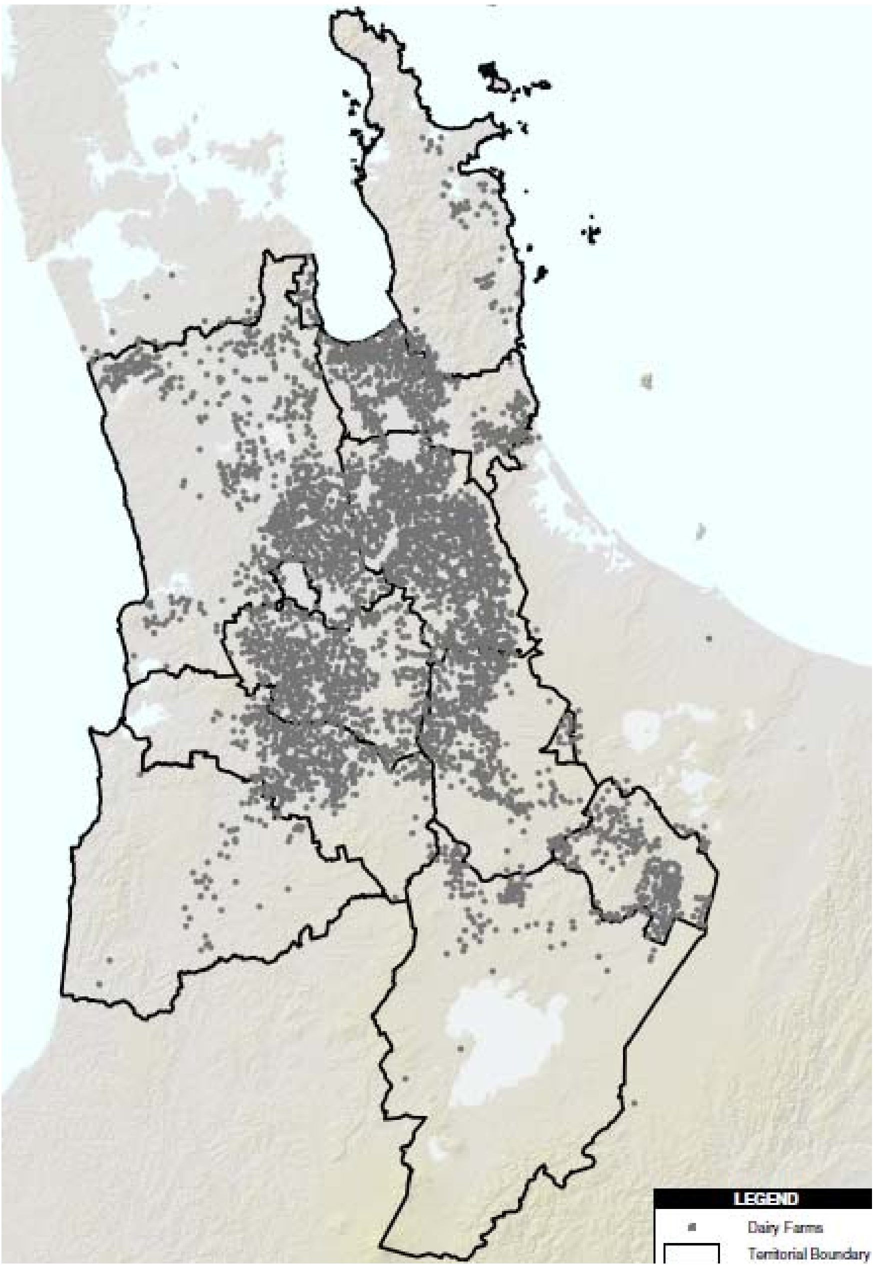

Figure 1 Dairy farming areas in the Waikato region

In addition to farm scale and production system, rainfall (average annual rainfall is 1,250 mm) soils and topography are significant contributors to the variation in grazing management practices adopted across the region.

The interview sample included farmers with dairy farms located in the Waikato River catchment upstream of Lake Karapiro and in the Hauraki Plains area. Farmers were asked to characterise the soil/s on their farm so that the research team could assess whether the sampling had covered the range of soils in the region, and to some extent the drainage properties of the soils. The sample was then mapped against the region's soils. The table below shows the main soils in the region matched against the soil descriptions given by the interviewees and are listed from most to least free-draining.

Soil	Soil description given by interviewee
Pumice	Pumice, Taupo Pumice Ash, Pumice with Ash, Tirau with Taupo Volcanic Loam
Allophanic/pumice	Waihou Silt Loam, Waihou Sandy Loam, Tirau Sandy Loam, Ash over Pumice, Tirau Ash, Waitoa Silty Loam
Allophanic	Tirau Ash, Kereone Silt Loam, Volcanic Loam
Brown/Ultic	Springdale Loam, Sandy and Silty Loam
Podzols	Tirau Ash, Mairoa Ash
Organic	Peat Loam, Hauraki Peat Loam, Peat
Gley	Marine Clay, Waitoa Sandy Loam, Springdale Loam

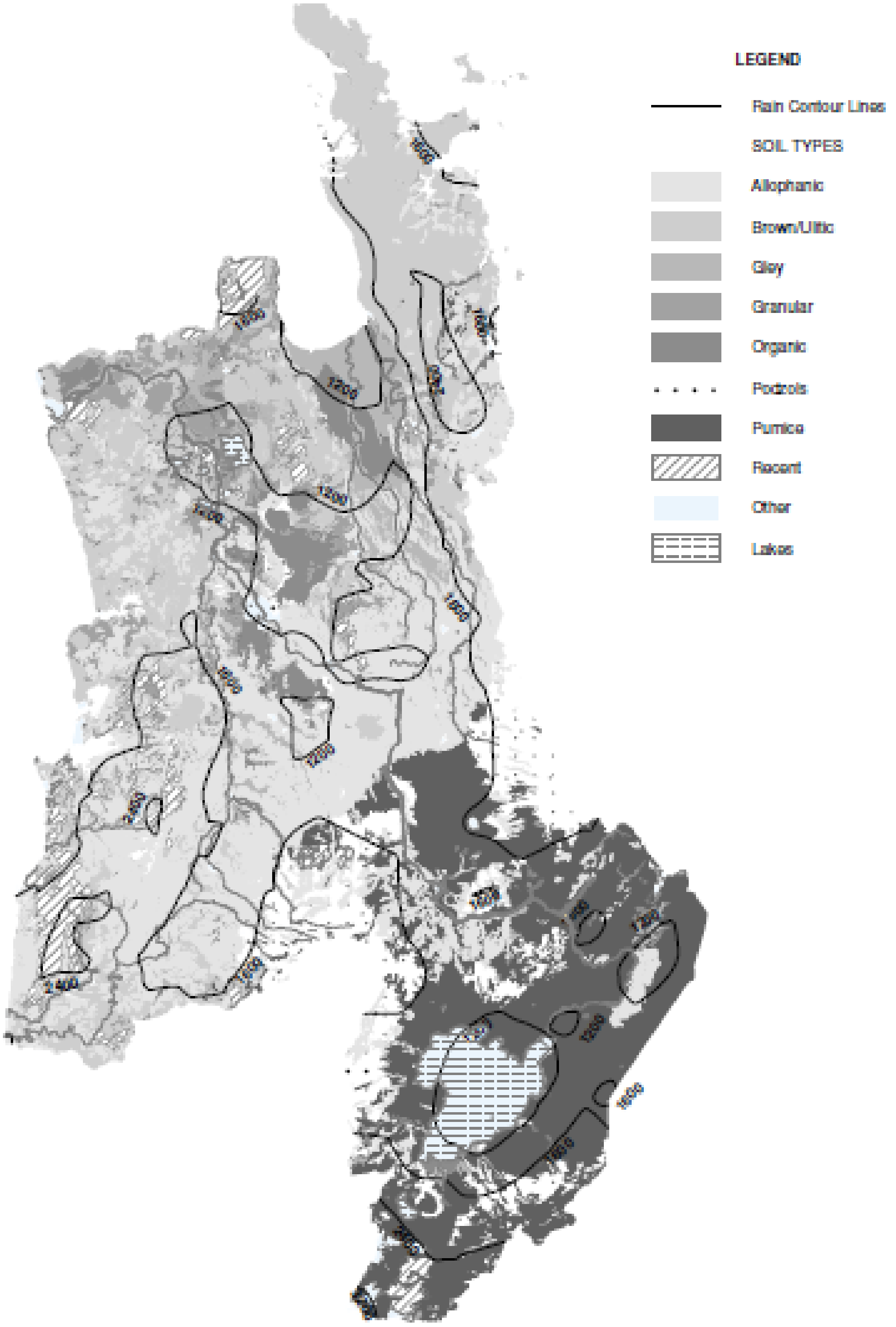

Figure 2 Distribution of soils and average annual rainfall in the Waikato region

2.1 Nutrient management practices

A range of nutrient management practices have been shown to reduce nutrient losses from dairy farms (Longhurst, 2008; Ritchie, 2007). Within the region, some practices that contribute to nutrient losses are regulated through the Waikato Regional Plan (WRP) to encourage nutrient mitigation to encourage nutrient mitigation such as those for dairy effluent disposal, fertiliser use and application, and stock exclusion from water bodies. However, a number of the practices that have been shown to reduce nutrient losses are un-regulated and adoption of these practices is voluntary.

As Ritchie (2007, page number) notes, “it is impossible to be definitive about which nutrient practices will be most affective across all farms… [and that] … not all practices have equal scope to reduce nutrient losses.” This highlights the need for customised assessments of nutrient mitigation practices for farms. Therefore, the following section briefly outlines the range of practices that are available to farmers to reduce nutrient losses. These practices should only be considered as background to the discussion of farm practices and not a definitive suite of practice recommendations.

Practices can be divided into those that assist with managing nitrogen (N) losses and those that reduce phosphorus (P) losses. This is because their pathways to water are different. Phosphorus travels attached to particles of soil or dung that wash off the land into streams, while nitrogen mainly leaches with drainage water through the soil to groundwater and eventually waterways. Phosphorus can also enter waterways from direct application of fertiliser or through effluent discharges. The majority of nitrogen (69 per cent) entering water from grazed farmland comes from stock urine, with 13 per cent comes from lanes or raceways, 8 per cent from dung and other natural sources, 5 per cent from applied sources and 5 per cent from N fertiliser (Environment Waikato, 2008).

The following mitigation options are regarded as useful nutrient management practices to reduce nutrient losses and are largely based on Longhurst (2008) and Ritchie (2007):

Nutrient Budget (NB) – a NB models farm inputs and outputs to predict the amount of nitrogen leaching and surface P run-off. Farmers can use the information from their NB to identify where savings in nutrients (particularly fertiliser purchases) can occur.

The Fonterra Dairying and Clean Streams Accord (2003) states that all dairy farmers must have systems to manage nutrient inputs and outputs. A NB should provide a system to determine the levels of nutrient surplus once all the farm inputs (fertiliser, feed supplements, clover N fixations, animal manure) and farm outputs have been calculated to estimate the levels of N and P leaching (Longhurst and Smeaton, 2008, p. 34).

Nutrient Management Plan (NMP) – a NMP extends the NB to take into consideration the whole farm context, and identifies where mitigation of N and P losses can occur. The NMP provides an action plan to reduce on-farm nutrient losses and is a requirement under the WRP once nitrogen fertiliser is being applied at rates greater than 60kg/N/ha/year (Appendix 2). Under this rule a NB must be modelled using OVERSEER® or other approved programme.

These actions may fall into one or several of the following categories:

- fertiliser management
- effluent management
- soil management
- pasture management
- production and stock management
- riparian management
- cropping management

- management of waterways risk from hot spots: silage pits, offal holes and farm dumps (Environment Waikato, 2009a).

Fertiliser Management

- Nitrogen management – recommended practices include avoiding N applications during the winter when there is more risk of leaching (May to July), making sure N is applied about 4-6 weeks before there is a feed deficit and when there is a rapid uptake of N by actively growing pasture. High rates of N fertiliser may give short-term benefits at the expense of long-term environmental damage. Total N fertiliser applications of 200 kg N/ha/year or more should only be implemented after referring to the Code of Practice for Nutrient Management (New Zealand Fertiliser Manufacturers' Research Association Inc, 2007) and obtaining the advice of an accredited consultant (Roberts and Morton, 2009 p.49).

  In general farmers could consider reducing N inputs in line with their NB and look at making more use of effluent as fertiliser. Using nitrification inhibitors may be beneficial on some farms depending on climate and soil variables, resulting in reductions in N loss.

- Phosphate management – phosphorus adheres strongly to soil particles. In the main these are transported via overland flow to waterways depending on the availability of natural drainage pathways, which are in turn controlled by climate, catchment characteristics and land management (McDowell, 2008, p. 8). For this reason it is important to avoid winter pugging of soils, manage timing of stock grazing on steeper slopes and near waterways to minimise run-off, avoid soluble fertiliser P applications during high risk months (May to October), and consider slow release forms of phosphate fertiliser.

  For most farms, it is appropriate to maintain soil Olsen P levels in the target range (20-30 for ash and sedimentary soils, 35-45 for pumice and peat soils) to get the best agronomic return (Ritchie 2006).

- Effluent management - under the Waikato Regional Plan (WRP) farmers can choose between a consented system (typically pond systems that discharge treated water to waterways) or to comply with regulations on the application of effluent to land under the Permitted Activity rules (see Appendix 1). Farmers in the region tend to favour deferred irrigation, where effluent is applied to land from a storage or effluent pond (Dexcel 2007). In most cases this practice allows effluent to be stored until soil and climatic conditions are suitable for application.

  There are a number of recommendations intended to improve efficiency and reduce the environmental impact of dairy effluent systems. It is recommended that dairy effluent systems have adequate storage capacity to get through wet periods, especially in reasonably high rainfall regions (1400+mm) (Longhurst and Smeaton 2008). Additionally, recent research has shown that hydrophobisity or 'dry patch syndrome' may also limit effluent application in prolonged dry periods, particularly in pumice (Taylor pers. comm. 2009). A stormwater diversion should be in place so that rainwater is not entering the storage area.

  Fertiliser input can be reduced on effluent blocks where omitting fertiliser N inputs can "reduce N leaching by at least 1 kg N/ha/yr on average" (Longhurst, 2008, p17). The effluent block area should be at least sufficient to meet the regional plan rules (see Appendix 1). Increasing the application area will increase the nutrient gains and decrease fertiliser inputs. Use of potassium (K) can also be reduced as K concentrations in effluent can often be higher than N concentrations. In addition to the extent of the application area, it is important that the rate and concentration of effluent application should comply with the rules so that the whole system works to limit nutrient loss.

Winter management – the environmental effects of leaving cows on wet pastures for extended periods have been widely documented (Betteridge et al., 2003, Ritchie, 2006, McDowell et al., 2008). Stocking pressure can severely damage the topsoil through pugging and compaction which can lead to poor infiltration to sub surface soils. If stock remain on these areas:

> "…damage to roots and burial of plants in the mud make the pasture unpalatable and irretrievable to stock….these effects create a direct reduction in subsequent pasture yield. As well as the damage to existing pasture and suppression of N-fixation, future pasture growth is limited by compaction due to physical resistance within the soil and anaerobic conditions that restrict root growth" (Ritchie 2006, p. 4).

Using standoff areas (standoff pads, feed pads, yards or herd homes) is recommended to reduce the time spent on paddocks, alleviating soil compaction during the wetter months of winter when nitrogen leaching risk is highest. Recent research states that the use of standoff pads can have the potential to significantly reduce N loss. Factors which affect the efficiency of standoff pads are the surface type, area per cow, frequency of use and time on the pad. Standoff pads should be designed so effluent can be collected, contained and treated before application, and should be constructed using carbon based materials (for example sawdust or shavings chips) (Longhurst, 2008). Feed pads should also have systems in place to manage effluent as cows may be on the pad for at least 2-4 hours per day when feeding (Dexcel, 2005).

In the Waikato region, there are no specific rules in relation to the practice of using sacrifice paddocks as stand off areas. Instead farmers are guided by the general rules which prohibit run off and discharge of contaminants into waterways (see Appendix 1). However, sacrifice paddocks are not recommended because the concentrated treading from cows can cause excessive pugging and soil compaction, restricting porosity. Saturated soils can then contribute to phosphorus runoff through overland flow. Where sacrifice paddocks are used, it is suggested that they need to be carefully managed by avoiding the use of paddocks near waterways and to distribute feed in different parts of the paddock to minimise stock trampling (Environment Waikato, 2008).

Wintering off, or reducing stock over winter by sending a proportion of the herd to winter at another location when the risk of N leaching is high, is a key strategy to reduce N loss, as the majority of N loss comes from stock urine.

Supplementary feed – supplements can be used to overcome feed deficits instead of relying on N to boost pasture growth. Several factors need to be considered to ensure this practice enables nutrient mitigation rather than increasing nutrient loss.

One factor is the crude protein level of various types of feed. The higher the crude protein level, the more nitrogen a feed contains. For example, palm kernel and maize silage contain 16 per cent and 8 per cent crude protein respectively, whereas pasture contains 20-25 per cent and Lucerne 18-22 per cent (Longhurst and Smeaton 2008, p.21).

In addition to a focus on low-N input supplements, nutrient mitigation practices are key to the management of grown supplements. There are a number of winter forage crops suitable for New Zealand dairy farms, the most common being brassicas and cereals.

Beare et al. (n.d. p.1) state "intensive grazing of forage crops during wet winter conditions is conducive to poor utilisation and long term damage to soil quality with consequent effects on the productivity of the following crops or pasture". As cropping is nearly always incorporated into the re-grassing programme, care needs to be taken not to leave bare soils exposed as this increases the risks of runoff, sediment loss, faecal contamination and direct losses of N through mineralisation and volatilisation processes.

Concentrating large numbers of stock for long periods in cropped paddocks can result in pugging and compaction of soil, increased risk of P and N loss from urine and dung and transport of faecal coliforms from dung, and damages the soil reducing long-term productivity.

Riparian management – in terms of nutrient management riparian fencing can reduce the amount of P, sediment and microbes (such as faecal bacteria) entering the water by preventing stock from trampling banks and accessing waterways. Wetland areas are effective at removing nitrate in drainage water, so again fencing to restrict stock access is important. Riparian planting further helps stabilise banks and block the movement of soil particles from land into waterways. In general, the steeper and longer the slope that feeds into a waterway the wider riparian planting needs to be to achieve the maximum filtering effect (Legg 2004).

However, riparian management is less successful at reducing N entering waterways as this tends to pass into groundwater from the paddock surface, rather than be transported with soil particles into waterways (Waikato Regional Council, 2008).

General farm environmental management– hot spots such as silage pits and offal holes or badly maintained tracks and races are areas that can result in nutrient loss. Good design initially, or for maintenance, will remove most of the risk of nutrient loss from these areas (for example, cut-offs to direct water into rough grass or wet areas).

Reduction of P losses - in addition to the practices described already, a number of other practices specifically assist in the reduction of P losses:

- Controlling erosion and sediment sources in upper catchments through soil conservation works;
- Changing stock types (for example, running lighter stock particularly during winter and on steep slopes);
- Grazing management of sensitive areas (for example, no heavy stock near waterways during winter);
- Keep Olsen P within the agronomic optimum range so that any soil loss does not transport high P loads to waterways.

3 Theoretical framework

Kaine (2004) suggests that a way of understanding the likely adoption of innovations is to apply farming systems theory and principles from consumer behaviour theory from the marketing literature to gain an understanding of the variability in the way grazing management practices have been adopted and applied. Farming systems theory holds that farm context (strategic, labour and lifestyle, technology and practice, and biophysical dimensions) determines the likelihood of an innovation (that is, new farm technologies and practices) offering a net benefit and, consequently, being adopted. This means the value of changes on farm can only be properly appreciated by understanding how they integrate with other practices in the farm system (Crouch, 1981, p. 126). Kaine (2004) proposes that through the application of principles from consumer behaviour theory we can genuinely understand the likely population of adopters (the market) for an innovation. This is important as often the 'scope' of strategies designed to encourage adoption of certain innovations is thought to be all farmers, whereas the likely population of voluntary adopters may in fact be considerably smaller.

Consumer behaviour theory seeks to understand the decision-making processes of individuals when they are making purchase decisions about products and services. The theory proposes that purchase decisions are categorised as being on a continuum between low and high involvement (Assael, 1998). Involvement refers to the personal relevance or importance of a product or service to the consumer, and is not an attribute of a product.

High involvement purchases are those where considerable effort is put into the purchase decision prior to, and post the purchase, for example purchasing a house or a car. Whereas with low involvement purchases such as buying bread, little cognitive effort is required with consumers preferring to rely on habit, price or other attributes (e.g. grain). Kaine and Johnson (2004) state that adoption of innovations by farmers is a high involvement decision, especially where the innovation is novel and unfamiliar, needs integrating into current farm management and has financial implications. Using this approach, we can describe the segments within a market for an agricultural innovation based on the benefits sought by the farmer, and therefore develop strategies to increase the 'rate' of adoption.

Kaine and Johnson (2004) propose that "where failure of an innovation can have serious consequences for their business, farmers may sensibly resist the introduction of new technologies or practices – thus non-adoption can be seen as a strategic and rational response to risk" (Kaine and Johnson, 2004).

Figure 3 and Figure 4 below illustrate the importance of understanding the scope and rate of adoption of an innovation. Figure 3 shows the total population (N1) that will likely voluntarily adopt a technology or innovation (the market). The use of non-regulatory persuasive policy initiatives such as provision of extension, promotion or incentives (for example Environment Waikato's Clean Streams incentive) has the effect of increasing the rate of adoption in this population (that is shortening the time of adoption by all users from T1 to T2) (Kaine and Johnson, 2004, Pannell et al. 2006). Importantly, the total number of adopters (N1) does not change.

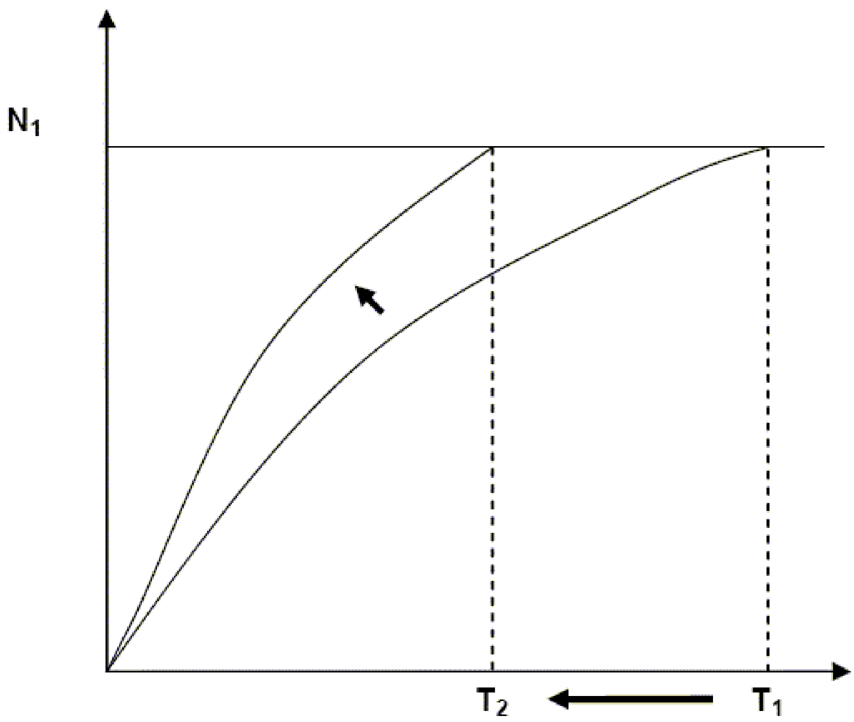

Figure 3: Accelerating the rate of adoption (source: Kaine and Johnson, 2004).

However, often policies are in place to ensure environmental outcomes. These policies may not align with farmers' motivations to adopt innovations that are beneficial to their business and integrate into their farming system, such that practices that may be considered best practice for environmental outcomes may not voluntarily be widely adopted (Pannell et al. 2006; Kaine et.al., 2004).

The graph below illustrates how the implementation of a regulatory policy initiative can expand the population of potential adopters by creating a need for change in those not 'in the market' voluntarily.

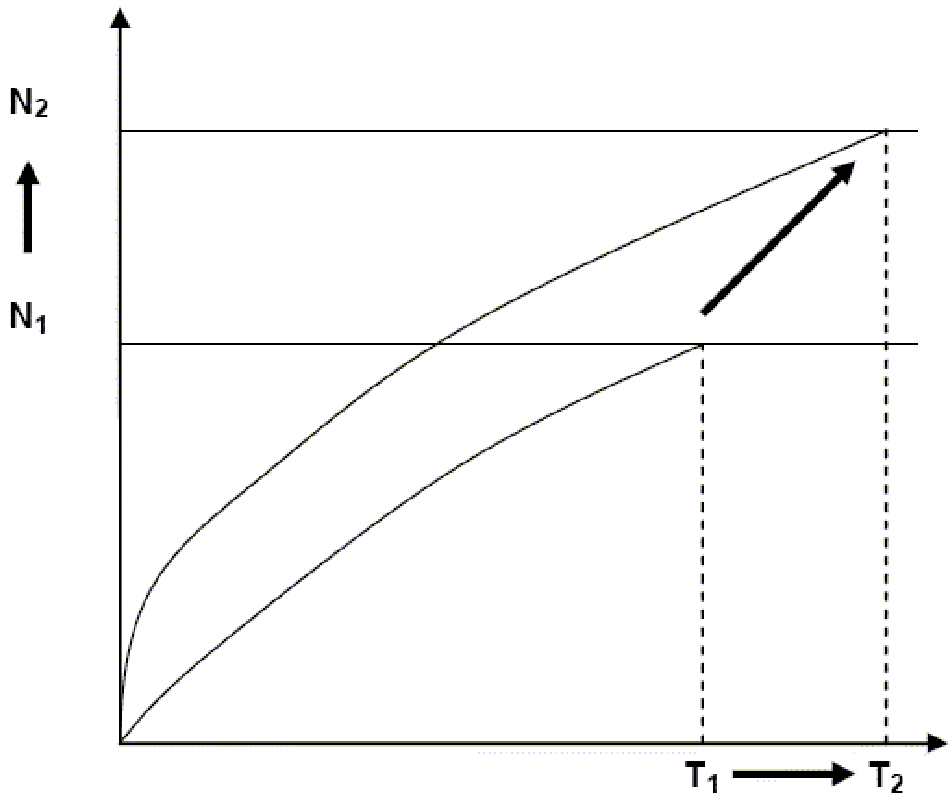

Figure 4: Increasing the population of adopters (source: Kaine and Johnson, 2004).

4 Method

Two kinds of qualitative data collection are used in the application of the Kaine Framework; laddering and convergent interviewing. These qualitative techniques are used to explore the perspectives and diversity of experiences of the participants (Flick, 2002). This method enables the researcher to explore in detail, various components of a farming system from the perspective of each participant to develop a wider picture of their farming system as a whole. A general introductory statement is offered but the interview is largely directed by the interviewee.

Convergent interviewing is used to determine the sample size. Researchers take a reflexive approach to sampling, analysing interview content continuously, so that sampling concludes when no new themes emerge to explain the phenomena of interest (Dick, 1998). While snowball sampling alone may be used with convergent interviewing, given the influence of soil and topography in determining winter management, purposive sampling was also used to efficiently identify participants in this study. The combination of laddering and convergent interviewing techniques provides a basis for generalising the interview findings, subject of course to any bias in sampling.

Semi-structured interviews were conducted with agency stakeholders prior to interviewing to provide the researchers with subject area background and the governance context in which farmers' are making their decisions.

In total 36 personal interviews were conducted between March and December 2008. They were conducted in two phases; the first phase consisting of 14 interviews was conducted in the Upper Waikato catchment, and the second phase of 22 interviews around the Hauraki Plains area. This gave a satisfactory coverage of soil and topography within the Waikato region's main dairy areas.

Farmers' decision-making was explored using the laddering technique. This technique is particularly useful as it specifically seeks to reveal chains of reasoning behind people's decision making by discovering the attributes, consequences and values behind a purchase choice (Grunert and Grunert, 1995; Reynolds and Gutman 1988). This was done by encouraging participants to talk through their decision-making. Interviewers clarify their understanding of the participants' reasoning by summarising what had been said. This ensures that the interviewers have understood the interviewee correctly and allows the interviewee the opportunity to add or explain in more detail particular aspects of their farming context. As Kaine suggests this can 'reveal subtle differences' in farmers contexts that are important to identify in terms of the applicability of certain practices' (Kaine, 2008, p. 91)

The interviews were carried out by two or more people this enabled one person to remain actively engaged in conversation, prompt the interviewees, ask for clarification and generally encourage and maintain a free flowing dialogue while the other recorded the conversation in written form, recording as much of the conversation verbatim as possible. Interviews were carried out in the farmers' homes or at a location that suited them (for example the milking shed) and typically took 40 minutes to an hour to complete. This timeframe proved to be sufficient in terms of allowing each farmer to explain their reasoning behind their grazing management practices. After each interview, the research team took time to debrief and discuss each farm context in detail. This process assists in identifying the similarities, accuracies and consistencies between recorded notes, and enables the sharing of information that may have been missed by one team member, but captured by another.

The data was then analysed case-wise to ensure that the research team had a detailed picture of individual farm contexts and the influencing factors that contributed to each farmer's decision making. Then cross-case analysis allowed the research team to identify patterns in key farming practices and explore and describe similarities and differences between farmers' systems.

For two key winter management practices, wet soil management and wintering stock on/off the home farm, the research team classified farmers into benefit segments based on the variability of those management practices and the decisions driving that variation. Decision-making trees summarising the segmentation were developed to explain the findings.

4.1 Sample structure

It is useful to look at farm attributes of the interviewees to assess the coverage of the sample. In total, 36 farmers participated in the study. Herd size ranged from 70 to 3900 cows with a median of 470. A greater proportion of herds had over 300 head compared with the regional proportion in 2007 (81 per cent and 38 per cent respectively). Reflecting herd sizes, the sample comprised a greater proportion of farms of 120 to over 400 ha (58 per cent) compared with the regional proportion of 38 per cent of farms in this size range. Farms effective area ranged from 40 to 1275 ha, with the median effective area being 234 ha. The annual stocking rate ranged from 1.6 to 4 cows per hectare, with an average rate of 3 cows/ha (median of 3.3 cows/ha), similar to the regional average stocking rate of 2.96 cows per effective hectare (DairyNZ, 2010).

As mentioned above, farms were on a range of soils and also a range of topographies from all flat land, to those with a mixture of flat and rolling land, to some with steeper areas.

DairyNZ (2008) classify production systems from one to five, based on whether feed is imported, and the time of year and amount of imported feed used. The five types of dairy farm systems are not an indication of size, profitability or scale of operation of individual farms. The DairyNZ (2008) classification of farm production systems was applied to the sample[1].

In Table 1 the sample is compared with the 2007/08 DairyBase survey of owner operators in the Waikato region - a self-selected sample of 199 farmers (Sutton, pers.comm, 2009). Our sample contains slightly more farmers in the low to medium input levels.

Table 2: Farm production system classification

System	Description	Level of input	% of sample	DairyBase % of region
1	All grass, all stock on and no feed imported. No grazing off the effective milking area[2]	low	53	37
2	Some feed imported, grazing off (4-14% feed imported)			
3	Feed imported to extend lactation (approx 10-20% of feed is imported)	med	25	37
4	Imported feed at both ends of lactation (30-40%)	high	22	26
5	All year round imported feed (25-40% but can be up to 55%).			

Note: The drought over the summer (2007-08) meant that many farmers considered themselves to be in a transitional stage in terms of feed inputs. Many were importing more feed than in previous years due to general uncertainty about the future climatic conditions and some were importing less than in previous years as feed prices increased with demand. While the intended focus of the interviews was on farmers' 'usual' practice, it appeared that some farmers were re-assessing their usual practice.

5 Findings

This section is divided into the key management components of a dairy farm system with particular emphasis on winter management, as this is the key period for nutrient loss. Each subsection has a detailed summary of the research findings for a particular practice and evidence for the findings is provided by representative quotes taken from the farmer interviews.

5.1 Grazing management

Maximising milk production from grazed pasture involves careful management of pasture growth (Grieg and Sheridan n.d). Research suggests a recommended grass residual length of 1500 – 1600 kg DM/ha as this is thought to be the optimal length to maximise pasture production by taking advantage of the actively growing state of the grass (DairyNZ, 2008a). Otherwise a pasture surplus can occur and dead materials can accumulate affecting the quality of the pasture. Alternatively, if pasture is grazed too low this can damage the plant, decreasing production and persistence of good pasture sward, and bare ground can be exposed (Fleming, 2003).

[1] Applying this classification was somewhat arbitrary as some farmers could not tell us accurately the percentage of feed they imported, especially those with system 2 and 3 farms.

[2] Note: According to this classification system, production system 1 states: "no grazing off the effective milking area", however in this sample some farmers with grass based systems also wintered off.

No specific practices are recommended for the amount of grass left after the paddock has been grazed in relation to nutrient management. However, grazing pasture too low can increase the risk of nutrient and sediment loss to waterways through runoff if bare ground is exposed, and slope and proximity to waterways should be taken into account.

Farmers' decisions on management of pasture rotations and grass residuals were based on experiences (past and present) driven by their farm context. This involved constant monitoring of climatic conditions, seasonal variations, soil characteristics, growth rates and pasture species while trying to match feed requirements at critical times of the year for example through the winter and for calving. Farmers consistently noted that their objective was to promote and ensure adequate grass growth and utilisation.

5.1.1 Pasture rotation and grass residuals

Across the range of farm systems outlined by interviewees, pasture rotation was found to be fairly consistent. In general, spring pasture rotations were between 20-30 days. Rotation was generally kept at about 20 days through the summer, with some shortening of the rate to 15-18 days when feeding out, and was lengthened by March to 30 days. Winter rotations were between 80 -120 days, with most farms at 100 days over the winter period.

Some farmers changed rotation on specific days of the year (for example May 1st lengthening to a winter rotation rate), while others changed rotation depending on pasture and weather conditions. Farmers noted the importance of planning ahead to always know they had adequate feed available. This included regular farm walks as a means of monitoring grass levels. Farmers commonly assessed grass residuals by eye, although some also used a plate meter. One farmer insisted his staff use a plate meter to ensure consistency of records.

"Use my eye-o-meter… and a computer that dates back 50 years." (Hauraki production, system 1)

"By eye, you get a better re-cover. If cows leave some grass behind you know they are being feed" (Hauraki, production system 3)

"A plate meter is just a tool to get your eye right. Usually try to aim for 1300 – 1400 but now I'm quite happy to leave a little more" (Upper Waikato, production system 1)

Grass residual levels quoted ranged from 1300kg DM/ha up to 2400kg DM/ha, with most farmers stating they aimed for between 1400 – 1600kg DM/ha. However, some farmers commented that they liked to keep higher grass residuals (1700+kg DM/ha) because they wanted to make sure they had enough grass at the beginning of calving. Some farmers mentioned that they were sceptical of the 'recommended level' of 1400-1500DM/kg, commenting that having one level does not always account for the differences in grass type or rate of growth, as these comments demonstrate:

"at this stage residuals are 2000, need 2500 for calving" (Upper Waikato, production system 4)

"Not too short, not too long, it depends on who's promoting the recommendations; our grass is thinner so we would run high" (Hauraki, production system 3)

"Lincoln University promotes 1500 [kg DM/ha] for better quality pasture, but I think other things like calf rates are compromised" (Hauraki, production system 3)

"There's an old saying, grass grows grass" (Hauraki, production system 2)

"It's a bit of a juggling act (getting the level right)" (Upper Waikato, production system 3)

5.2 Wintering practices

Wintering practices are a key focus for nutrient management on dairy farms as during this period N leaching is high (Ritchie 2007). As stated previously, having stock on wet pastures can result in soil compaction, erosion, leaching and run-off of nutrients. In addition fertiliser application through winter should be avoided. These practices are discussed in section 5.3.3.

Two key considerations drove the wintering practices of farmers in the study; slowing winter grass growth and/or pasture damage by stock in wet conditions. These conditions both lead to feed deficits that needed addressing. Wintering practices farmers adopted were those that provided sufficient feed for their herd over winter. Section 5.2.1 discusses the drivers for wintering stock off or keeping them at home, while Section 5.2.2 discusses management of wet soils.

The relationship between managing feed deficit because of slow pasture growth and due to pasture damage in wet conditions is complex, resulting in a broad range of management practices by farmers. Some farmers needed to manage stock for a lack of grass growth in combination with wet soils, while others primarily managed for pasture damage in wet conditions. This indicates the importance of wet soil management across all dairy farms and highlights the significance of climatic conditions and farm context such as topography and soil type in farmers' decision-making.

5.2.1 Wintering on and off the farm

As shown in the table below, the majority of farmers in Hauraki Plains area kept their herd at home (13 out of 19 farmers) compared with the 7 out of the 17 farmers in the Upper Waikato catchment. Six of the 19 farmers in the Hauraki Plains area and 10 out of the 17 farmers in the Upper Waikato catchment wintered off. Geographic area alone was not an indicator of whether farmers were able to winter their herd at home, climate, soils and topography influenced farmers wintering decisions as discussed below.

Interviewees were classified into six segments focussing on the strategies farmers used to manage grazing over winter. The diagram below starts by considering winter pasture deficit as this is a primary consideration in farmers' decision making to winter off or keep their herd on the home farm.

In this study a winter feed deficit is classified as having to purchase supplements over winter and does not include those supplements made on farm that may also be used over winter (such as hay and grass silage). Wintering off involves transporting a proportion of the dairy herd to a grazing block over the winter months, reducing the stocking rate on the home farm.

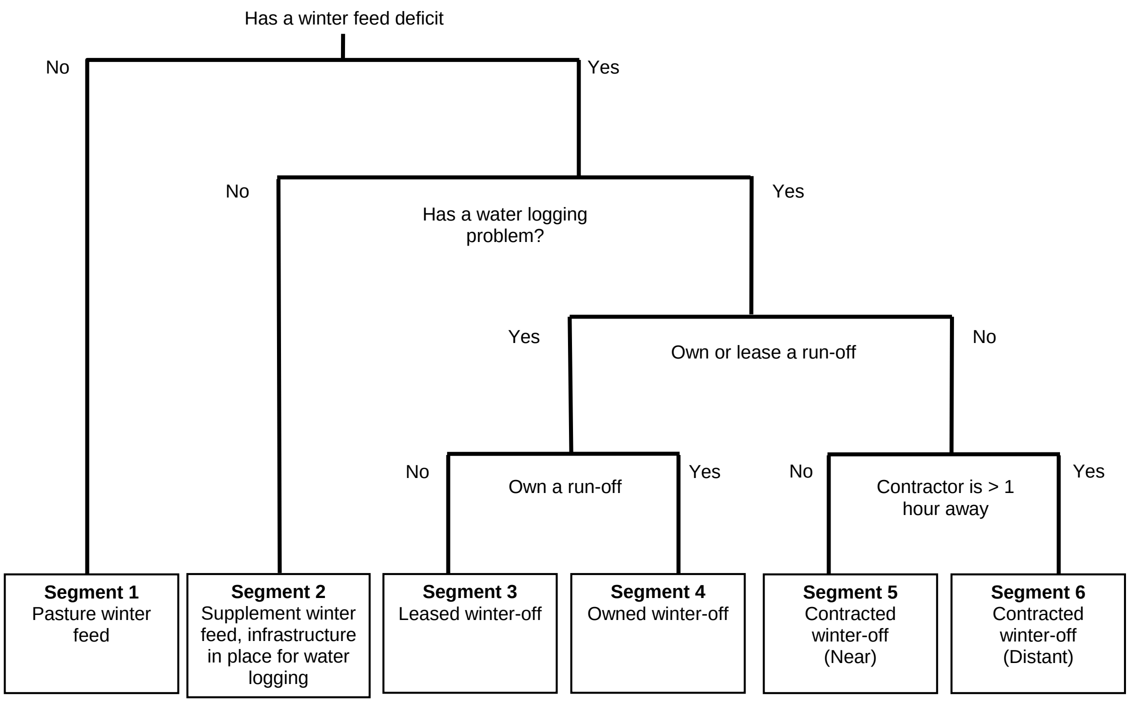

Figure 5: Decision tree for wintering on or off the farm

5.2.1.1 Wintering on

In this study, 20 out of 36 farmers kept their herd on their home farm over winter (7 in segment 1 and 13 in segment 2[3]). Farmers in segment 1 did not have a winter feed deficit, while farmers in segment 2 needed to incorporate some purchased feed to enable them to keep their herd at home.

Segment 1 farmers had grass-based systems (production system 1). All farms were on fairly flat land, however there was a mix of soil ranging from more free draining soils (allophanic and pumice), to soils susceptible to water logging (brown and gley). Of note are those farmers with soils prone to water logging who chose to winter at home. For these farmers, strategies to manage wet soils were in place, for example standing cows on the yard or other stand off areas, moving the herd to freely-draining paddocks or altering pasture rotation length (management of wet soils is discussed in further detail in 5.3.2). For some farmers control of animal condition was the key reason for keeping stock at home, while for others in the Hauraki area having sufficient grass growth during winter meant they did not need to winter off.

"grass growth rates allows us to [keep herd at home]" (Hauraki, production system 1)

"always done it [wintered at home] enough grass at home to feed simply don't need to" (Hauraki, production system 1)

Segment 2 represents those farmers who wintered at home, incorporated some purchased feed into their production system and had infrastructure in place to manage waterlogged soils. Again soils varied, with some on free-draining soils and a number on gley and organic soils prone to water logging. One farmer stated that his free-draining soils allowed him to keep the herd at home and manage through wet weather by altering pasture rotation; another with a herd home used it through the winter to prevent pasture damage.

"we have enough room to move them around" (Hauraki, production system 3)

[3] In both segments, farms were from the Hauraki and the Upper Waikato.

“I can keep them all here…all free-draining here” (Upper Waikato, production system 4)

Again, some farmers in the Hauraki area mentioned having enough grass growth through winter meant they did not need to winter off.

For farmers in segments 1 and 2 being able to monitor and control cow condition was a direct benefit of keeping the milking herd at home during winter.

“Greater degree of control” (Upper Waikato, production system 4)

A number of farmers talked about their own experiences, or those of others, of times cows had returned home in poor condition, incidences of missing stock or even stock deaths, because of mismanagement by the contract grazier as these quotes illustrate:

“There are some real horror stories out there with grazing” (Hauraki, production system 4)

“You can get variable results when you send them off” (Hauraki, production system 2)

"Been there, done that… get them home and you may as well have kept them at home and starved them" (Upper Waikato, production system 2)

For some farmers the cost of contracting graziers factored in their decision to keep the herd at home. Grazing prices were quoted as between $16-18 per head in the East Coast or Northland, to up to $30 per head in the Waikato. Some saw the choice of moving the herd to a more affordable area as too risky if the grazier was unknown to them and the increased distance would mean less frequent visits to monitor herd condition.

Another reason for wintering at home that was often expressed was time, with one farmer noting it was *“too much hassle”* because of the need to keep checking on cow condition and the distance to do so. Another stated that he used to winter cows off, but now preferred to bring extra feed onto the farm instead *“its about control of lifestyle…you don’t have issues”.* Other benefits from choosing to winter at home were savings on (increasing) transportation costs and time spent on organising transportation and grazing contracts.

5.2.1.2 Wintering off

In total 16 of the 36 farmers interviewed wintered off. The percentage of animals wintered off ranged from 8-66 per cent of the total herd, with the average being 34 per cent. The stocking rate on the home farm over winter for farmers who wintered off ranged from 1 to 3.3 cows/ha, with the average being 2.3 cows/ha (median of 2.2 cows/ha).

The key reason for wintering off across segments 3 to 6 was to overcome a feed deficit and avoid damaging waterlogged soils. This enabled farmers in this segment to maintain productivity, pasture growth and herd condition over winter. Ensuring that there was enough pasture over winter months by reducing the stocking rate was the most common reason for wintering off, with some farmers, particularly those in the Upper Waikato catchment, stating that their grass growth was too slow in winter to retain their whole herd. Almost all farmers in these segments purchased feed supplements as part of their production system with the exception of two farmers in segment 3 who ran grass-based systems.

“To reduce stocking rate - sees the farm benefits, builds up grass cover going into calving” (Hauraki, production system 3)

Almost all of the farmers commented that it was critical to maintain the live weight of their cows and have a healthy herd returning from wintering away in order for cows to get into calf. This was the key to maintaining the overall productivity of the herd.

Costs, including rising transportation costs, proximity, land availability and confidence in the grazier were the key factors in farmers' decision-making around wintering off. Nine farmers chose to manage their own stock, while seven farmers contracted a grazier.

Some farmers commented that it was sometimes difficult to find available grazing blocks nearby. Others noted that even with land available, the prices within the Waikato region were higher; in some cases almost double the prices of grazing blocks outside of the Waikato.

Segment 3 - Four farmers leased land on neighbouring or nearby properties. Blocks were managed using existing staff as these farmers believed that this allowed for tighter control and constant monitoring of cow condition.

"…rather look after our stock ourselves" (Hauraki, production system 4)

"we manage stock with our own staff while grazing away, so can keep a check on health" (Upper Waikato, production system 1)

"never done half as well as when you do it yourself" (Upper Waikato, production system 2)

Segment 4 - Five farmers owned and managed their run off blocks. The advantages of owning related to the control of herd condition and costs. It reduced the stocking rate on the home farm relieving pressure on pasture over winter, which helped ensure good pasture condition for calving. It meant farmers felt able to monitor their cows more frequently and the price of contracting grazing made it economic to own and manage their own run off block.

"take pressure off grass, drops stocking rate"
(Hauraki, production system 3)

Segment 5 - Five farmers used graziers who were located within an hour from their home farm. For these farmers it was important that graziers were within a close proximity to their home farm so they could retain some control over cow condition through regular inspections.

Segment 6 - Two farmers used contract graziers who were located more than an hour away from the home farm. One commented that they had established a good working relationship with the grazier and that this relationship was important to maintain and therefore worth the extra distance.

5.2.2 Wet soils management

Of the 36 farmers interviewed, only 7 said that pugging of pastures was not an issue on their property (5 were in the Upper Waikato region and 2 in the Hauraki region). These farms were on free-draining pumice, podzol or brown soils.

For those farms with soils prone to pugging, the soil, climate, topography and extent of pugging varied. Ten farmers described their farms as particularly bad for pugging, eight were in the Hauraki area on soils prone to pugging such as gley, organic and brown and two were farming in the Upper Waikato on allophanic/pumice soils. Pumice soils can become prone to pugging with compaction over time (Environment Waikato, 2008), and as these farmers noted top soil build up over time making pugging more of an issue for them than previously.

"We've built up this wonderful layer of top soil... if we damage it [pasture], it doesn't grow for six months …better limiting your damage to one area, than damaging your whole farm. It doesn't make sense to face that sort of damage. It's crazy."
(Upper Waikato, production system 4; pumice)

While a number on farmers on pumice soils still enjoyed free-draining conditions.

“Soils are more porous here …haven’t found need [for stand-off areas] …don’t have pugging issues” (Upper Waikato, production system 4; pumice)

In general, for the farmers who stated pugging was a management issue for them, their key concern was protecting pasture growth from damage. A few expressed concerns about the damage to soil structure and long-term effects on pasture growth, explaining that pugging damage can reduce pasture productivity for many months or even years:

"I hate pugging, pasture won’t return so going to be non productive land". Animal health as well, especially if calving, buggers up the soil structure, area doesn't drain well" (Hauraki, production system 2, gley soil)

"…look after soil structure if you damage it it's never going to be right is it, takes a long time" (Hauraki, production system 1, gley soil)

“Our soils are very sensitive here, so we have learnt the hard way not to thrash it. We still have damage from three years ago” (Hauraki, production system 2, brown soil)

As noted the extent of pugging varied between farms, and there were a number of strategies employed to manage pugging. For those on the wettest soils, grazing management to prevent damage involved frequent monitoring of weather and pasture conditions and, for some, standing off cows for extended periods throughout the winter months. The diagram below takes the farmers’ descriptions of the practices used to manage wet soils through the winter and categorises them into five segments.

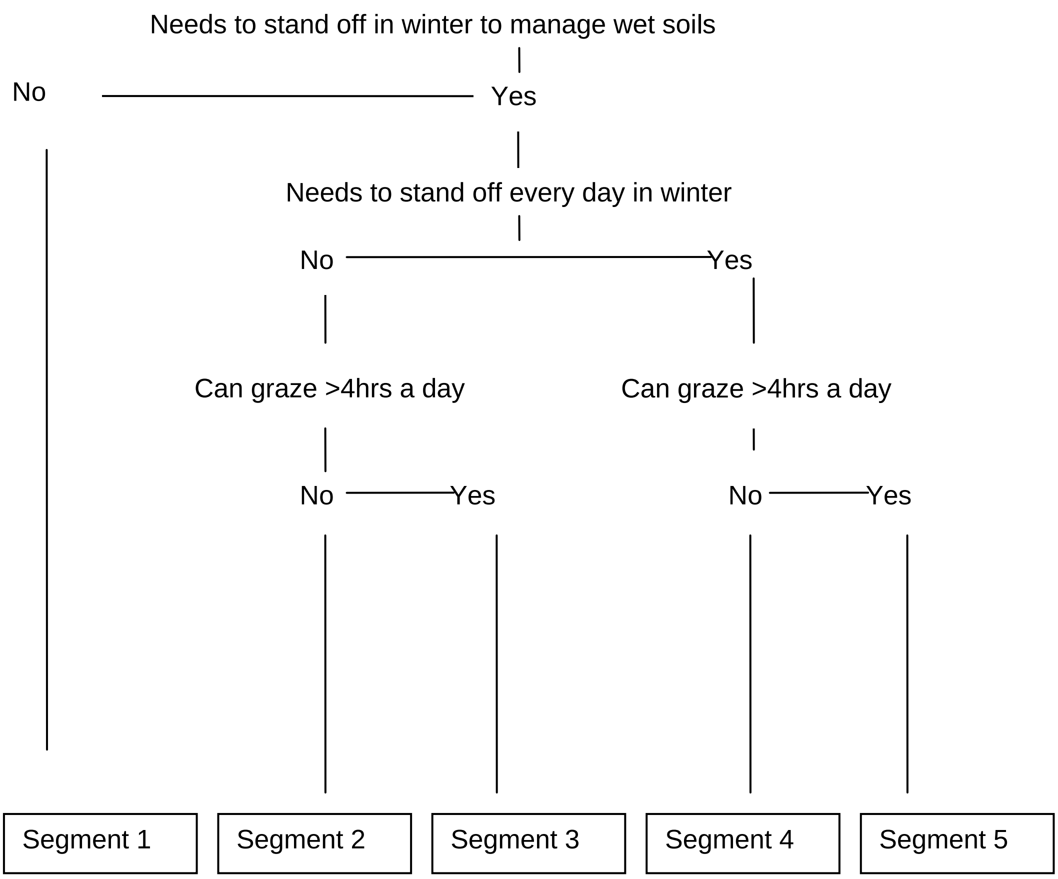

Figure 6: Decision tree for wet soils management

Segment 1 - In total, 9 out of the 36 farmers interviewed were categorised as segment 1 as they grazed their herd/s on pasture every day through the winter, not requiring stand off areas to manage their pasture in wet periods. Farms were on rolling, rolling to steep, or flat to rolling land, and on free draining soils. All but one of the farmers in segment 1 said that they experienced none, or only some, pugging in wetter months[4]. While most of the farmers in segment 1 sent some of their herd away over winter, some farmers wintered their entire herd on the home farm. Farmers in this segment generally managed pugging through their grazing rotation and shortening the rotation in wet conditions. The condition of paddocks was monitored closely and cows were moved to other paddocks when needed.

Soils are more porous here - haven't found need [for stand-off areas] - don't have pugging issues (Hauraki, production system 4, pumice soil)

"…free draining soils so don't need a stand off pad. Move cows around, get up early to move them. Experience tells me what I need to do" (Upper Waikato, production system 4, pumice soil)

"If paddock gets too wet, I put them in another one, when it dries out, they go back" (Hauraki, production system 1, brown soil)

Segment 2 - Three farmers were in segment 2. They were able to graze their herd on pasture most days in the winter, but when they did need to stand the herd off they were off for 20 hours or more, only back on the paddocks for a maximum of 4 hours. This was as infrequently as 1-2 times (or as many as 30-40 times) over the winter. Farms were situated on flat land with organic, allophanic or gley soils. Only one farmer did not winter off his herd. Pasture damage was limited by standing cows on either a standoff pad or feed pad or on the dairy yard.

Segment 3 - Similar to farmers in segment 2, farmers in segment 3 were able keep their herd on the paddocks for most days through the winter, with some farmers standing the herd off as many at 10 times. Stock were stood off for less time than for segment 2, generally for up to 16 hours per day. Most farmers used the yard at the dairy shed as a stand off area, two used the feed pad and a few had stand off pads. Two farmers moved their stock on to their steeper areas and one farmer used the crop area for stand off. Some used a combination of areas to accommodate their herd size. Most farms in this segment were on rolling land, some with flat or steep areas on their property. A number of farms were on flat land. Farms were on allophanic, pumice, organic, brown, podzol or gley soils.

Segment 4- farmers stood their cows off every day through winter. Cows were stood off for 20 hours or more on a stand off pad and were only grazing for a maximum of 4 hours. Farms in this segment were on flat land with brown or gley soils or a mixture of both.

Segment 5- Similar to farmers in segment 4, farmers stood their herd off every day through the winter on either a stand off pad or in the yard. However, the standing off period was typically shorter, around 16 hours, and grazing periods longer. All of the farms were described as being on peat and gley soils, with two on flat and one on gentle rolling topography. One farmer in this segment had a herd home where the herd was removed to from paddocks for approximately 16 hours a day during winter, which effectively minimised pugging on his farm.

Wet soils management technologies

In total, only 9 out of 36 farmers had stand off pads, with post peel/shavings being a common surface. Some farmers mentioned that the effluent from the pad went to the farm effluent systems, while others stated that pads absorbed the effluent and they were able to use the dried shavings later as fertiliser.

[4] This farmer was on allophanic/pumice soils and moved the herd to new pasture when there was heavy rain.

“the pads absorb the effluent, when it’s dry we scrap off and put into maize paddocks and use it as an extra source of nutrient (Hauraki, production system 2).

Farmers noted a number of benefits associated with having stand off pads as this comment reflects:

"I think they're value for money…cows don’t lose body heat…cold wet days cows use so much energy. Mastitis can be a concern … has to be monitored …[use of pads means] grow better grass, leave better residuals, avoid pugging, soil damage (Upper Waikato, production system 1).

For four farmers, the standoff pad was not of sufficient area for their whole herd to stand off so at times they also used their yard and/or sacrifice paddocks (areas used for standing off such as the holding paddock next to the yard or cropped areas).

Five farmers had feed pads and these were all in segment 2. Two used these for standing off, while another two farmers also used a standoff pad and/or the yard. One farmer did not use his feed pad for standing off because of the risk of cows falling into feeding bins. In his experience cows had either lost their balance or were pushed into feeding bins, then had become stressed and were unable to get themselves upright, and in some cases, had died.

Four farmers used sacrifice paddocks for standing off. Three of these farmers were in segment 2, on relatively free draining soils (pumice and allophanic soils) and moved the herd to sacrifice paddocks when it looked like it would rain. These areas included crop paddocks, steeper hill country and holding paddocks near the dairy shed. One farmer was in segment 5 on peat soils, stood cows off in paddocks which needed pasture development. The comments below illustrate the benefits farmers noted of allowing cows to stand off in these areas in terms of preparing the pasture for replanting:

“..let them stand in there and get them to pug, then plough and crop in summer (Upper Waikato, production system 5)

“If it’s going to rain, we put herd on steep slopes, they trample the brown top[grass] which is good. It helps establish good pasture, then we follow with top seed grass” (Upper Waikato, production system 2)

5.3 Nutrient management

5.3.1 Nutrient budgets

A nutrient budget identifies nutrient inputs to the farm, such as, fertiliser, purchased feed, clover, nitrogen (N) fixation and effluent. It also identifies where nutrients go off the farm (outputs), such as farm products, transfer to non-productive areas - for example, races, stock camps, yards - leaching and runoff losses to waterways and gaseous losses to the air.

In discussion about their fertiliser practices, all farmers stated they had a NB. Many commented that this happened after being approached by their fertiliser representative. In addition, many farmers believed the Fonterra Clean Streams Accord was a driver of increased awareness of nutrient management and uptake of NBs.

However, some farmers questioned the usefulness and applicability of a NB for their farm as they believed it to be a ‘one size fits all’ approach. Most farmers adjusted their fertiliser use to what they believed to be the ‘right’ amounts based on their experience and felt an approach based on current pasture conditions suited better. Therefore, it was common for the NB to be used as a guide only.

“I’ve changed it [the nutrient budget]” (Upper Waikato, production system 2)

"Well that [nutrient budget] is sort of best guess… just a general guide… we use our eye rather than a piece of paper, and obviously you need to stay below maximum loading" (Upper Waikato, production system 2)

"It's hardly specific to one farm, it doesn't take into account the contour of the land, it's not our bible" (Upper Waikato, production system 2)

For those farmers who found their nutrient budget to be useful, the predominant reason given was they believed following the recommended amounts led to reduced costs.

"*the recommendations are useful; it's reduced my inputs, especially with prices these days" (Upper Waikato, production system 2).*

Some farmers stated they liked having a NB in place to ensure that they were not pressured into purchasing fertiliser they did not need as some believed that fertiliser representatives had a vested interest when making fertiliser recommendations.

"*the fert rep [fertiliser representative] can't sell you more than you need, it's a transparency thing" (Hauraki, production system 2).*

5.3.2 Nutrient management plans

Under the Waikato Regional Plan, a NMP must be used to plan fertiliser application where N fertiliser is applied at greater rates than 60kg of N/ha/yr (see Appendix 2). In general, most farmers were applying amounts greater than this, however only two farmers interviewed had a NMP. A few expressed an interest in finding out about, or were considering undertaking a NMP.

"You're never too old to learn I suppose" (Hauraki, production system 2)

"…but will be thinking we might need to …given what the papers are saying, our whole attitude has to change about the environment' (Hauraki, production system 3)

"It's the next step along the way, it's fine tuning down to a fine point, it will help minimise wastage" (Upper Waikato, production system 2)

5.3.3 Fertiliser use and application

Discussions with farmers around fertiliser covered type, quantity, application rate, timing and monitoring of soil fertility.

A number of farmers (14) applied their main fertiliser applications in split dressings in spring and autumn, with a further 9 farmers dressing in the spring. One farmer stated that he did not put his super on until the autumn. Many farmers used separate quantities of nitrogen at various times throughout the year, that is, in addition to the nitrogen component of the main fertiliser type. However, a few farmers stated that they had a 'no N' policy. The comments below illustrate their concerns about the use of N:

"Urea is useless, it's got nothing in it …I can survive on water but now and then I need food, that's my logic" (Hauraki, production system #)

"Owners don't believe in nitrogen …they believe that it should be used as a tool, not just because it's there, soil is better off not using N"(Hauraki, production system #)

"Regime of no N …it does mean a lower stocking rate" (Hauraki, production system #)

Balance was the most common fertiliser supplier with Ravensdown and Summit Quinphos being the other commonly mentioned suppliers. One farmer sourced his fertiliser from Agrissentials as he preferred an organic product.

The choice of fertiliser was largely based on recommendations from fertiliser representatives, while some farmers relied on farm consultant's recommendations, or sought recommendations from both. The products were slightly different between companies however, the main fertilisers applied were nitrogen, phosphate, potash, magnesium, sulphur, potassium, DAP, cobalt, selenium and sulphate of ammonia. Additionally, a small number of farmers were using or trialling chicken manure as their main source of fertiliser considering it to contain sufficient nitrogen for their needs.

"we don't use Urea because it's in the chicken fertiliser. It's cheaper…and getting more and more popular" (Upper Waikato, production system 2)

"…hardly use any Urea anymore, it's [chicken fertiliser] got quite a bit of N in it" (Upper Waikato, production system 1)

Many farmers stated they believed that they, and other farmers, were being more conservative with fertiliser use in recent years due to the increasing costs, as these comments show:

"With the price of fert [fertiliser], you don't want to put any more on that you have to (Hauraki, production system 3)

"In the late 1980s people stopped using fertiliser but then people started building levels up to get a reserve, [now] it's better just to use what you need than put extra on" (Upper Waikato, production system 2)

"I've been putting less and less on because of cost" (Upper Waikato, production system 4)

Nitrogen application

The levels of nitrogen use on the farms ranged between 30 N kg/ha/yr and 200 N/kg/yr. With regards to the WRP fertiliser rule, most farmers were applying amounts greater than 60kg/ha which is the trigger for having a Nutrient Management Plan prepared.

Three farmers stated they were not using N as a separate dressing, with one stating that he had a "no N policy".

Most farmers applied N in spring and autumn, with a few stating that applications followed the grazing rotation. Soil condition was a key decision criterion as to when to apply. Applications were avoided when soils were too cold, too wet or too dry to get a worthwhile grass response.

Many farmers also talked about the unsuitability of applying N to dry soils, so summer months were avoided.

"it's no good when the soil is dry" (Hauraki, production system 3)

"You don't get a response" (Hauraki, production system 3)

In general, winter months were also avoided. However, a few farmers stated that they did apply N in the winter and some started spring applications in July.

"N doesn't work if soil is too cold" (Hauraki, production system 3)

"It's a waste of time [in winter], it's much better in spring when conditions are right" (Upper Waikato, production system 2)

"…don't put N on if it less than 10 degrees" (Upper Waikato, production system 4)

A few farmers discussed pasture condition as an indicator of when to apply N, rather than having a set time of year.

"If we get good growth it's not much of an issue, it's all pasture dependant. If I feel a pinch coming on, I will put some N on" (Hauraki, production system 3)

"strategic use for feed management" (Hauraki, production system 1)

The use of nitrogen also required management to ensure that grass growth matched the feed requirement:

"If you put N on and grass grows fast, you'll waste the N"
(Hauraki, production system 4)

"Trying to match the growth with cows…trying not to get too much surplus"
(Hauraki, production system 4)

A number of farmers mentioned the rising cost of N and this was a key driver in their use of N.

"when grass is growing, we boost it using N. It's cost effective if you use it smart but becoming less and less as prices rise" (Hauraki, production system 3)

'When grass is growing, we'll make it grow! N is becoming less cost effective as price increases' (Upper Waikato, production system 2)

Use of Nitrification Inhibitors

Nitrification inhibitors can reduce N leaching by slowing the "the conversion by specific soil bacteria to nitrate" (Longhurst and Smeaton, 2008, p.21). Their use can be cost effective as it reduces the amount of nitrogen that needs to be applied. Nitrogen inhibitors were not found to be in use by most farmers in this study. One farmer was using a Summit Quinphos product called 'SustaiN Green' which he said was supposed to last longer and leach less N "not supposed to leach as much, last longer about 8-10 weeks. It's hard to tell the benefits". Two farmers mentioned they were interested in nitrification inhibitors, but noted that there was a lack of accessible information available:

"we are interested in it but there's no decent information about it" (Upper Waikato, production system 2)

"…not enough knowledge [about nitrification inhibitors] in local areas" (Hauraki, production system 1).

Olsen P

Farmers reported Olsen P levels ranging from 25-90, with those farmers on pumice soils reporting the highest levels compared to those on other soils. Olsen P levels were generally above the recommended optimum economic return levels of 20-30 for ash and sedimentary soils and 35-45 for pumice soils, with seven of the 36 farmers reporting levels within the recommended ranges for their soils.

Some farmers stated that they were reducing their Olsen P levels:

"… it was a huge saving for the boss, we cut back because the levels were so high [Olsen P 90], NB was useful. Potash is coming down too. Just need to make sure that we don't cut back too much that the levels drop (Hauraki, production system 4)

"[Olsen P] 70, this is really high so has held back in the last 2-3 years" (Upper Waikato, production system 3)

"Fert rep [fertiliser representative] asks what we want to produce off the land... works out whether to maintain or lower so we're not wasting fertiliser.... Used to be told to have P levels up here but really don't need them. ...late '80s downturn stopped fertiliser to cut costs...guys had a mentality to build up [P levels] and mine them down. ... better to just use what we need and not put extra on" (Upper Waikato, production system 2)

"Had a high rate of P, so dropped levels in autumn because we had a high rate of cows with metabolic disorder (Hauraki, production system 1)"

While others thought their Olsen P levels were where they wanted them:

"P is an issue for us. Leaching is a substantial part of the problem. No matter what you put on our soil is lacking in organic matter. Olsen P is 55-70 …it's different on pumice soils to clay soils and these are the levels to target on pumice soils" (Upper Waikato, production system 2)

35 - 45. Right where we want them to be (Upper Waikato, production system 1)

"Maintenance P as a rule" (Hauraki, production system 3)

Soil testing

Soil tests are a recommended tool to ensure that optimum soil fertility levels are not exceeded. About half the farmers in this study conducted soil tests every two years, with another third conducting them every year. Soil test were carried out to assist in managing pasture fertility and inform fertiliser purchases with an eye on costs. Some farmers stated they liked the independence of soil tests rather than relying solely on the recommendations of their fertiliser representatives or their own judgement.

"only apply the recommended levels… fert [fertiliser] bills are minimal" (Upper Waikato, production system 4)

"If anything is shown to be lacking from the soil test then we do follow up" Upper Waikato, production system 3)

"[independent consultant] he knows the area and tells me what to do [from soil tests]...he has no fertiliser company to push" (Hauraki, production system 1)

"do it by experience and look of the paddock ... but the soil test will see if I'm right" Upper Waikato, production system 1)

5.3.4 Effluent as part of the fertiliser regime

Davies et al (2006) studied compliance and effluent management practices of Waikato dairy farmers. We sought to provide an understanding of how effluent is managed in relation to farmers' fertiliser regime.

There were a range of effluent systems in place with most farmers (26) using travelling irrigators to apply effluent to land under the permitted activity rule. Nine farmers had pond systems in place and one a pot system. Two farmers had a consent to discharge in addition to their travelling irrigator system because of the topography and layout of their farm.

"*Layout of farm, farm not dead flat, huge trouble getting up on hills..." (Upper Waikato, production system 5)*

Some farmers mentioned the importance of timing of effluent applications.

"Only spray when it's dry weather and before the rain comes" (Upper Waikato, production system 1)

"If soil gets too dry you get run off so it's better to spread when it's not too dry, pumice soils get dry very quickly" (Upper Waikato, production system 2)

Storage capacity ranged between the systems with most farmers operating under the Permitted Activity rule needing to irrigate daily due to limited storage capacity to others with holding tanks or ponds able to store effluent for up to 6 weeks. Those with pond systems under a discharge consent had holding capacity of between 3 months and 5 years.

Increasing the area of effluent application can be an effective means to reduce fertiliser inputs. Some farmers mentioned that they had either increased their application area, or would like to extend it, in order to capture more nutrient benefits and decrease fertiliser costs. For these farmers the cost of change to their system was less than the benefit they expected as a result of decreased fertiliser costs. However, costs can be significant and prolong decision-making as this quote illustrates:

"Looking into a separator but will cost $150,000 …will take up a massive amount of land so where the compromise is, I don't know (Hauraki, production system 3)"

Many farmers felt that paddocks where effluent was applied usually did not need any extra fertiliser and recognised the saving in fertiliser costs:

"We are making a saving by not putting on effluent area" (Hauraki, productions system 1)

"The nutrient budget guy said we don't really need to put fert [fertiliser] on" (Upper Waikato, production system 2)

"[on effluent blocks] separate testing, don't add urea… cheapest form of N" (Upper Waikato, production system 3)

However, some farmers did apply small amounts of fertiliser on effluent areas, with one farmer noting that the recent drought and decline in pasture condition has change his usual practice:

"We don't fertilise paddocks effluent goes on except a bit of urea now and again - minimum amount" (Upper Waikato, production system 4)

"its so bloody [sic] dry, we needed something to get them going [application of N on effluent block]…put P on to raise levels, better off maintaining them, getting them back up again" (Upper Waikato, production system 4)

"K and N mix in Oct miss the spring dressing" (Hauraki, production system 1)

5.4 Feed supplements

Incorporating feed supplements into the existing farm system, can help to fill pasture deficits that may occur over winter or through summer. This section describes the range of supplements used on farms, some of which are grown on the farm or run-off and some are imported, for example meal and palm kernel. In this research, 27 out of the 36 farmers interviewed incorporated feed supplements into their farm system.

Farmers often referred to the purchase or growth of feed supplements as "*insurance*" against feed deficits.

5.4.1 Grown supplements

There was a range of crops commonly grown on farms that included lucerne, chicory and brassicas, such as turnips, swedes, kale and choumoellier. The main reason farmers utilised areas for cropping was to ensure that they had enough feed to carry them through a feed deficit over winter or through the summer. An additional reason was that cropping was part pasture development.

Maize and grass silage were also produced. One farmer grew a surplus of silage to sell. Some farmers indicated that they would like to increase the size of their current maize block to be able to grow more in the future. Three farmers grew swedes as supplementary feed.

"[feeding swedes] Helps build up a layer of fat…so when they calve and lose weight, they can draw upon that extra weight and cycle a lot earlier…I swear by it! It's the cornerstone of our success…It's so beneficial for the cows… it's very high in kilojoules" (Upper Waikato, production system 2).

Turnips were commonly grown as a summer crop and were part of re-grassing programmes. Paddocks were typically grazed bare and then re-seeded.

" Break fed, taken back to bare ground, re-sown in Autumn to permanent pasture" (Hauraki, production system 2)

5.4.2 Purchased supplements

Farmers named a number of purchased supplements they used: meal, grains, molasses, tapioca, kiwifruit and palm kernel. Palm kernel (PK) was a popular supplement with 22 farmers incorporating this into their system. There was a mix of opinions about the use of this supplement with some farmers commenting on the benefits in terms of filling feed deficits*:*

"We fill in some of the production lows by plugging in some PK" (Upper Waikato, production system 4)

"PK is useful for removing the uncertainty" (Upper Waikato, production system 4)

"PK is an excellent feed, It's self regulating, cows won't gorge themselves on it… That's the beauty of it, you can start and stop" (Upper Waikato, production system 2).

However, there was concern about the rising price of palm kernel:

"You don't want to buy it just for the sake of it" (Upper Waikato, production system 4)

Some of the farmers using PK noted that they had only decided to purchase palm kernel given the threat of feed shortages caused by the drought and this was not part of their normal practice. For these farmers it was a temporary solution and they did not intend to buy palm kernel in the future:

"Trying not to buy PK, it's our backup but we have to look after cows" (Hauraki, production system 3)

"Didn't use to [use PK] and won't continue to because of the cost" (Upper Waikato, production system 1)

"I brought PK last year [drought] because ran out of silage. Don't intend on buying anymore. Once calves go [sold] I should be able to cruise through with enough feed" (Hauraki, production system 2)

A couple of farmers also believed there were biosecurity risks posed with the imported feed such as palm kernel.

"There could be anything living in there, couldn't there?"
(Upper Waikato, production system 4)

"It's a huge benefit [being a grass based production system] but we are fast losing it, biosecurity isn't good in New Zealand" (Hauraki, production system 3)

It was common amongst the grass-based farmers to mention the financial investment needed to move to an imported feed system, and noted that it was not a management direction they wanted for their farm. As Ritchie (2007, p.24) points out "farmers may have varying attitudes about whether they want to be in a low-input or high-input system for reasons of lifestyle, labour, attitude to debt and risk, production competitiveness". These farmers reiterated the importance of grass management and that grass was the cheapest and most readily available form of feed. The move to import extra feed involved major adjustments to the overall farm system, which they considered to be expensive and labour and time intensive:

"First and foremost you have to have proper utilisation of grass, it's the cheapest feed"
(Upper Waikato, production system 1)

"Our system, we just want to feed grass" (Hauraki, production system 1)

"This is what New Zealand is good for, grass-based systems"
(Upper Waikato, production system 1)

5.4.3 Feed system

Associated with the recommendation to use lower N feed, is the use of feed pads as these can help increase the efficiency of feeding supplements, providing a specifically designed feeding platform to reduce feed waste. Feedpads can also be used as standoff areas for management of wet soils.

Only 5 of the 36 farmers had feed pads (herd size ranged from 380-600). The most common reasons for constructing a feed pad were to increase production flexibility in terms of being able to choose when to dry off, the ability to reduce supplement waste, control and flexibility of feed (for example during the drought) and to improve calving conditions and rates.

"You can get cows to cycle with a feed pad" (Hauraki, production system 3)

"Feed pad improves milking, the cows are healthier because they get more to eat"
(Upper Waikato, production system 4)

"It does create a lot of work, sure it's easier to feed on paddock, but there's a lot of wastage…the cows only eat half of what they could in paddock, which saves us in feed" (Upper Waikato, production system 4).

As stated in section 5.2.2, farmers also used their feed pad to assist in wet soils management.

"Cows will be quite content, they will sit down, it's when they are hungry that they start to wander and pugging can become a problem" (Hauraki, production system 3)

Farmers gave a number of reasons for not having a feed pad. Many felt quite strongly that they required more labour and staff to manage them. Farmers believed that many farm workers preferred not to work with a feed pad system, which made it harder to find staff. Some farmers had experienced this on previous farms. Other concerns related to the cost of constructing and running a feed pad, and uncertainty as to whether it would be worthwhile in terms of financial gain. Some farmers made reference that unless you were "*in the top 10 per cent of farmers*" it would not be financially viable to change to a feed pad system. A few farmers also mentioned the visual and environmental impacts of installing a feed pad:

"They are environmentally ugly things…They are big concrete jungles that need work" (Upper Waikato, production system 2)

One farmer who had recently brought a farm with a feed pad chose to use it for storage rather than to feed on, based on his experience of using a feed pad on his previous farm. He commented that he did not like them because the feed can get wet and soggy and cows can slip on the concrete.

Where meal was used, it was either fed in the shed, on a feed pad or in a herd home. Where palm kernel was used, it was fed in the paddocks, on feed/stand off pads or in the shed.

The majority of farmers fed maize, hay and grass silage out in the paddock. Regardless of the means of feeding out, the focus was to try to reduce waste as much as possible. For example, the farmer with the herd home stated that feeding in the home "*saves a lot of money...less waste"* as it minimised trampling of the feed. Another farmer who fed out in the paddock followed the fence lines for the same reason, to minimise trampling.

5.5 Riparian management

Riparian fencing and planting is used as an effective way to reduce the amount of phosphorus, sediment and microbes entering the waterways (Environment Waikato, 2008). Three farmers reported that they had no waterways on their property and three had ephemeral waterways. Eighteen farms had drains, all of which were fenced except for one farm where the farmer had not fenced as water did not run all year. Twelve farms had waterways in the form of rivers, streams and wetlands. All farmers bar one stated that these waterways were fenced.

Benefits given for fencing the waterways and drains were consistently said to be: to prevent stock trampling and eroding drain banks and from wandering in and getting stuck or on to another property.

"everything was fenced when we arrived but I would have anyway…it's a nuisance when cows get in and wander down…we do know we have to keep the water quality up so we take it seriously" (Hauraki, production system 3)

"…have done a lot of fencing, all the main drains are fenced, the others are too small. It's common sense, don't want to lose stock" (Hauraki, production system 3).

"you get less erosion from cows standing on steep stream banks" (Upper Waikato, production system 1)

Other reasons given for fencing were for aesthetic value, where fenced waterways looked *"nice and tidy and more attractive",* and some noted that they felt this added to the farm's value.

A few mentioned the environmental benefits of fencing and planting, which motivated them to manage their riparian areas.

"*We do know we have to keep the water quality up, so we take it seriously" (Hauraki, production system 3)*

"...and for environmental reasons so they don't bugger up the drain banks" (Hauraki, production system 2)

"I don't let any run off into them…well as much as I can save…like they're crystal clear…"(Upper Waikato, production system 4)

Only three farmers mentioned they had undertaken riparian planting in addition to fencing waterways. In general the details of riparian fencing such as the proximity to waterways and materials used for fencing were not discussed during the interviews.

Some farmers had received financial assistance towards their fencing under the Environment Waikato Clean Streams project or through the South Waikato District council.

Farmers raised a few concerns about riparian fencing and planting. One farmer was not keen to take up an incentive because of the requirement to place a covenant over the area, which he felt would affect the resale value of the property. A few farmers mentioned that regular flooding was an issue on their property, with on-going maintenance and repair discouraging re-fencing. Weed management required in planted areas was raised as an issue, and one farmer gave retaining access for fishing as a key reason for not undertaking planting.

6 Discussion

This study has shown that the grazing management practices of dairy farmers are influenced by their farm context. This has implications for policy development and education programmes.

The following table takes the commonly recommended nutrient management practices for the Waikato region and briefly discusses the findings for each practice, commenting on current practices and potential obstacles or barriers to adoption.

Table 3 Summary of farm practices for nutrient management

Recommended Management Practice	Summary of practices and potential barriers to uptake
Nutrient Budget Nutrient Budgets assist farmers to identify where savings can be made and monitor the amount of nutrient leaching occurring from their system	Uptake amongst farmers was high due to the recent push by Fonterra and the fertiliser industry. Findings from this research indicate that many farmers prefer to use a combination of soil test results, recommendations from trusted farm consultants/advisors and their own experience to determine their fertiliser regime rather than follow a nutrient budget exclusively. Farmers also liked to retain the flexibility to alter their practices in response to seasonal conditions throughout the year. In general, farmers viewed nutrient budgets as a helpful tool, even if only used as a general guide, and some found that it had led to saving in fertiliser costs.
Nutrient Management Plan (NMP) A NMP provides farmers with a list of actions to mitigate N and P losses from their system	This study found a general lack of awareness about nutrient management plans, with only two farmers having a NMP. Many farmers were confused as to what a NMP entailed, indicating a knowledge gap in regards to this intervention. In general, most farmers were applying amounts in excess of the 60kg of N/ha/yr threshold in the Waikato Regional Plan, which requires a NMP to be in place. This implies a knowledge gap in respect of the rule. The effectiveness of nutrient management plans depends on their successful implementation, and recommendations in a NMP may have significant impacts on a farm system. While NMP preparation may focus on a Nutrient Budget and some best management

Recommended Management Practice	Summary of practices and potential barriers to uptake
	practices, a farm system based plan prepared by a farm consultant may cost in the order of $3,000 to $5,000. This is a significant cost given farmers are not aware of the advantages, if any, that a NMP offers them over a nutrient budget.
Fertiliser management - nitrogen management Nitrogen management practices include: avoiding applications in winter to reduce the risk of leaching, reducing N rates in line with the Nutrient Budget, using nitrification inhibitors	Many farmers avoided application of nitrogen fertiliser during the winter months because they want to ensure pasture uptake. Farmers are aware of the importance of temperature and moisture to get maximum value from their fertiliser. However, a few farmers did apply small dressings of nitrogen through the winter months, and these were seen as essential to promote pasture growth. The rising costs of N resulted in a reduction in the amount of N applied for a number of farmers. However, N was seen by a number of farmers as a cost effective and preferred way to provide feed. None of the farmers we interviewed were using nitrification inhibitors. Farmers were cautious, as there is limited research on the actual benefits in dollar terms. Nitrogen management was motivated by desire to ensure adequate pasture production, hence farmers that use nitrogen are likely to resist any suggestions that they substantially reduce their nitrogen use though they may be willing to trial more efficient N technologies.
Fertiliser management – phosphate management Phosphorus adheres strongly to soil particles, which can be transported via overland flow to waterways. Management practices should avoid pugging of soils, stock grazing on steeper slopes and near waterways and avoid soluble fertiliser P applications during high risk months, use slow release forms of phosphate fertiliser	Three quarters of the farmers had Olsen P levels on farm above the recommended optimum economic return levels of 20-30 for ash and sedimentary soils and 35-45 for pumice soils. Because of increased costs a few farmers were withholding fertiliser applications and dropping or “mining” Olsen P levels. Some farmers were dropping their Olsen P levels as nutrient budgets become more of a management tool. However, many farmers viewed their Olsen P levels as ideal and were interested in maintaining them. Most farmers applied their main fertiliser either in split spring and autumn dressings or in spring. Uptake of slow release forms of phosphate fertiliser was low with none using these forms currently and only a few having trialled them in the past. Phosphorus management was strongly motivated by desire to maximise pasture production, hence farmers are likely to resist any suggestions that they substantially reduce their store of phosphorus in the soil.
Fertiliser management – effluent management Key recommendations to reduce the environmental impact of dairy effluent systems are to have adequate storage to get through wet periods, storm water diversion in place to divert rainwater entering storage, omit fertiliser N inputs on effluent blocks, increase	Almost three quarters of farms had travelling irrigator systems under the regional plan Permitted Activity Rule. Most systems had limited storage with many needing to irrigate daily. Some had holding tanks or ponds able to store effluent for up to 6 weeks, and some farmers stated they were aware of not applying in wet periods. Those with pond systems under a discharge consent had holding capacity of 3 months up to 5 years. Most farmers were aware of the benefits of using effluent to replace fertiliser and lower costs, and were modifying fertiliser application on effluent blocks. Some still applied fertiliser when they felt it was needed. Similarly, some farmers were in the process of extending application areas or had recently extended areas in order to lower

Recommended Management Practice	Summary of practices and potential barriers to uptake
application area to capture nutrients and decrease fertiliser inputs.	costs. Effluent management was influenced by farm context and existing expensive infrastructure. This suggests farmers are unlikely to alter their effluent management in the short-term.
Wintering practices – wintering off, managing wet soils Reducing stocking pressure over winter by wintering off, that is sending a proportion of the herd to another location when the risk of N leaching is high, or by using stand off areas (stand off pads, feed pads, yards or herd homes) to reduce time spent on paddocks, alleviating soil compaction during the wetter months of winter when nitrogen leaching risk is highest are key strategies to reduce N loss.	This study shows that winter management practices are influenced by a number of interconnected factors such as soil structure and susceptibility to pugging, herd size, type of production (grass-based / imported feed) and land availability to manage wet pasture. Many farmers who were able to keep stock at home during the winter had a strong preference for this action because of the desire to control cow condition. The cost of wintering off is a major barrier for some farmers. Finding affordable grazing within the Waikato region was not always possible, bringing increased stock transport costs and for inspection visits. Other farmers noted that they had sufficient space to manage their stock on their farm. Therefore wintering off was seen as unnecessary with no added benefit to their management system. Technologies such as feedpads, stand off pads or herd homes can require considerable capital investment. Of note was the finding that some farmers felt their current practices were sufficient to manage wet soils and stand off infrastructure was considered unnecessary. Conversely some farmers used their stand off infrastructure extensively through the winter. Wintering off was strongly influenced by farm context particularly the need to manage feed deficits, water logging and farm infrastructure. This suggests farmers are unlikely to modify their wintering practices.
Supplementary feed Imported low-N supplements can be used to overcome feed deficits instead of relying on N to boost pasture growth. Crops can support feed deficits, but concentrating large numbers of stock for long periods in cropped paddocks can result in pugging and compaction of soil, increased risk of, P and N loss from urine and dung and transport of faecal coliforms from dung, and damages the soil reducing long-term productivity.	This study found that the use of feed to supplement pasture deficits depends on whether there is enough space available to grow supplementary feed, the cost of purchased feed and ability to feed out. Farmers noted that farm topography and soils affected their ability to feed out on paddocks. In terms of bought in feed, some farmers strongly expressed that the move to a higher input farm was not desirable because of increased costs and management. Other farmers maintained that N was the cheapest way to fill feed deficits and did not see a financial benefit to either buying in or growing feed. Turnips were commonly grown as a summer crop and were part of re-grassing programmes. Paddocks were typically grazed bare and then re-seeded. Supplementary feeding practices were strongly influenced by farm context particularly the capacity to grow supplementary feed, the cost of purchased feed and ability to feed out. This suggests farmers are unlikely to make major changes to their supplementary feeding practices to reduce nutrient emissions.
Riparian Management Riparian fencing can reduce the amount of P, sediment and microbes (such as faecal bacteria) entering the water by preventing stock from trampling banks and	Many farmers reported fencing of waterways and drains. For most, this was done to stop stock wandering and damaging banks. Some mentioned they were aware of the benefits to water quality also. For some farmers, a barrier to uptake was the threat of recurrent flooding and damage to fencing. This was costly to repair so areas prone to flooding were purposely avoided.

Recommended Management Practice	Summary of practices and potential barriers to uptake
accessing waterways. Riparian planting further helps stabilise banks and block the movement of soil particles from land into waterways.	Few farmers mentioned that they had undertaken riparian planting. Those that had felt it made their property more attractive. A couple of farmers noted management of weeds in planted areas was of concern. This suggests farmers are unlikely to invest in riparian fencing to reduce nutrient emissions.

Summary and recommendations

Even though the environmental and economic benefits of a particular practice may appear to be well established, at the farm level there may still be sensible hesitation amongst farmers to adopt practices as the transition to a new practice may be of little or no benefit, involve significant costs, or present unwanted management issues.

This research has shown that there are a number of factors that farmers must consider (such as climate, soils and topography) when assessing new practices. Benefits may not be present for those farmers who in their opinion have sufficient management methods in place to get through winter months. There is some hesitation where there is insufficient information available about a particular practice, for example the use of nitrification inhibitors. For some farm contexts change in practices may simply be impractical, for example a shift from an effluent pond system to land application.

For these reasons, it is clear that 'a one size fits all' approach to nutrient management is not suitable and a more nuanced farm level approach is needed. In addition, for some wintering practices such as wintering off farmers will be very resistant to change while other practices (such as type of N or P applied) may be more easily changed.

It is clear from the table above that while there are a number of wintering practices that are currently undertaken that align with the policy objective to reduce nutrient leaching, particularly during the winter risk period. These practices are generally adopted for the purpose of maintaining farm productivity through managing pasture and stock condition. In addition, from a policy perspective, some practices have been adopted but not necessarily in a manner that will achieve the policy objective, for example the extent of riparian management.

Based on the findings reported here we recommend that Waikato Regional Council:

12. Continue to work closely with farm advisors/consultants to ensure consistency of messages around nutrient management tools and methods of disseminating information to farmers.

13. Work collaboratively with industry to promote the economic benefits of using a nutrient budget as a primary nutrient management tool.

14. Work to lift farmers' understanding of nutrient budgeting and interpretation of Overseer results to increase farmers' perception of the value-add of nutrient management to their business

15. Focus on the promotion of the purpose of Nutrient Management Plans and the associated regulations that require farmers to have a NMP in place. Waikato Regional Council should focus on promoting the benefits to farmers of using a NMP.

16. Work towards increasing awareness, understanding and use of new technologies such as nitrification inhibitors and alternative low-N feed

supplements by continuing to advocate for regional field trials, offering incentives and through promoting the economic and environmental benefits.

17. Work towards clarifying policies in relation to effluent storage. Continue to promote sound effluent management and application practices. Continue to advocate for industry support in regard to compliance with effluent regulations. Continue to advocate for improvements in the design of effluent systems to reduce failures.

18. Consider an investigation into the development of recommended grass residual lengths for the Waikato region (which considers the variance in soil type, rainfall, temperature etc) to limit nutrient losses through overland flow.

19. Continue to promote riparian management and address the gap between farm practice and effective nutrient mitigation through targeted communication about requirements and offering incentives.

20. Incorporate the variability in farm context in any voluntary nutrient management 'tool kits' promoted.

21. Promote research on nitrogen and phosphorus transport mechanisms to waterways, and in particular the risk periods for stock management and fertiliser application.

22. Recognise the variation in farm context in any regulatory framework put in place to promote nutrient management practices on farm.

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Appendix 1

3 Water Module

3.5 Discharges*

3.5.5 Implementation Methods - Farm Effluent Discharges

3.5.5.1 Permitted Activity Rule - Discharge of Farm Animal Effluent onto Land

The discharge of contaminants onto land from the application of farm animal effluent, (excluding pig farm effluent), and the subsequent discharge of contaminants into air or water, is a **permitted activity** subject to the following conditions:

a. No discharge of effluent to water shall occur from any effluent holding facilities.
b. Storage facilities and associated facilities shall be installed to ensure compliance with condition a).
c. All effluent treatment or storage facilities (e.g. sumps or ponds) shall be sealed so as to restrict seepage of effluent. The permeability of the sealing layer shall not exceed $1x10^{-9}$ metres per second.
d. The total effluent loading shall not exceed the limit as specified in Table 3-8, including any loading made under Rules 3.5.5.2 and 3.5.5.3, 3.5.6.2, 3.5.6.3 or 3.5.6.4.
e. The maximum loading rate of effluent onto any part of the irrigated land shall not exceed 25millimetres depth per application.
f. Effluent shall not enter surface water by way of overland flow, or pond on the land surface following the application.
g. Any discharge of contaminants into air arising from this activity shall comply with permitted activity conditions in Section 6.1.8 of this Plan.
h. The discharger shall provide information to show how the requirements of conditions a) to g) are being met, if requested by the Waikato Regional Council.
i. The discharge does not occur within 20 metres of a Significant Geothermal Feature*.
j. Where fertiliser is applied onto the same land on which farm animal effluent has been disposed of in the preceding 12 months, the application must be in accordance with Rule 3.9.4.11.

Advisory Notes:

- Dischargers should note that many territorial authorities have specific rules which set minimum separation distances between treatment or disposal systems, adjoining properties, roadways and houses.
- In relation to sealing effluent treatment or storage facilities as referred to in condition c), the permeability requirement of $1x10^{-9}$ metres per second can generally be met through standard compaction procedures on soils with more than 8 percent clay. If the soil has less clay than this, special measures may be required (e.g. an artificial liner). Also, clays may not be suitable for storage facilities that are regularly emptied or are left dry for some time. Environment Waikato can provide advice on soil types and sealing requirements.
- Effluent treatment and storage facilities should be constructed in accordance with the publication ‘Dairying and the Environment - Managing Farm Dairy Effluent’ (1996) by the Dairying and the Environment Committee. Copies of this guideline are available from the New Zealand Dairy Research Institute, Private Bag 11029, Palmerston North.
- With regard to the effluent application rate in condition d), the standard of 150 kilograms of nitrogen per hectare per year can be converted into a minimum

irrigation area and a maximum depth of effluent that can be applied each year. To do this for farm dairy effluent the following factors must be known or estimated:

a. The amount of nitrogen excreted by the cow - this can vary greatly (depending upon the composition of pasture, fertiliser use and animal management in the milking shed), but generally averages about 20 grams per cow per day.
b. The volume of nitrogen excreted by the cow - this can vary greatly (depending upon the amount of water used for washing down the yard), but averages a volume of 50 litres per cow per day.
c. The average lactation period - this is the average number of days that the cows are milked per season. It depends upon the potential of an area for dairy farming, and pasture management practices. A typical lactation period for cows in the Waikato Region is about 270 days, and can range from 190 days up to 300 days. It is important that each farmer consider their individual situation when estimating lactation period.

- Using the average values as specified, 150 kilograms of nitrogen per hectare per year equated to both:
  a. a land area requirement of 360 square metres per cow (i.e. about one hectare per 27 cows)
  b. an annual effluent loading rate of 75 millimetres per year.
- Discharges of contaminants into or onto land within 20 metres of a Significant Geothermal Feature are addressed by Rules 7.6.6.1 of this Plan. Significant Geothermal Features are defined in the Glossary, and in Development and Limited Development Geothermal Systems, identified on maps in Section 7.10 of this Plan.
- To comply with condition f) application rates need to be adjusted for soil and seasonal climatic conditions. Generally, ponding should not occur if the application depth requirements in condition e) are complied with and the instantaneous application rates (per second) are appropriate to these conditions. In practice, implementation of this condition will acknowledge that some minor ponding on the land, for short durations may occur where there are areas of soil compaction.

Appendix 2

3 Water Module

3.9 Non-Point Source Discharges*

3.9.4 Implementation Methods - Non-Point Source Discharges

3.9.4.11 Permitted Activity Rule - Fertiliser Application

The discharge of fertiliser* into air and onto or into land is a **permitted activity** subject to the following conditions:

a. The discharge shall not result in any objectionable odour or particulate matter beyond the subject property boundary.
b. The discharge does not result in any avoidable direct application of fertiliser to any water body.
c. Where the fertiliser is being used in other than domestic gardening situations the fertiliser must be applied in accordance with the NZ Fertiliser Manufacturers Research Association, 1998 (updated 2002): Code of Practice for Fertiliser Use.
d. A nutrient management plan of the type specified in Table 3-10 must be used to plan fertiliser application where nitrogen fertiliser is being applied at rates greater than 60kg/N/ha/year.
e. The contents of the nutrient management plan required by condition d) must be made available to the Waikato Regional Council upon request.
f. A nutrient management plan shall be provided to Environment Waikato on request in accordance with condition d) where fertiliser is to be applied to an area of land that has also had farm animal effluent applied to it within the preceding 12 months.

Table 3-10 Nutrient Management Requirements by Land Use Type

Land Use Type	**Nutrient Management Plan Requirements**
All Land Uses applying more than 60Kg N/ha/yr	A nutrient management plan must be prepared that, as a minimum records the following information for at least nitrogen (N) and phosphate (P) (in units of kg of N and P per hectare per year) : • Inputs from fertiliser. • Inputs from other sources such as manures, green crops and soil mineralization. • Outputs in product. • Results of soil testing for levels of available N and P. • Documentation of consideration given to climatic and soil conditions for the life of the crop to account for the effects of rainfall and irrigation on the potential for N and P leaching through the soil in to ground and surface water. • Practices that will be implemented to reduce nutrient and sediment losses from the property and to avoid, remedy or mitigate adverse effects on the environment.
Pastoral	The nutrient management plan specified above must

	be developed based on the outputs of either Overseer (AgResearch) or any other nutrient management planning tool that meets the criteria set out in the fifth advisory note below.
Commercial Vegetable and Fruit Production, Arable/Mixed Cropping and Livestock or any other land use not otherwise captured in this table	From 1 January 2011, the nutrient management plan specified above must be developed based on the outputs of any nutrient management planning tool that meets the criteria set out in the fifth advisory note below.

Advisory Notes:

- The discharge of fertiliser into air and onto or into land that does not comply with Rule 3.9.4.11 is a discretionary activity in accordance with Rule 3.5.4.5.
- Application of fertiliser should follow the good practice guide on fertiliser use in Section 3.9.7 and any other relevant industry nutrient management tools, including "Doing it Right" (the Franklin Sustainability Project, 2002).
- The processes for determining the objectionable effects of odour or particulate matter beyond the property boundary are set out in Chapter 6.4 of this Plan.
- This rule does not specify a nutrient leaching rate for the model. It is Environment Waikato's intention to survey modelled leaching rates and if necessary develop rules that specify nutrient leaching rates for sensitive locations in accordance with Method 3.9.4.8.
- In order to comply with the requirements of this Rule Nutrient Management Planning tools other than Overseer and SPASMO must:
    a. Be a Crown Research Institute, University or Industry developed model that has successfully completed commercial trials commensurate with climatic, terrain and soil conditions expected to be encountered in the Waikato Region.
    b. Be able to predict annual, seasonal or crop nutrient losses at either a paddock or total crop area scale with a margin of error no more than 30%.
    c. Have been calibrated against current versions of either Overseer or SPASMO, or versions that are no more than 3 years old, and any departures from those models when using identical data sets documented and explained.
    d. Have product maintenance and support currently available as of the date of use or guaranteed for a period of one year.
- A register of nutrient management planning tools that meet the criteria set out in the above advisory note is maintained by Environment Waikato. If by 2011 models that meet these criteria have not been developed for the subject crop or land use, a model based on the crop or land use with the most similar nutrient leaching behaviour will be acceptable.