THE MATRIX OF GOOD MANAGEMENT: DEFINING GOOD MANAGEMENT PRACTICES AND ASSOCIATED NUTRIENT LOSSES ACROSS PRIMARY INDUSTRIES

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Abstract

Across New Zealand, regional authorities are taking steps to maintain or improve the quality of freshwater. Although regional differences exist in the approaches being taken, the need to define agricultural good management practices (GMP) and understand the impacts of GMP on freshwater quality is a recurring theme. However, there are no commonly agreed definitions of GMP for these purposes and there has been no systematic attempt to estimate nitrate (N) and phosphate (P) losses associated with farms operating at GMP.

Environment Canterbury aims to address this through a collaborative project with agricultural industries (dairy, sheep and beef, horticulture, arable, deer and outdoor pigs) and research agencies.

The project commenced in 2013 and involves:

1. Each agricultural sector defining GMP through engagement with farmers and other rural professionals working in that sector;
2. A consensus approach to establishing GMP across sectors;
3. Defining the main farm systems using data collected from actual farms across the region;
4. Using OVERSEER® to model expected nutrient losses from these farm systems, assuming they operate at the defined GMP, across the diversity of soils and climates in Canterbury;
5. Developing methods for grouping similar farm systems, soil and climate combinations together.

The main output from the project will be industry-defined GMP and a table of N and P loss benchmarks for a range of farming systems operating at GMP across Canterbury's soils and climates: the 'Matrix of Good Management'. Results are expected by July 2015.

In Canterbury, this will:

- Inform community deliberations regarding freshwater quality targets by setting out N and P losses that are achievable by farmers operating at GMP;
- Enable improved estimates of total catchment loads of N and P associated with diffuse losses from agriculture by quantifying these for current farm systems;
- Improve predictions of total catchment loads of N and P arising from land use change;
- Provide clarity to farmers regarding industry agreed benchmarks for nutrient losses.

Nationally, the project will demonstrate a collaborative approach to defining agricultural GMP and a robust process for quantifying the associated N and P losses. These aspects of the project will have applicability beyond Canterbury.

Introduction

The recommendations in the Freshwater Reform 2013 and Land and Water Forum emphasise the use of agricultural good management practices (GMP). In addition, Regional Councils must apply the National Policy Statement for Freshwater Management 2011 (Anon, 2011) to set, and manage land uses within, water quality limits. To meet these obligations, councils, land owners and communities need good information about the nitrate (N) and phosphate (P) losses arising from different land uses managed to GMP standards.

Various agricultural sectors promote the concept of GMP and have prepared lists of practices to show examples of GMPs. In some regions, e.g. Waikato, there have been efforts to bring together agreed menus of GMP across different farming sectors (Anon, 2014a). However, in Canterbury, there is not a clearly articulated set of GMP developed and agreed by each industry sector represented. Moreover, for any given GMP there will be a range of estimated nutrient losses, depending on farm system, soil type and climate zone, but the magnitude of these losses has not been evaluated systematically.

The Matrix of Good Management (MGM) project aims to identify expected N and P losses under GMP across the range of farming systems, soils and climates within the Canterbury region. This will be achieved through collaborative research and stakeholder engagement involving the primary industries, researchers and Environment Canterbury. The key steps are:

1. Each agricultural sector will define GMP through engagement with farmers and other rural professionals working in that sector;
2. The main farm systems will be defined using data collected from actual farms across the region;
3. These farm systems will be applied to the OVERSEER® model (www.OVERSEER®.org.nz), assuming the farms operate at the defined GMP, across the diversity of soils and climates in Canterbury. Expected N and P losses will be estimated from the model;
4. Methods will be developed for grouping similar farm system, soil and climate combinations together.

Within Canterbury, the N and P losses set out in the MGM will form benchmarks for farmers. They will provide Environment Canterbury with good estimates of N and P losses under a range of land uses, which will assist them in their understanding of current and future catchment loads. The Council and local communities will have good quality information with

which to explore policy options to balance environmental, social, economic and cultural outcomes against community expectations of water quality (Anon, 2014b).

Nationally, the MGM project could be an important tool for addressing the New Zealand-wide challenge of intensifying land uses and protecting water quality. If the MGM approach is successful and endorsed by communities and industry then other councils may be able to apply a similar approach, and/or some of the results, in their region with savings in cost and time.

Overall, it is anticipated that the MGM project will assist with the implementation of GMP on farms and will provide robust estimates of the nutrient footprint of farms operating at GMP. In addition, two research work streams in the project are focused on wintering systems and intensive cropping systems, and these will provide improvements to the OVERSEER® model (Anon, 2014c).

Industry approaches to defining good management practice

An important element of the design of the MGM project is the central role played by each of the primary sectors involved (dairy, sheep and beef, horticulture, arable, deer and outdoor pigs) in defining GMP. Although each sector is represented within the project structure by appropriately experienced executive staff, a highly consultative approach involving farmers and other rural professionals is being taken by each sector.

While existing conceptual definitions of GMP, e.g. from the Land and Water Forum, have provided a useful starting point for discussion, the aim within the MGM project is to describe the practical farming actions that are considered to constitute GMP. In other words, each sector is aiming to articulate the reasonable management actions that farmers could be expected to take when farming well.

Details regarding methodology to achieve this vary across sectors. This is partly because some sectors have already aggregated and published GMP 'menus', e.g. Beef + Lamb New Zealand's Land and Environment Planning Toolkit (Anon, 2014d), while others have hitherto focused on delivering specific GMP tools, e.g. the Foundation for Arable Research's AmaizeN nutrient management software (Anon, 2014e), rather than seeking to articulate a holistic view of GMP.

Regardless of the starting point, each sector has taken an iterative approach to defining GMP, generally involving workshop sessions with groups of farmers and rural professionals. Draft lists of tangible GMP measures arising from these discussions have been the subject of further discussion and refinement within industry sectors.

Whilst this process is not yet complete, sufficiently well-developed menus of GMP have been produced to enable the grouping together of sector GMPs on the basis of areas of farm management decision-making, e.g. nutrient planning. Grouping in this way may be helpful in comparing GMP across sectors for the purpose of evaluating equivalence.

Characterising farming systems

Another aspect of the MGM project is to determine the relevant farm systems to include in the matrix. Various methods are being used for this but common across all industries is the importance of current farm data. All industries have collected, or are in the process of collecting, information on farm systems and farm management from a sample of the farms in

Canterbury. For the smaller sectors this has been by invitation (deer, outdoor pigs). For others, a random sample of farms has been selected and invited to participate (horticulture, arable, beef and sheep) or data from a large industry database of OVERSEER® files have been used (dairy, courtesy of Ravensdown Fertiliser Co-operative). Data being collected from the farms are detailed enough to establish descriptions of farm systems in either Farmax Pro (Webby *et al.*, 1995), Farmax Dairy Pro (Bryant *et al.*, 2010) or APSIM (Keating *et al.*, 2003) models and to calculate their nutrient losses using the OVERSEER® model (Wheeler *et al.*, 2006; Cichota *et al.*, 2012). Farmax is not being used to describe typical farm systems for the dairy industry, but a cluster analysis will be conducted using the Ravensdown database, including OVERSEER® output, to describe farm systems, management and accompanying nutrient losses.

At the time of writing this paper, all industries were in the process of collecting and verifying the data. In meetings with farmers and other relevant industry players the data will be 'sense-checked' to ensure the farm systems and management are relevant to the industry in Canterbury, and true outliers and gaps are identified. The final sample set will be assessed to ensure that it covers the relevant range of soils, climates and topography for each land use in Canterbury. When all areas with a relevant presence of a particular industry are covered by farms in the sample, it will be assumed the sample is sufficiently spatially representative of the region. Where substantive gaps are identified, either across the region or across farm systems, the industries involved will endeavour to collect more data to address these gaps.

Table 1. Sample size of farms per industry

Industry	**Sample size**
Outdoor pigs	16
Deer	13
Horticulture	25
Arable	23
Beef and sheep	30
Dairy	205

Characterising the variation in climate and soils within Canterbury

Within Canterbury there is considerable variation in the key environmental conditions that influence nutrient losses from farms. Annual rainfall on the agricultural land varies from 430 mm/yr in the eastern McKenzie Basin to 5500 mm/yr close to the Main Divide, elevation ranges from sea level to 2360 m above sea level, soils range from very poorly drained to well drained with estimates of Profile Available Water (to 1 m depth) that range from 45 to 235 mm. Development of the MGM requires that this continuum of variability is categorised or 'discretised' into climate zones and soil types that still capture the main characteristics of the resulting variation in nutrient losses.

The primary sources of information for climate and soil respectively are the NIWA Virtual Climate Station Network (Tait *et al.*, 2006) and S-map (Lilburne *et al.*, 2012a). There are a possible 1491 virtual stations in the agricultural parts of Canterbury and over 650 S-map siblings. Many of these will be very similar to each other. A clustering exercise will be undertaken to group the climate stations and soil types into a more manageable set. A simulation approach will then be used to simulate nutrient losses, e.g. from a single urine patch or wheat crop using APSIM across all of the climate stations under a few key dryland

and irrigated soils over a period of 30 climate years. A similar analysis will be undertaken on the soils, allowing both climate stations and soils to be clustered into groups. The final number of clusters will reflect the practical requirements of the MGM as well as the variation in the modelled results. Not all clusters will be relevant to all farm systems. This will be determined using AgriBase™ (a database of farm type, ownership, location and management in New Zealand) and information from the industries.

Modelling Nutrient Losses

Ultimately the MGM will provide values of expected N and P losses for farms managed under agreed GMP. This will necessarily mean that a model will be used to assess the nutrient losses because no feasible systems exist that measure losses at the whole farm scale (Vogeler & Snow, 2012; Lilburne *et al.*, 2012b).

OVERSEER® works at the whole-farm scale, is widely used in New Zealand, is freely available and was accepted by the industry representatives on the MGM project as the best tool available to assess nutrient losses for the purposes of the project (Williams *et al.*, 2012). Modelling (and measuring) any biological system will be subject to error but some of these errors cancel out when one model output is compared to another. For this reason we take the approach that the same model (and version of that model) should be used to both set the target nutrient losses and to assess compliance.

The modelling work to produce the nutrient losses needed for the MGM has been conceptualised in three stages, as shown in Figure 1. The work will begin by utilising the collation of realistic farm management information that has been described in the section headed '*Characterising farming systems*'. This will provide detailed farm-level information that will allow models to be constructed for 312 existing farms in Canterbury, representative of the participating industries. The first stage is modelling the nutrient losses for these farms, using OVERSEER®, to provide estimates of the likely current levels of nutrient losses.

Stage Two in the modelling involves assessing the likely nutrient losses from those farms when they are managed under the agreed GMPs (see section: '*Industry approaches to defining good management practice*'). For some farms, perhaps many, this will mean no change to current farm management, and nutrient losses under GMP will be the same as those under current management. However, for other farms it is likely that management changes will be required. For example, changes in the overall or temporal pattern of stocking rate, changes in the amount or timing of fertiliser or irrigation applications, or changes in how crop rotations are managed.

While minor changes to the farm management can be made in OVERSEER® alone, more substantial changes must be supported by external information about how these changes will affect the biophysical production system. In these cases other models will be used, such as APSIM (Keating *et al.*, 2003) and Farmax (www.farmax.co.nz) to calculate the effect of management changes on farm inputs (e.g. fertiliser, supplements) and production outputs. That information will be combined with that collected for Stage One to construct an OVERSEER® representation of the farm under GMP. Comparison of the nutrient losses calculated under Stages One and Two will indicate, very generally, the likely changes in nutrient losses between current management and GMP and will also assist with a sense-check of GMPs as to whether they might be straying into best, rather than good management.

Although a considerable effort will be placed in modelling the 312 farms, this number is a small (circa 1%) fraction of the total number of farms in Canterbury. Therefore, Stage Three will expand the farming systems modelled in Stage Two to a more comprehensive set of farm systems and then to extend the range across the relevant clusters of soils and climates in Canterbury (see section headed '*Characterising the variation in climate and soils within Canterbury*'). A variety of methods will be used to expand the farm systems from Stage Two. These methods (Figure 1) will include APSIM, Farmax, a Linear Program and other statistical methods. The result will be a set of farm systems that are considered representative for Canterbury at the given environmental conditions and that are then assessed for nutrient losses using OVERSEER®.

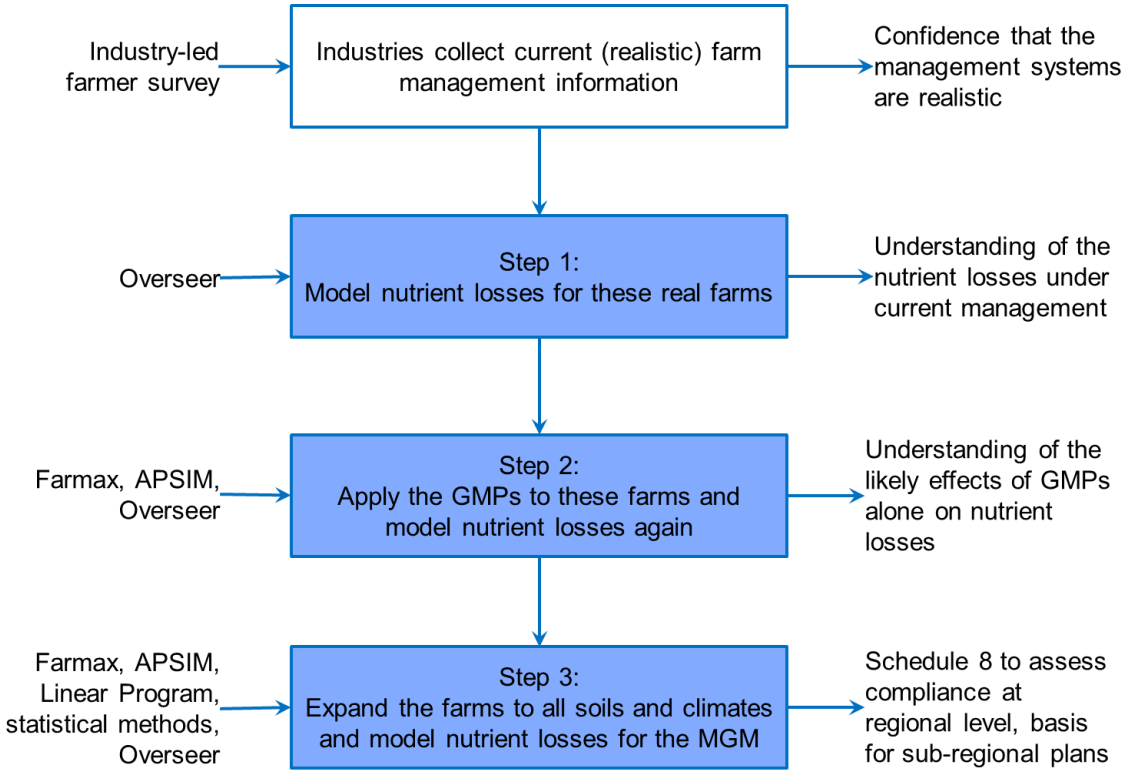

Figure 1. Modelling schematic showing the steps from collection of the farm systems data to the generation of the expected values of N and P loss for Canterbury farms managed under GMP that will populate the MGM.

The 'Matrix'

The main output from the project will be a table, or matrix, of N and P losses for a range of farming systems operating at industry defined GMP across Canterbury's soils and climates, which would form part of the region's Land & Water Plan. Landowners would be able to compare their estimated nutrient losses from OVERSEER® with the values from the matrix.

Environment Canterbury's expectation is that all farms greater than 5 hectares, or properties exceeding a nitrogen leaching threshold, by 2017 would be applying GMP aligning with the national consensus that GMP should be the minimum performance standard for farming

activities[1]. In catchments where the nutrient loads do not deliver the agreed water quality targets, the Canterbury Water Management Zone Committee and the local community would discuss what mechanisms would be required to achieve the catchment water quality targets, including requiring farmers to go beyond good management practice.

Summary
This project aims to take a consensus approach, involving primary industry sectors, research institutes and Environment Canterbury to quantifying the typical N and P losses that are expected to occur from the range of farming systems, soils and climates across Canterbury when managed to GMP. This presents significant social, political and technical challenges but has the potential to deliver robust, credible and transparent benchmarks that will be invaluable in managing farmland to minimise N and P losses on the basis of outputs rather than nutrient inputs.

At this relatively early stage, none of the key steps in this work has yet been completed but good progress has been made in defining farm systems and defining GMP.

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