BEFORE THE ENVIRONMENT COURT **ENV-2010-WLG-000148**

UNDER	the Resource Management Act 1991
IN THE MATTER	Of an appeal under Clause 14 of the First Schedule to the Act
BETWEEN	**FEDERATED FARMERS OF NEW ZEALAND** APPELLANT
AND	**MANAWATU-WANGANUI REGIONAL COUNCIL** RESPONDENT

EVIDENCE OF DOUGLAS CHARLES EDMEADES

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My Qualifications and Experience

1. My name is Douglas Charles Edmeades. I hold the following qualifications: MSc (Hons) in chemistry (University of Auckland), PhD in soil science (Canterbury University) and Diploma in Management (University of Auckland). Initially (1976) I was employed as a soil scientist at Ruakura Agricultural Research Centre (Research Division, Ministry of Agriculture and Fisheries). I became Group Leader (Ruakura Soils and Fertiliser) in 1988 and, with the formation of AgResearch Ltd, (1992) I was made National Science Leader (Soils and Fertiliser).

2. It was as national science leader I instigated and management the research project that lead to the development of OVERSEER. This included setting the specifications for OVERSEER. Importantly this included making it a Decision Support System for experts on an annualized time basis.

3. In 1997 I left AgResearch and established my own company agKnowledge Ltd. AgKnowledge provides farmers with a) nutrient management advice (Nutrient Management Plans) throughout New Zealand, b) publishes technical information for farmers and consultants (the Fertiliser Review) and c) undertakes research on behalf of clients. In this private capacity I continue to publish research papers in the scientific literature.

4. Cumulatively I have 35 years of experience in soil fertility, pasture nutrition and nutrient management, have written over 100 research papers, several book chapters and one book. Of particular relevance to this case I will refer to a recent paper (Edmeades et. al. 2011. "Setting the Standard for Nutrient Management Plans" a copy of which is appended)

5. I have read the Environment Court's practice note, Expert Witness – Code of Conduct, and agree to comply with it. I have not omitted to consider

material known to me that might alter or detract from the opinion I express.

Scope of Evidence

6. My evidence will discuss:
   a. The evolution, development and purpose OVERSEER.
   b. The estimated N loadings for the 19 scenarios ('Approaches') determined by Roygard et al (ref) relative to the target loadings.
   c. The LUC approach for determining and managing nitrate leaching from dairy farms?
   d. The use of the phrase "reasonably practical" in respect to "farm management practices for minimizing nutrient leaching ....".

The Development and Use of OVERSEER

7. I was appointed Group Leader (Soils and Fertiliser), Ruakura, MAF Research Division in 1988 and then in 1992 became the National Science Leader (Soil and Fertiliser), AgResearch. I was instrumental in the design and development of OVERSEER.

8. OVERSEER was designed as a 'Decision Support System' to assist Farm Consultants make decisions about fertiliser use. It is a farm management tool designed to make comparisons between different fertiliser scenarios over average annual time- steps. In the international context, and for the purpose it was designed, OVERSEER is 'leading edge technology'.

9. In terms of the nitrogen component of OVERSEER, Dr Ledgard developed the initial N model and is responsible for its ongoing development (Ledgard Evidence in Chief).

10. An important output from the N model is the estimated annual rate of nitrate leaching. More specifically it is the predicted amount of nitrate N

leaving the root zone of the soil. It does not represent the amount of nitrate getting into the receiving water.

11. Dr Ledgard (s42 report dated August 2009) estimates that the variability (the error +/-) in OVERSEER derived N leaching losses to be "in the order of +/-20%". The sources of these errors are a) farm-derived errors (amount and timing of N fertiliser use, stocking rate, animal productivity and winter management practices) and user-defined variables (rainfall, pasture development status and pasture clover content). The principle of 'junk in = junk out' applies. In addition there are the inherent 'errors' within the model itself due to our inability to accurately quantify all aspects of the nitrogen cycle. For these reasons OVERSEER must be used with extreme caution when applied as a tool to inform policy decisions such as the One Plan.

Application of OVERSEER to the One Plan

12. Roygard et al. (Evidence 14 February 2012) have used OVERSEER to calculate the N loadings on the various sub-catchments within the MWRC (Manawatu-Wanganui Regional Council) for 19 different management scenarios, referred to as 'Approaches' (Table 1) from which they have calculated the percentage improvement (+) or degradation (-) relative to the current state (Table 2).

13. The percentage differences all fall within the error (used in its statistical meaning) range (+/- 20%) in the estimates of nitrate leaching. In other words the estimated N loadings for the 19 scenarios are within the limits of detection of OVERSEER. It would be nonsensical to say one scenario is better or worse than any other. Certainly it is to be hoped that polices, which may affect the livelihood of farmers in the region, should have a stronger evidential basis.

Estimated Nutrient Loadings

14. Within the evidence of Roygard et al. (14 February 2012) there are comparisons of the current N loadings with the target loads required to achieve the 'ideal' water quality (Table 6). The reductions in the current N loadings required to achieve the water quality targets are about 50% on average across all the sub-catchments. This is much greater than the predicted beneficial changes likely to result from applying their best scenarios, numbers 6 & 9 (about 10-15%) (Table 2).

15. The scenarios 9-15 used in the Evidence of Roygard et al. cover a wide range in 'loss limits' from 33 kg N/ha/yr down to 15 kg N/ha/yr. The estimated improvements, relative to the current situation, are estimated to be from -12% (range -1% to -41%) to +5.9% (range -3% to +14%). Thus even with large changes to N loading from 33 kg N/ha/yr down to 15 kg N/ha/yr, the likely improvements in water quality would be small (about 18% being the difference between -12% to +6%), relative to the changes required (up to 50%) to achieve the water quality targets.

16. If it is assumed that the target, actual and scenario loadings reported by Roygard et al. in the evidence are correct then it appears that very large changes on-farm have very little effect on water quality. For example, a 50% reduction in nitrate leaching - which would represent large changes in farm management practices that may not be practically feasible and/or economic – is required to achieve an improvement in water quality of about +18% (i.e. from -12% to + 5.9%), which is small relative to the required change (+50%) if the target water quality is to be met.

17. Several inferences can be drawn from this:
    a. There is little that can be done on-farm, using current technologies to achieve the desired water quality targets
    b. The water quality targets are unrealistic given current technologies.

c. There are other sources of N, apart from nitrate leaching from dairy farms, that significantly impact on water quality
d. The assumptions used in the calculations of the nutrient loadings are not correct. In particular the connectivity between the amount of nitrate N leaving the root zone (as estimated by OVERSEER) and the amount getting into the receiving waters needs to be questioned.

Land Use Capability Approach

18. The use of LUC as a basis for determining and managing nitrate leaching from dairy farms (both new and existing) is fatally flawed and, in my opinion, it is most unfortunate that this concept has been introduced into these hearings.

19. There are 4 reason for this:
    a. LUCs per se do not determine the actual or predicted amounts of nitrate leached from dairy pastoral soils.
    b. The LUC approach is inequitable
    c. The application of LUC to managing nitrate leaching in this case could *trap* future generations of farmers into a 1980s 'time warp'.
    d. The use of LUCs in setting and managing nitrate leaching levels is not logical.

20. LUC classes were introduced in the 1950's as an adjunct to soil maps. Soil maps were useful in terms of defining NZ soil resources but soil-mapping units did not necessarily infer anything in respect to the potential land uses and productive capacity of the soils. Importantly, when they were defined (1950s?) and latter upgraded (1980s?) they were based on the 'best available information and technology' available at that time. In other words the definitions and descriptions of LUCs are time-bound and in particular represent the 'best guess' scientists were able to make some 30 years ago.

21. The maximum allowable nitrate leaching rates given in Table 13.2, were derived by using the LUC as a proxy for the likely stocking rate that could potentially be carried on that class of land (refer MacKay s42 report). From this, the predicted nitrate leaching (or more specifically, the predicted amount of nitrate N leached in the drainage water below the plant rooting depth) for each LUC was calculated using OVERSEER, assuming than none of the practices and technologies developed in the last 30 years were being used (i.e. farms would be managed including: all pasture-feed with no supplements, no N fertiliser and hence optimal clover production, no feed or standoff pads, no herd homes, using the pasture cultivars and management of 30 years ago, no nitrification inhibitors, lower stocking rates at present, two-pond or nil effluent management, no riparian or wetland management etc).

22. Thus, the estimated maximum allowable nitrate leaching losses in Table 13.2 are indicative of the situation about 30 years ago. They are time bound.

23. It is then asserted that these estimated nitrate-leaching rates represent the amounts of N leached from the soil in their 'natural' state (Natural Capital Value, NCV). This carries the meaning that this is a 'starting point', a 'baseline' for considering the management of nitrate leaching. This is completely arbitrary – why not calculate the nitrate leached from the various land classes prior to the introduction of clover-based pasture - would that not be more natural starting point? [As an aside: it is my view that it is unfortunate that the concepts of NCV and Ecosystem Services (ES) have been introduced to these hearings]. These concepts have only recently been introduced into soil science. Most soil scientists are uncertain as to their meaning and application, at least to applied science and indeed their relevance to these proceedings].

24. Apart from the arbitrary use of the word 'Natural' the assumption implicit in this approach is that the average amount of nitrate leached (per hectare per annum) for each LUC is related to the potential stocking rate.

25. Our current understanding is that the amount of nitrate leached, or to be more correct, the amount of nitrate leached into the drainage water of the soil can be written as:

Nitrate leached = a function of the management of:
(Landscape, Farm type, Farm system, Animal, Pasture, Soil, Fertiliser and Effluent)

26. The components of each category are set out in the table below:

Category	**Components**
Landscape	Riparian buffers & Wetlands (natural & man-made)
Farm Type	Dairy, Sheep & beef, Cropping
Farm System	In situ gazing, partial grazing (standoff pads), nil grazing (herd homes),
Animals	Stocking rate, types of supplements with various N contents, wintering on or off.
Pastures	Clover content, pasture types (rooting depth) pasture production & utilization
Cropping	Cultivation technique, timing, fertiliser N practice.
Soil	Irrigation, drainage, soil fertility, pugging management, erosion management.
Effluent	System type and management, pasture or cropping.
Fertiliser	Amount & timing of N fertiliser.

27. LUC per se is not a factor listed in the above for the reason that nitrate leaching is determined by a group of factors much broader than those that determine LUC. However some of the essential components of the LUC, such as slope class, soil texture and carrying capacity are implicitly incorporated in the above.

28. To base policy for the management of nitrate leaching on LUC is therefore fatally flawed because LUC per se does not determine nitrate leaching rates for it fails to consider many other impacting factors.

29. Not only is this approach flawed, but it is not logical, for it implies that if the farming practices of 30 years ago were now applied, the water quality problems presently confronting Horizons Regional Council would be solved!

30. Basing future nitrate management on LUC would also be inequitable. Consider the situation of a farmer now farming on the lowest class of land. Thirty years ago is would be unlikely that such land would be used for dairying. Certainly the stocking rate based on the LUC would be low and hence the likely leaching losses low. With irrigation, supplements, modern pasture species and management this activity (dairy farming) is now economic. But the proposed policy based on LUC could mean the dairying on this class of land would not be possible if the LUC-based N cap is to be meet.

31. The alternative situation is also problematic. A farmer on the best class land would, based on this approach, have a relatively generous nitrate-leaching cap. But with current technologies and farm management practices (see Table above) it could well be possible to reduce the actual nitrate loading below the limit required by the LUC, thereby contributing to even better water quality. The LUC based policy would however not encourage such activity.

32. The list of management practice given in the above table is open ended – it is not time bound like the LUC concept. As new technologies are identified, tested and developed they can be added into the mix of management factors to control nitrate leaching. Examples include the ongoing development of nitrification inhibitors and deeper rooting pasture plants or herd homes, coupled with cut-and-carry pasture

management. It is conceivable with these, and other yet to be thought about ideas, future dairy farmers may be able to remain economically viable and still achieve nitrate loading below those set out in Table 13.2. Any policy for managing nitrate leaching must be open-ended and enable and encourage future innovation. The LUC based policy does not allow for this and traps dairy farming into a 1980's time warp.

33. Roygard et al. evidence (February 2012) have calculated the likely N loadings for 5 LUC scenarios (referred to as 'Approaches in Table 1). They have also calculated the effect of each scenario on N loadings relative to the current situation expressed as percentages (Table 2). In all cases the percentage differences are within the error associated with the use of OVERSEER and in any case are not dissimilar to the differences achieved from apply single number limits (Table 2), allowing for the errors associated with these estimates, falsifying the view that there is something special or unique in the LUC approach.

34. For the reasons set out above the LUC based approach is arbitrary and essentially meaningless. It gives the appearance of being based on sound science when it is not. For this reason it is potentially dangerous.

35. In my evidence below I set out a science-based approach, which is robust and in my view has integrity. If this approach is not appropriate for other reasons, then I suggest consideration of appropriate single N loss value for application to dairy farms in priority water management zones as part of the rules framework. Such N loss value(s) would be adopted based upon appropriately benchmarked industry values of N leaching loss and would be more appropriate than the proposed LUC based approach. This approach is transparent and is based on practical reality rather than pseudo-science.

Is There A Better Approach

36. Twenty-three Water Management Sub-zones have been identified within the Horizons Region. For each Sub-zone the current water quality has been assessed and the "desired" (scientifically, the "ideal") water quality standard determined. From this information the loadings of soluble inorganic nitrogen (SIN) required to achieve the "desired" water quality for each Sub-zone has be determined.

37. These water quality standards and SIN loadings should be the baseline from which practical nitrate loadings for each catchment should be set. This approach would be more objective and transparent than setting arbitrary levels based on LUC units.

38. It is accepted that to achieve these absolute water quality standards in the short-term may not be economic and hence practical, but such an assessment is based on current knowledge and technology. Any forward looking policy must encourage and allow for new technologies which have not yet be thought about or developed. In this sense these goals are aspirational goals but this should not be a reason for abandoning them in favor of arbitrary and inequitable levels based on LUC.

39. It is within this context that the phrase "reasonably practical" as used in the Decision Version of Chapter 13 (policy 13-2C (b)) can be given expression and meaning.

40. It is suggested that the community making up each Water Management Subzone should, with the assistance of information from the Regional Council, decide what water quality standard they require relative to the target loadings as set out in Table 6 (Roygard et. al. pg18 evidence 24th February 2012). They could also set, with the assistance on the Regional Council, realistic timeframes to achieve the community-determined water

quality standard, which balances the economic needs of the community with their chosen environmental goals.

41. Once these decisions have been made, a process is required to link the community-determined water quality standards back to specific farm management practices and technologies appropriate to achieve this standard.

42. The Decision Version of the One Plan suggested that this link is provided by farmers developing Nutrient Management Plans (NMP). They suggested that these should be based on the Fertiliser Industry's "Code of Practice for Nutrient Management".

43. The Industry's Code of Practice for Nutrient Management (2007) takes the user through a 7-step process whose endpoint is the selection of the appropriate Best Management Practice (BMP) suitable for the risks identified and the requirements of the farm.

44. Subsequent thinking and development by scientists independent of the Fertiliser Industry (Edmeades et. al. 2011. "Setting the Standard for Nutrient Management Plans" a copy of which is appended) suggests that the Industry's approach could be made more applicable, effective and robust.

45. Specifically the points they have raised are:
    a. Other NMPs have been developed by other organization and these ideas should be incorporated (e.g. agKnowledge Ltd "Total Nutrient Management" plans and the Ritso Society Inc., "Environmental Management System" specifically for major irrigation systems).
    b. The Code is generic and does not have the mechanism that links the specific water quality requirements (as defined the water quality scientists) of a given catchment (as defined by the Regional

Council) to the desired farm management practice. Thus, successful environmental outcomes cannot be guaranteed.

c. Currently the Code relies on the adoption of generic BMPs. Adopting BMPs may not achieve the desired environmental outcome and/or may unduly impinge on the farms production and economic goals. BMP's must be evaluated on a case-by-case basis)

d. The Code does not provide a mechanism to manage the inherent conflict between production and financial goals of the farmer and the environmental and social goals of the community. This problem is compounded by the goals of the large farmer-owned co-operatives who supply to or purchase from the farmer.

e. The Fertiliser Industry's Code is proprietary and can only be delivered by those in the fertiliser industry. There are about 200 private farm consultants who are quite capable of developing and delivering NMPs to farmers.

46. Edmeades et al. (2011) after considering the legal requirements for NMPs at both the national (RMA) and regional (Regional Council Rules) levels have proposed an 11 Step NMP based on the application of the FESLM (Framework for the Evaluation of Sustainable Land Management) definition of sustainability, which provides a practical framework which enables specific catchment goals for water and soil quality, as set out in Regional Council plans, to be linked directly to specific farm management practices required to achieve those goals. It is in the public domain.

47. The application of the FESLM framework at the individual farm levels requires that farm goals be specified in respect to: production, economics, risk, environmental and social. While the farmer is largely in control of the production and economic goals, the goals (standards) adopted for environmental and social compliance will be set largely by the society in which the farm operates. Specifically, the farmer will be required to adopt the water quality standards required for the catchment in which his farm is located.

48. If this approach was adopted by the One Plan, the ground water nitrate concentration required for the particular water management zones which have been identified would inform the environmental goal for the farm regarding N loss from the farming enterprise.

49. This approach is not prescriptive because it gives the farmer total flexibility as to which practices and technologies to apply. He may for example choose to modify the stocking rate and thus alter his goals with respect to production and/or economics. Equally he may choose a high tech solution, building a herd home and operating a cut and carry system thereby approximately halving the nitrate loading.

50. This approach is not dependent on BMPs. This is appropriate because adopting all the relevant BMPs may not achieve the desired environmental goal or may unduly impinge on the farms production and economic goals, without achieved the desired environmental outcomes.

51. This approach encourages the development of new ideas and technologies not currently being thought about or applied. A farmer may well develop his own novel approaches to the problem such a tile draining the whole or parts of the farm, collecting the drainage water and extracting the nitrate!

52. This approach encourages farmers and their advisors to select the more cost effective options for a given situation.

Conclusions

53. The approach suggested by Roygard et. al. in evidence lodged on the 14 February 2012 is by no means conclusive. The estimated reductions in N loadings for the 19 scenarios are all within the limits of error (used in the statistical sense) introduced by the application of OVERSEER. It would be nonsensical to choose one scenario over any other. Furthermore, the

estimated reductions in N loadings calculated for the 19 scenarios are small relative to the actual changes required to reach the desired water quality target.

54. The use of LUC's to determine the allowable N leaching loss level for existing and new dairy farms is similarly flawed because N leaching is affected by many more factors that are not included in an LUC classification. The fact that LUCs can, if time-bound, be construed to represent the NCV of a soil is irrelevant to the issue confronting these proceedings.

55. The most effective method to improve overall farm performance with regard to N leaching losses on dairy farms is the case-by-case application of Nutrient Management Plan which includes all the reasonably practical management options required to reach the environmental goals set for the farm, which are linked to the water quality required by the individual sub-catchments and as determined by the community in that sub-catchment.

Dr D C Edmeades

March 2012.

Appendix

SETTING THE STANDARD FOR *NUTRIENT* MANAGEMENT PLANS

Dr D C Edmeades[1], Dr M Robson[2], Dr A Dewes[3]

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INTRODUCTION

Nutrient Management Plans (NMP) are a relatively new concept in New Zealand and, for reasons discussed in this paper, are likely to become mandatory for many, at the individual farm level, within the next 5-10 years. This prospect should be vigorously embraced and encouraged by all those involved, especially farmers, because it is now known that NMPs not only reduce the environmental footprint but also can have significant economic benefits (Edmeades 2008).

The task ahead is enormous. It will require a clear vision of where we have come from and where we are headed. For this purpose Figure 1 is instructive.

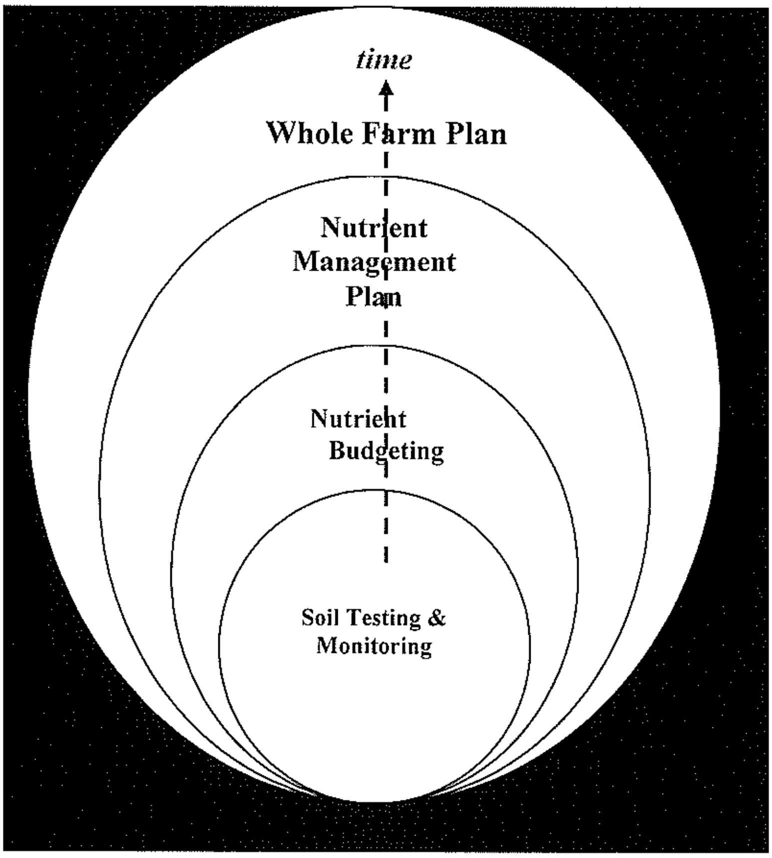

Figure 1: Nutrient Management in Context

Monitoring soil fertility has become routine since the mid 1950s when soil testing was introduced. With the development of OVERSEER® in the early 1990s Nutrient

Budgeting (NB) has also been adopted. Nutrient Management Plans (NMP) are now on the horizon with the future prospect that they will become a component of the wider Whole Farm Plans (WFP).

The tentative efforts to date to develop NMPs have been *ad hoc* and hence the purpose of this paper is to outline an approach to nutrient management planning and attempt to define the minimum requirements of a NMP in terms of the technical and non-technical attributes which a NMP should embrace.

DEFINITION OF NUTRIENT MANAGEMENT

Nutrient management includes managing the nutrients (with emphasis on N and P because they are the major 'pollutants') coming onto or leaving ***a farm***[1]. It includes, obviously, the management of fertilisers (organic and inorganic) and any other significant sources of nutrients moving across the farm boundary (e.g. feed supplements) and for dairy farms, effluent management.

It must also include aspects of pasture, crop, animal and land management where these impact upon the movement of nutrients on to, from, and around the farm.

Because the fertility of the soil is a primary determinant of a) the need or otherwise for fertiliser and b) the losses of nutrients from the farm, an accurate assessment of average soil fertility of a given farm or management unit, relative to the economic optimal soil nutrient levels, is an ***essential foundation*** of a NMP. This point must be emphasized because it logically requires that a NMP must consider the goals and the economics of the specific farming enterprise.

LEGAL REQUIREMENTS FOR NMPS

The purpose of the Resource Management Act (1991) is "to promote the sustainable management of natural and physical resources." In terms of the Act "sustainable management means managing the use, development, and protection of natural and physical resources in a way, or at a rate, which enables people and communities to provide for their social, economic, and cultural well-being and for their health and safety while -

- (a) sustaining the potential of natural and physical resources (excluding minerals) to meet the reasonably foreseeable needs of future generations; and
- (b) safeguarding the life-supporting capacity of air, water, soil, and ecosystems; and
- (c) avoiding, remedying, or mitigating any adverse effects of activities on the environment".

The RMA (1991) is given effect through the regional council's Air, Water and Land (Soil) management plans and with some exceptions[2] farming, including the use of

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[1] It is accepted that there is at present no clear definition of 'a farm' in the context of an NMP. Given the legal requirement for NMPs (see later) much will depend on the specificity required by the Regional Councils in their Regional Plans. Is the average loading of N and P across all the blocks (LMU – see later) within a given farm, all that is required?. Can farms under common ownership be amalgamated for the purpose of a NMP?

[2] See footnote 3

fertilisers, is a permitted activity (i.e. does not require a specific consent) providing the farmer, as a minimum, complies with the Code of Practice For Nutrient Management (a Fertiliser Industry initiative) which in practice embraces the Dairying and Clean Streams Accord (a Dairy Industry Initiative).

Environment Waikato has taken this a step further and under Rule 3.9.4.11[3] fertiliser application is a permitted activity subject to:

1. Having a Nutrient Management Plan (NMP) when nitrogen fertiliser is applied at rates greater than 60 kg N/ha/yr and when any fertiliser is applied to land to which animal effluent is applied.
2. That there is no objectionable odour or particulate matter beyond the farm boundary,
3. That there is no direct application of fertiliser to any water body.
4. Following the Code of Practice for Nutrient Management.

The Environment Waikato guidelines specify that a NMP is based on a Nutrient Budget (NB) which must document all inputs and outputs (of N and P) and assess the potential losses of N and P. Also the NMP must identify actions to minimise any losses of nutrients (N and P) and it is suggested that these actions can be considered under a number of categories[4]. Environment Waikato does not specify what actions or management practices should or could be adopted on any given farm to minimize avoidable losses of N and P. It is left to the individual land owner to implement those options and practices which best suit the farm and its operation.

Environment Waikato does however require that NMPs are made available on request. This implies that the plans are in writing, are accessible and in a form and format that can be readily understood by a third party.

While Rule 3.9.4.11 requires farmers to prepare, and have available, a NMP, it is not specific as to what constitutes a NMP. Furthermore, no goals, guidelines or criteria are set as to the nutrient loadings of N and P required for a specific farm or indeed specific catchment after taking due consideration of the desired quality of the receiving waters. The philosophy inherent in Rule 3.9.4.11 is *laissez faire*[5] – it assumes that farmers are sufficiently self-motivated to achieve at least some qualitative reduction in the N and P losses from their property.

DEVELOPMENT OF NUTRIENT MANAGEMENT PLANS

The Fertiliser Industry's response to the RMA (1991) was to develop a "Fertiliser Code of Practice" on the understanding with regional councils that fertiliser use would

[3] Regional Councils can and do differ in their application and implementation of the RMA. For the purposes of this paper we will apply the rules as set down by Environment Waikato, which appear to be the most advanced in respect to this issue (accessed 15/5/2008)
[4] The categories suggested include: Effluent, Soil, Pasture, Production and Stock, Riparian, Cropping and the risk to waterways from 'hot-spots' such as silage pits, offal holes, farm dumps
[5] There are exceptions including the farms in the catchments of the Taupo and Rotorua Lakes for which nutrient caps are being applied and also for some specific, large irrigation schemes in South Island for which resource consents including NMPs are required

be a permitted activity providing farmers complied with this Code. Subsequently it was realised that fertiliser use is but a subset of nutrient management. Thus the Code was broadened and renamed, "Code of Practice for Nutrient Management with Emphasis on Fertiliser Use" (NZFMRA 2007).

The Code defines a NMP as:

> "A written plan that describes how the major plant nutrients (nitrogen, phosphorus, sulphur and potassium, and any others of importance to specialist crops) will be managed. The NMP applies only to that area of the property which is under the direct management oversight of the property manager. The nutrient management plan aims to optimise production and maximise profit value from nutrient inputs while avoiding or minimising adverse effects on the environment."

The Code sets out "Seven Steps" that are required to prepare, implement and monitor a NMP (Figure 2). Important features include: Setting the farm goals, identifying the specific land management units (LMU) within the farm, and for each LMU, identifying and assessing the risks (defined as a combination of the likelihood and consequences of specific event giving rise to nutrient losses occurring), the fertiliser requirements and a nutrient budget.

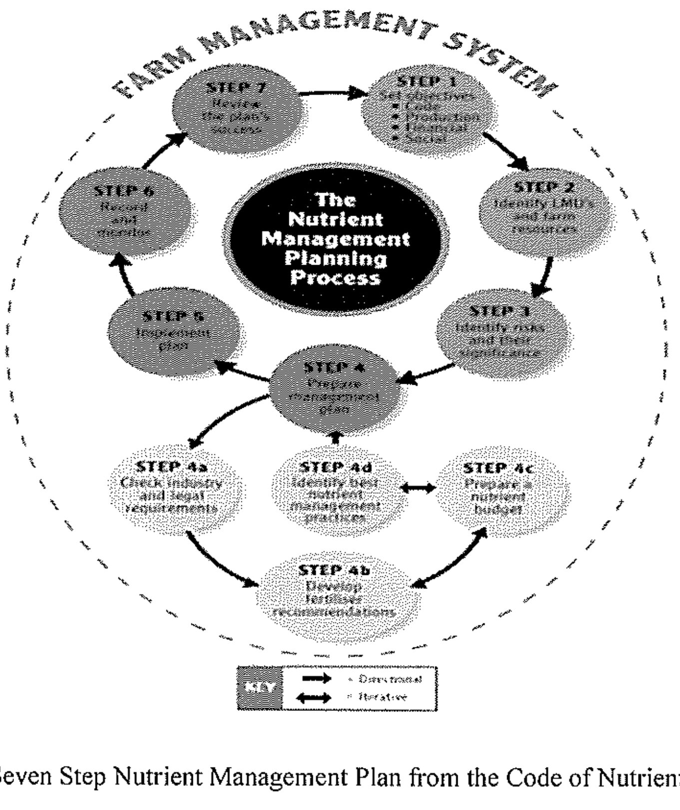

Figure 2: The Seven Step Nutrient Management Plan from the Code of Nutrient Management.

The Code includes a NMP Template together with 'User Guides' and associated 'Fact Sheets'. It appears that the intention of the Code is self-assessment by the land owner to be undertaken by ticking the appropriate boxes. For some reason the 'Template' does not follow the Seven Step process specified in Figure 1 and importantly does not include a Nutrient Budget.

The Fertiliser Industry has now modified and computerised the NMP template to allow the Field Representatives to prepare NMPs for their clients. It is designed so that generic comments and statements can be cut & pasted into the report and appropriate boxes "ticked." Best Management Practices (BMP) for the use of fertiliser N and P and for effluent are defined and are relied upon as the standard to be achieved Goals in terms of the desired nutrient loadings are not considered and there is no attempt to quantify the effects of a given BMP on the nutrient loadings. Nutrient Budgets are included but the Seven Step Process of the Code is not followed.

There are also some privately developed and owned examples of NMPs. For example, the Ritso Society Inc. has developed an "Environmental Management System" specifically for major irrigation systems. In essence, and similar to Fertiliser Industry's NMP Template, it in part relies on the application of some BMPs covering the various aspects of management. Once again no consideration is given to setting goals for nutrient loadings or what the impact of the BMPs on these loadings might be. Similarly agKnowledge Ltd has developed its own plan, "Total Nutrient Management" (TNM™) which places emphasis on the optimising soil fertility and hence the profitability of the farm at the LMU level. It includes a NB and in a semi-qualitative manner provides the farmer with management options to reduce nitrate leaching and P runoff.

Best Management Practices

Most of the NMPs constructed to-date take the user though a process which ends, as far as the farmer is concerned, with the application of various BMPs. For example the Code of Nutrient Management includes BMPs for Fertiliser Storage and Handling, the Use of Fertiliser N and Fertiliser P. Similarly, the "Environmental Management System" designed by Ritso Ltd, includes a BMP for the design and management of Irrigation Systems. However, the use of generic BMPs is problematic.

There is likely to be a mismatch between a recommended suite of generic BMPs and the unique nature of issues on farms and catchments. What may be best practice in one place may not be optimal, desirable or indeed required, in another place. For example, applying the BMP for the use of fertiliser N may be less useful to the wider environment if indeed phosphorus is the key issue. Similarly, adopting a BMP for riparian planting may be of little benefit if the goal is to reduce N leaching to groundwater. Also each farm is unique. Adopting the BMP for effluent management may be ineffective in terms of managing nitrate leaching if in fact the major source of N leaving the farm is discharged from a standoff pad.

Thus the application of a generic suite of BMPs to all water quality issues is of limited value because there is no identification of the catchment specific problem (s) and linking this to a farm specific solution (s) required to mitigate the identified problem (s). Expressed differently, a knowledgeable farmer would not write a generic NMP for his/her farm. He/she would identify the specific problem(s) and then identify the specific solution (s) required on the farm to deal with that problem(s). Thus, while the term "BMP" carries the implication of an automatic good outcome, successful environmental outcomes rely on more than BMPs alone.

This highlights another problem with BMPs – they are typically written with technical help by organisations for farmers – in this sense they are top-down solutions. What are in fact required are bottom-up solutions that begin with the requirements of the catchment and work through a process up to specific solutions on the farm. This has other advantages: it allows the farmer flexibility and has the possibility of serendipitous, novel and practical solutions coming directly from farmers.

New Approach Required

In our view a new approach to nutrient management is needed which enables goals to be set and requires that specific and quantifiable farm management activities are developed and applied to achieve those goals. Also, any new approach needs to be sufficiently flexible to be applied to all farms but robust enough to be empower the RMA (1991) at the farm level.

Smyth and Dumanski (1994) developed what they called a Framework for the Evaluation of Sustainable Land Management (FESLM) which defines sustainability through balancing and integrating goals set in five areas, which the authors referred to as pillars: Production, protection, viability, acceptability and risk. In their original form, the goals in the individual pillars are multi-layered and complex. In the interest of practical application on farm we have simplified the terms and propose that:

Any farm management practice is sustainable if the following five goals are achieved simultaneously:

- Production – does the practice achieve the desired production goal?
- Risk – does the practice reduce the risk of not achieving the production goal?
- Economic – is the practice economic?
- Environment – is the practice sustainable with respect to soil, water, air and other relevant resources?
- Social – is the practice socially acceptable?

This definition embraces the philosophy and purpose of the RMA (1991). The FESLM approach, like the RMA, is "effects based" and broadens and makes more explicit the definition of sustainability in the RMA which embraces social, economic and cultural well-being. Importantly FESLM provides the framework to link the regional council's Air, Water, and Land (Soil) plans in an objective, specific and quantitative manner to the individual farm. In practice it will be the farmer who defines the production and economic goals for his farm but the environmental and social goals will be determined by the wider community via the RMA (1991) through the regional council's Air, Water and Land (Soil) management plans.

The application of the FESLM is robust and flexible. The goals for water and soil quality are not, and indeed, should not be uniformly the same for all catchments and thus, differences between catchments can be expressed and managed in this manner via the regional plans. This has been made explicit in the recently released Regional Policy Statement from Environment Waikato[6].

Similarly, the farmer has maximum flexibility in terms of his farm management. This is because FESLM like the RMA is 'effects-based' – it should not matter whether a farmer follows generically prescribed BMPs or otherwise. The environmental and social consequences of his farming activities will be assessed and audited solely against whether he has achieved the appropriate goals for the catchment or region in

[6] Released in 2011 http://www.ew.govt.nz/Policy-and-plans/Regional-Policy-Statement.

which his farm is located. This effects-based approach, unlike BMPs, will encourage novel farmer-initiated ideas for environmental management.

The connectivity between the farm and environment, which this framework allows, will enable farming practices to be evolved over time so that the future management of agriculture will be based on the requirements of the receiving waters. Up until now this has not been generally possible, except for those specific catchments where an N-cap is now in place.

Finally, this approach makes explicit what is implicit in the RMA – that there must be a balance between farm production and hence the economic welfare of the nation and its citizens, and the need for environmental goals to protect the resources of air, water and land. It is our experience that farmers are very comforted by the FESLM approach because it enables this balance to be formalised and expressed.

MINIMUM REQUIREMENTS FOR NMPs

Non-technical Attributes

Purpose and Motivation

Leaving aside the legal imperative with its environmental and social drivers, NMPs must have a clear **purpose** and this purpose must be sufficient to **engage** and **motivate** all sectors of the primary industries to support their use, so that widespread and permanent changes in on-farm management will occur –"what counts is what works". There is little point in introducing NMPs otherwise. What must be avoided is the situation which arose in some cases around the introduction of NBs. Fonterra and the Fertiliser Industry, to their credit, made a large effort to deliver NB to all dairy farms but this process did not always constructively engage the farmers, except enabling them to 'tick the box' when the shed inspector arrived. On-farm management practices in many cases did not change primarily because the resulting NBs and their implications were not fully explained to the farmer. This can be the outcome of 'top-down' management solutions in this field of activity.

So what will or should motivate the adoption and use of NMPs? There are three differently motivated sectors to consider: the farmer, the related service industries and the central and regional governing bodies.

Farmers will be motivated to engage in the process of NMP providing they can see value – does having a farm specific NMP add value to my farm? Primarily this will be seen in monetary terms and the positive news is that it is estimated (Edmeades 2009) that the value of N and P leaking from an average dairy farm is about $5,000 to $10,000. Using nutrients efficiently, as instructed by a well defined and designed NMP, is good for the bottom line and for the environment. There are also less tangible drivers which farmers will embrace and these are embedded in phrases like, 'being a good steward to the land' and, 'leaving the land in better condition.'

Central and regional government will be motivated to support NMPs if they can see that they will achieve their policy goals. In particular, regional councils will become committed to NMPs if they can see that they are the vital mechanism that links their regional plans for Air, Water and Land (Soils) management directly onto the farm. This is further strengthened if NMPs provide a mechanism to manage catchments on an individual basis.

The motivation for the related servicing industries (dairy, meat, wool and fertiliser) is also direct. Many commentators argue that the New Zealand brand should be based on its 'clean green image'. NMPs could be a very important farm-based component of that brand. Thus, NMPs are likely to be 'good for business.' Furthermore, most are co-operatives owned by farmers – the farmer could benefit financially at their individual farm level and at the corporate level by way of dividends.

A danger that must be avoided is imposing NMPs on the industry that involve more paper work for little or zero benefit. Reversing the issue: is the information to be compiled and analysed in the development of a NMP, as set out in Table 2 going to be useful – can it be utilised for reasons other than the NMP to further improve the various components of the agricultural sector?

The information in the NMP should inform the farmer about the status of one of his most important assets – the soil. It should be apparent from the NMP what the farm goals are and how the fertiliser plan is directed to achieving those goals. It should be obvious whether the current soil fertility is balanced and optimised and that every fertiliser dollar is well spent. The NMP must also provide information on what mitigations options are available on a given farm and what is their likely effect on minimizing N and P losses. Ideally, cost and benefit analyses of the options would be desirable.

The information in a NMP must be available (see Section on Legal Requirements) for auditing purposes. Thus the regional council could have access to on-farm information which should provide some confidence that their regional plans are being enacted. This information may also be instructive in the ongoing process of developing regional Air, Water and Land (Soil) plans.

Similarly, the information from well designed NMPs could be used by the fertiliser industry in their planning cycles. For example, how many farms in a given region are above the optimal nutrient levels and hence require no fertiliser, how many require only maintenance fertiliser and how many need capital fertiliser? If so what are amounts of fertiliser required for a given region. In other words the information could be used to improve the efficiency of their business and their marketing.

Integrity

There is an inherent conflict between environmental compliance and farm productivity. This arises because generally, intensification is a positive driver of productivity but has a negative effect on nutrient loadings. Modern farming must find a way of managing this conundrum and find ways of improving productivity and at the same time reducing the environmental foot-print. Nutrient management lies at the heart of this dilemma and the usefulness or otherwise of NMP will depend on how well these dual and opposing goals are managed.

This is a further reason to adopt the FESLM definition of sustainability into NMPs because it provides an objective and transparent mechanism to balance the conflict inherent in achieving production and economic goals and at the same time achieving the desired environmental and social outcomes.

Including the FESLM definition also protects the nutrient management process against the conflict of interests that resides within some of the major stakeholders. Consider for example; what position would the cooperatives (Fonterra and the two large fertiliser companies), adopt if the price of milk was $10-$15/kg MS? Intensification resulting in greater volumes of milk and more fertiliser sales would be in their financial interests and indeed the financial interests of their co-operative owners – the individual farmers. But it would not necessarily be in the interests of the regional councils who are charged with the responsibility of managing New Zealand resources under the RMA.

To protect the integrity of the process, NMPs must be grounded in sound, robust science. The interpretations and advice offered must be technically defendable and able to withstand peer scrutiny. An NMP should be independent of commercial considerations: continuing to advise farmers to apply P fertiliser when the Olsen P levels are above the economic optimal, or recommending high fertiliser N inputs when they are not required based on the farm goals, may be good outcomes for the fertiliser company but they are not desirable from an environmental perspective.

<u>Effective, Relevant and Functional</u>

If NMP are to be effective and result in changes in on-farm management, a strong positive relationship between the farmer and the consultant, based on credibility and trust is essential. This requires a large investment of time, energy, skill and knowledge. So to, considerable time is required on-farm to initially gather the relevant information and make the appropriate assessments and then prepare a clearly expressed written report to a peer review and auditable standard.

It has been estimated that a full NMP report of the type envisaged would take about 2 days to compile, in addition to the 2-6 hrs required for the farm visit and the question has been raised, are there sufficient skilled personal at present to undertake this task? (Edmeades & Taylor 2007).

The NMP must be farm specific to be relevant – individual farm visits are essential. The adoption of the FESLM approach will ensure this is the case but the credibility inherent in this approach could be undermined if generic, cut-and-paste templates are adopted.

It can be argued that NMPs would have greater relevance to the farmer if they were to flow from a Whole Farm Plan (WFP). However it is unlikely that WFP will become compulsory and furthermore, different skill sets are required to complete a whole-farm analysis as distinct from developing a nutrient/fertiliser plan. For some farmers introducing a NMP as a consequence of a WFP may be more effective as a means to change on farm practices which impact on nutrient loss. Alternatively because of the legal imperative for NMPs, the most immediate entry point for many farmers will be via an NMP. As a consequence, some farm management practices may change (e.g. wintering cows off, changing stocking rate, using lower N feed supplements) as a means to reduce the environmental foot-print and rationalize the fertiliser expenditure.

In practice, which approach is adopted by a given farmer will depend on the skills of his consultant. The proposed non-technical attributes of an NMP are shown in Table 1.

Table 1: The non-technical attributes required in a Nutrient Management Plan

Attribute	Consequences for defining a Nutrient Management Plan
Legal requirements	Must comply with RMA (1991), Regional Councils; Air, Water and Land (Soil) Plans and the Code of Practice for Nutrient Management
Purpose & Motivation	1) Farmers: must add value (financial or otherwise) to the farmer's enterprise. 2) Service industries: must enhance their businesses especially protecting the "clean-green" brand. 3) Government and regional councils: provide a mechanism to implement the Air, Water, Land (Soil) plans on farm in a direct and quantitative manner
Integrity	Must be science-based and technically sound (based peer reviewed science) and preferably delivered by impartial consultants. Must be robust enough to manage the inherent conflict between productivity v environmental goals.
Effective, relevant and functional	Goals and mitigation options must be relevant, specific and quantifiable. Process must be easy to understand and applied and reports must be readable, understandable and accessible. Process should fit into a Whole Farm Plan.

Technical Attributes

It is a given that NMPs must comply with all the legal specifications discussed earlier. It is also essential to ensure that a NMP is specific and hence relevant to a given farm - it must be based upon the goals of the farm. Similarly, it is fundamental that a NMP must identify the various blocks or Land Management Units on a given farm. For the present purposes a LMU or block can be defined as areas of different soil group (sedimentary, volcanic, pumice, peat, podzol or sand), slope (steep, easy, rolling or flat), land use (grazing, cropping including silage and hay, runoff, effluent) or past fertiliser history, as indicated by the current soil tests.

It follows that the soil fertility for each block must be defined and monitored and that nutrient inputs should be calculated to ensure that each block is operated within the economically optimal nutrient levels that maximise the long-term profitability of the farm reflecting the farm's production and economic goals. A nutrient budget should be prepared for each block and for the average for all blocks on the farm[7]. A nutrient budget only indicates some of the risks on the farm (specifically N leaching and P runoff) and does not include other risk factors such as soil quality, and in particular soil drainage and compaction and the accumulation of heavy metals and nutrient 'hot-spots' around yards, raceways, feed-pads and silage bunkers. All of these risk factors[4] need to be appraised and a list of mitigations options prepared relevant to that farm and taking into account the farm environmental and social goals.

It is essential that the NMP is audited on a regular basis and for this reason the NMP must be set out in a written report that is accessible and comprehendible. The key purpose of the audit is to ensure that the goals set for the farm are being achieved. Needless to say the farmer's prime interest is likely to be the production and

[7] See footnote 1

economic goals whereas the third party auditor, let us say from the regional council, will likely focus on the environmental and social goals.

AN ELEVEN STEP NMP TEMPLATE

From the above a NMP template is proposed with eleven essential steps beginning with and based upon the FESLM definition of sustainability (Table 2). This builds onto and expands the 7 steps in the Code, noting that the risk assessment is introduced at Step 3 in the Code whereas it is inserted at Step 9 in the proposed scheme logically following consideration of the nutrient budget, soil quality issues and hot-spot's. In practice this difference is minor because this process is likely to be iterative

Table 2: The Technical Requirements of a Eleven Step Nutrient Management Plan.

Step	Activity	Comments
1	Define farm goals	Use FESLM pillars of Production, Risks, Economic, Environmental and Social to define farm specific goals. The environmental and social goals must link directly and specifically through the mitigation options (Step 9) to the regional Air, Water and Land Plans.
2	Identify farm blocks (LMUs)	This is the smallest unit of management on the farm as far as nutrient management is concerned. For dairy farms this identifies the 'Effluent' block.
3	Monitor soil nutrient levels	Develop a robust soil/pasture/animal testing protocol setting out the transects to be used on each LMU and the frequency and timing of sampling.
4	Define the economic optimal nutrient ranges.	Monitor soil fertility levels against the economic optimal nutrient levels for each LMU[8]
5	Calculate nutrient and fertiliser requirements	Determine the nutrient requirements for each LMU by comparing the soil nutrient levels to the optimal ranges. Include other non-pollutant nutrients (K, S, Mg, trace elements, and lime) to ensure the soil fertility is balanced (c.f. soil quality)
6	Prepare Nutrient Budget(s)	From the NB, estimate the losses of N (N leaching) and P (runoff) for each block and the average for the farm[9]
7	Assess soil quality	Consider all aspects of soil quality (biological, chemical and physical) and especially drainage, pugging, compaction and accumulation of heavy metals.
8	Assess "hot-spots"	Include offal pits, lane-ways, silage bunkers, fertiliser storage facilities and farm dumps.
9	Define risks[10] and mitigation options	Prepare a list of management options[11] that could be implemented on the farm to reduce N and P loadings and improve soil quality with a quantitative assessment[12] of their likely benefits.
10	Prepare NMP	The standard: it must withstand peer review and be understood by an third party (auditor)
11	Audit NMP	Review the NMP[13] and update Steps 1-10 noting any deviations from the NMP.

[8] It may not be necessary to determine the economic optimal nutrient levels for each farm or farm block. Some general ranges particularly for Olsen P could be determined based on farm production and more specifically farm gross margin

[9] This will depend on how the Regional Councils will apply the rules – at the LMU level, or the average farm level?

[10] The risk assessment introduced at Step 3 in 'the Code' is inserted at Step 9 here, to follow consideration of the nutrient budget, soil quality issues and hot-spots. In practice this difference is minor because this process is likely to be iterative

[11] This is the point in the process where the risks (as suggested by the Code of Nutrient Management) can be assessed and these could be addressed under the headings suggested by Environment Waikato (Effluent, Soil, Pasture, Production and Stock, Riparian, Cropping and the risk to waterways from 'hot-spots" such as silage pits, offal holes, farm dumps)

[12] At this point it is not possible to be quantitative about the effects of some mitigation techniques – further science is required. The intention is to be as quantitative as the science allows.

[13] Ideally the NMP should be reviewed and an annual basis as is currently done when considering annual fertiliser requirements.

CONCLUSIONS

Nutrient Management Plans are likely to become mandatory within the next 5 to 10 years but there is currently no clear definition of the requirements of NMPs. Based on an analysis of the technical and non-technical attributes required in a NMP we have proposed an eleven step NMP. The plan is based around the application of the FESLM definition of sustainability which provides a practical framework which enables specific catchment goals for soil and water quality, as set out in regional council plans, to be linked directly to specific farm management practices required to achieve those goals. The application of the FESLM process also ensures that the eleven step NMP is sufficiently flexible to be applied at the farm level and robust enough to objectively manage the inherent conflict between production and environmental goals.

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