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OVERSEER®: Answers to commonly asked questions

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OVERSEER®: Answers to commonly asked questions

Report prepared for the Ministry for Primary Industries

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D. M. Wheeler and M. A. Shepherd

Reviewed by M. C. Freeman

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“Everything must be made as simple as possible, but not simpler” Albert Einstein

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1. Background

1.1 *Overseer* - introduction

Overseer® Nutrient Budgets (*Overseer*) is an agricultural management tool that assists in examining nutrient use and movements within a farm to optimise production and environmental outcomes. *Overseer* calculates and estimates the nutrient flows in a farming system and can be used to identify potential risks of environmental impacts through the calculation of nutrient loss such as run-off and leaching, and greenhouse gas emissions. Detailed information on *Overseer* can be found on the *Overseer* website www.overseer.org.nz

The *Overseer* Owners (Ministry for Primary Industries, the Fertiliser Association of New Zealand and Agresearch) have specified the following vision and mission for *Overseer*.

Vision

A robust, science-based decision support tool and policy support tool that is widely used for improving farm profitability, optimising nutrient use and minimising impacts on air, soil and water quality.

Mission

To:

- *Develop and encourage the use of the Overseer nutrient budget model towards the stated Vision*
- *Reflect a partnership between farmers, growers, the fertiliser industry, scientists and government*
- *Follow open and consultative processes with stakeholders*
- *Adopt good science*
- *Be consistent with domestic and international laws, agreements and standards*

The Vision and Mission have been implemented in the development of *Overseer* by:

- Capturing nutrient pathways and transfers within the farm system;
- Modelling processes where paths change using robust science processes;
- Using data that the farmer/consultant knows, is readily available, or for which suitable defaults are available;
- Ensuring that the methods of capturing pathways and modelling processes are commensurate with the data requirements;
- Maintaining consistency between farm systems by modelling all systems in an integrated model to the same scale; and
- Maintaining a focus on mitigation options.

1.2 Objectives of this report

Overseer is attracting increased levels of interest from a wide range of stakeholders, many with different requirements and expectations of the model and levels of understanding of the operation and application of *Overseer*. This interest in *Overseer* has arisen primarily because many regional councils have identified it as an important tool in the development and implementation of catchment nutrient management plans.

The Ministry for Primary Industries (MPI) has collated a comprehensive set of questions based on: emails and questions that had been directed at MPI staff, media reports, as well as MPI staff suggestions. This report provides responses to each of these questions.

The questions and responses have been grouped into the following categories:

1. General questions about the model: how it works, strengths and weaknesses
2. Model uncertainty
3. Model performance for different sectors
4. Policy development and application issues

This document provides a reference point for MPI and for any interested person or organisation. More detailed information on the development and application of *Overseer* is available on the *Overseer* website www.overseer.org.nz

2. Questions and answers

2.1 General questions about the model: how it works, strengths and weaknesses

2.1.1 What exactly does Overseer model and what doesn't it model? How does Overseer differ from other farm nutrient models?

In short:

- *Overseer* models nutrient flows around farm systems including off-farm losses of nutrients, and greenhouse gases emissions. It models pastoral, horticultural, arable and vegetable farm systems. It calculates an **annual** nutrient budget that represents the **long-term annual average**. It calculates losses to the edge of the farm.

- Therefore:
    - It is not a daily time-step, tactical tool.
    - It does not take account of transformations, attenuation or dilution once nutrients leave the defined farm, e.g., in between the farm and any receiving water body.
- It differs from other farm models in that:
    - It aims to be a practical tool in that it relies on input data that are easily obtainable.
    - It aims to model all farm systems, across all regions of New Zealand.
    - Its wide scope is both a strength and a weakness.

The review by Cichota *et al*. (2009) discusses differences between nutrient management models in some detail.

Overseer is based on many years of scientific research, primarily undertaken in New Zealand. A list of over 30 technical references relating to *Overseer* is available on the *Overseer* website www.overseer.org.nz

The following is a brief explanation of *Overseer*. A more detailed introduction is contained in the *Overseer* Technical Manual Introduction.

Overseer is a strategic farm-specific model and provides users with tools to examine the impact of nutrient use and flows within a farm, namely nutrient use efficiency and off-farm losses of nutrients, and greenhouse gases emissions. It models pastoral, horticultural, arable and vegetable farm systems.

Overseer calculates an annual nutrient budget for each block within a farm and for the total farm unit, taking into account inputs and outputs and nutrient transfers around the farm. The inputs and outputs used to estimate the nutrient budget are also used to provide indices such as nitrogen conversion efficiency. The data used to estimate the nutrient budget are also used to estimate greenhouse gas and energy emissions.

Overseer also provides a means to investigate a range of specific potential mitigation options to reduce nutrient losses. Users range from farmers and their consultants through to policy makers and policy implementers.

Within New Zealand, *Overseer* is the only strategic farm-specific, farm-scale nutrient model that targets farmers and consultants as users. It can model farm-specific nutrient budgets for seven nutrients (N, P, K, S, Ca, Mg, Na), acidity, and greenhouse gas emissions on a per product and per hectare basis. It is a best classified as a semi-process based model – the processes are modelled but using less complex methods than found in process models. The processes included in *Overseer* are based on robust modelling procedures using both peer-reviewed and non-peer-reviewed research carried out over many years over a limited range of sites and management options and science principles, and an extrapolation process based on science principles. *Overseer* is not a series of look-up tables, or a classic empirical model.

The Overseer boundary is the farm boundary, which need not be spatially contiguous, and the bottom of the root zone. The model does not include losses due to poor management practices; 'good management practice' (GMP) is assumed (see section 2.1.2). The model also does not include direct discharges into waterways such as direct runoff from raceways, bridges, or roads, or stock crossings. The model does not include losses or attenuation within waterways, or the vadose zone. The model also does not include losses due to catastrophic or large storm events, natural events such as earthquakes or volcanic eruptions. More detailed descriptions of the model are in the *Overseer* Technical Manual Introduction.

2.1.2 What are the assumptions (e.g., best practice, etc.) underpinning the model and what are their implications for the use of the model and in obtaining representative outputs?

The key assumptions used in *Overseer* are:

Assumption	**Notes**
Quasi-equilibrium	The model assumes that inputs and farm management practices described are in quasi-equilibrium with the farm productivity.
Long-term average	For a given farm system, the nutrient budget estimates the long-term annual average outputs if the management system described remained in place.
Actual and reasonable inputs	The model assumes that inputs including animal productivity are correct. There is no checking on whether an inputted farm system is practicable, possible or viable.
Mitigations	The quasi-equilibrium and actual and reasonable assumptions means that any management changes or mitigation changes must also include changes in animal productivity
Management practices	Assumes 'good management practices' have been implemented on the farm

Defining 'good management practice'

Generally, *Overseer* assumes that 'good management practices' have been implemented. For example, if fertiliser or effluent are applied, *Overseer* assumes the stated rate is applied evenly at the time stated i.e., there is no 'poor management' that would result in 'large' discharges. For effluent, good practice is defined as in the DairyNZ dairy effluent Environment: Managing/Operating Effluent Systems website, including ‘A Guide to Managing Dairy Farm Effluent’ (DairyNZ 2012), and for fertiliser in the Fertmark and Spreadmark codes of practice (New Zealand Fertiliser Quality Council, 2012a, b). Similarly, the model assumes that sources such as runoff from yards, races, bridges, silage heaps are all dealt with in a manner that doesn’t result in large point discharges. However, not all possible ‘good management practices’ have been assumed, e.g., specific riparian strips. Care would be needed in any use of Overseer to be clear about the extent to which a specific good management practice is already assumed within Overseer or needs to be explicitly modelled as an additional measure.

In general it is not feasible or appropriate to try and model ‘bad practice’ - there is a wide range of such possible practices that are not readily amenable to modelling. In addition, many practices covered by good management guidelines are also compliance issues.

However, *Overseer* can model some instances of ‘bad practice’, for example:

- Nitrogen fertiliser – applying large amounts in the winter or applying more than is required for the level of production;
- Over-stocking; and
- Over-irrigating – causing extra drainage.

2.1.3 The model is too complex. Farmers find Overseer too difficult to use. Overseer is too simplistic and does not capture complex farm systems. Comments on how to address this apparent dichotomy of views?

There will always be a tension between having the model ‘accurate’ and able to adequately capture complex farm systems, and the desire for an easy to use model. However, opportunities to improve data capture and simplify its use should always be considered.

New Zealand’s farm systems are complex and varied. Farmer confidence in the model seems to increase if the model is seen as capturing their system, so a lot of effort has gone into making sure that it is able to do this.

When used in a report mode (capturing the farm as it exists), the model was designed to apply to both farmers and consultants. A ‘first time user’ or someone not familiar with the potential complexity and range of New Zealand’s farming systems can find the model daunting. This relative complexity has resulted from increasing development of the model to meet user needs and to enhance its accuracy.

When used as a scenario tool, *Overseer* was designed from the outset to be an ‘expert system’. It is essential to have a thorough understanding of farm systems, how they respond to changes in inputs and how parts of a farm system and farm management are inter-connected. The Massey University Sustainable Nutrient Management course provides excellent fundamental training on nutrient management, but this course only uses *Overseer* to illustrate principles in nutrient management. Currently there are no formal training courses available on using *Overseer* either as a reporting tool or as a scenario tool.

2.1.4 Why do the numbers keep changing whenever the model is upgraded? What was the basis of the upgrade to Version 6 – more trial results? Better functionality? What does this mean for individual farm outputs?

Some *Overseer* output results have changed with the move to version 6 compared to results that would have resulted from the previous version for the following reasons:

- Integration of the pastoral, cropping and horticultural models in to a single model.
- Bug and problem fixes.
- Minor science updates.
- New features.
- New and improved application of science.

These changes are explained in more detail in reports available on the *Overseer* website Release notes page. The main reasons for the changes were an improved hydrology model (all nutrients), improved model for fodder crops, improved handling of irrigation, improved urine N leaching model based on new science.

As research in nutrient management continues to yield new knowledge and that is incorporated into the model, it is expected that outputs will continue to change. The implications of such changes will depend on many factors and obviously very difficult to predict in advance of the research.

New mitigation options or new farm management systems may require new features to be added so that the impact of these options can be reflected in nutrient loss estimates.

The integration process resulted in changes to ensure consistency across models, and resulted in a major upgrade of the fodder crop model.

New features that were requested by stakeholders were also added, such as providing for dairy goats, cut and carry blocks, and lucerne pasture.

As *Overseer* is a farm-specific model, the site of the change for individual farms depends on the site and management characteristics of the farm, and the type of change made. Thus, for example, changes to the urine N leaching model varied depended on the farm, and ranged from small decreases to large increases (see Technical Note 5 on the website for more detail). The consequences of any changes in for example, whole farm nutrient loss estimates, will depend on the magnitude of any such change and, if relevant, the nature of any applicable regional council rules/resource consents.

2.1.5 How long does it take to get new innovative mitigation options into the model?

A new mitigation option would need to be assessed to determine whether it is appropriate to evaluate for inclusion in *Overseer*. If it is accepted and funding made available, then a staged approach is followed to enter new features (including mitigations) into *Overseer*:

- Evaluation of scientific evidence;
- Development of an approach to incorporate new feature/mitigation into the model;
- Implementation into *Overseer* and testing.

This structured approach can take 18 months or longer, depending on the complexity of the change.

There will be an on-going challenge to prioritise changes/additions.

2.2 Model uncertainty issues

A number of reputable websites[1] provide comprehensive definitions of accuracy, precision, errors and uncertainty. There are also international standards for most of these terms[2]. The following section provides brief definitions and explanations in the context of the specific questions. While the term 'model uncertainty' is most applicable to *Overseer* whole farm nutrient loss estimates, it is important to consider the implications of other commonly used terminology.

The **accuracy** of a measurement system is the degree of closeness of measurements of a quantity to that quantity's actual (true) or accepted (where actual measurement is difficult) value. The concept of accuracy has limited application to the estimation of

[1] http://www.udel.edu/pchem/C446/error.pdf
http://scidiv.bellevuecollege.edu/physics/measure%26sigfigs/b-acc-prec-unc.html

[2] ISO (1993) *Guide to the Expression of Uncertainty in Measurement*. International Organization for Standardization (ISO) and the International Committee on Weights and Measures (CIPM): Switzerland.

whole farm nutrient loss where it is not practicable to measure directly, for example, the whole farm annual quantity of nitrogen leached to water.

The **precision**, also called **reproducibility** or **repeatability**, is the degree to which repeated measurements under unchanged conditions show the same results. This concept some applicability to Overseer nutrient loss estimates.

Errors are the level of disagreement between a measured value and the true or accepted (where actual measurement is difficult) value. The concept of an error clearly has limited application where actual measurement is not practicable and there is no "accepted" value.

Uncertainty, in the context of a model such as *Overseer,* can be defined as a potential limitation in some part of the modelling process that is a result of incomplete knowledge. The concept of uncertainty is the most applicable to the use of Overseer, i.e., given the number of assumptions and errors involved in the model there will be a level of uncertainty about the estimate of nutrient losses.

Box & Draper's (2007) statement that "… all models are wrong, but some are useful…" may at one level be seen as unnecessarily critical or even axiomatic. However, the statement is useful in highlighting that uncertainty is an inherent part of a complex biophysical model like *Overseer*.

The sources of uncertainty in environmental modelling can be divided into five distinct categories (Based on Walker *et al,* (2003)):

Sources of modelling uncertainty	**Brief description and comment**
Context and framing	This can include choices about the physical boundaries of the system being modelled, the range of factors to incorporate into a model, and specific prediction choices.
Inputs	Uncertainties about inputs that drive the model, e.g., fertiliser, production, supplements, soil type, climate, etc.
Model structure	Models simplify reality and may be based on an incomplete understanding of the processes and structure(s) being modelled, e.g., the Overseer engine and our understanding of the underpinning science.
Parameters	Parameters used in the model need to be estimated or inferred from sometimes very limited data, e.g., parameters that drive the urine N leaching, crop N leaching, etc.
Model implementation	This can include technical modelling choices and potential software bugs.

Table 1 An outline of the sources of uncertainty in complex biophysical modelling

Overseer is a complex model, and the sources of uncertainty outlined above should be considered in any application of the model. To date no formal analysis of the sources of uncertainty in *Overseer* has been carried out. Further work is needed to assess what would be involved in undertaking an appropriate uncertainty analysis. Similarly, sensitivity analyses can assist in understanding the key inputs that have the greatest influence on outputs. Sensitivity analysis of the previous model has being undertaken, and additional analysis on the current model is been undertaken in this financial year.

2.2.1 Errors

It is important to understand the context in which the word ‘error’ is often used. For example, the following potential sources of error in a model such as *Overseer* should be considered:

- Errors in input data and databases to drive a model, e.g., rate of fertiliser applied, nitrogen content of feed or fertiliser;
- Errors in measured data from experiments used to calibrate and validate the model; and
- The relationship between model assumptions, and data input errors.

Before responding to specific questions related to the level of uncertainty associated with *Overseer* model estimates, there are some important considerations that should be kept in mind, for example:

- The differences between accuracy and precision, error and uncertainty;
- The consequences of including something that is partially known versus the consequences of not including it; and
- How the uncertainty about for example, whole farm nitrogen loss estimates should be taken into account in catchment nutrient water quality management planning and implementation.

When interpreting a model’s predictive abilities, it is important to know whether the model has been calibrated (i.e., the process of adjusting model parameter values to maximise the agreement between a given set of data and the model outputs) (Trucano et al 2006, Refsgaard 2000). The next step in the application of a model like *Overseer* is to validate the model to provide a method of assessing the confidence that can be had in the modelled outputs (i.e., testing to see how well the model outputs fit a set of data

(Jorgensen, 2003)). *Overseers*' N leaching model has a significant amount of validation, whereas the P loss model is based on a calibration process.

Overseer can be used for a very wide range of farm systems in many different geographical settings. However, the uncertainty associated with whole farm nutrient loss estimates will increase for situations that are well outside of the calibration/validation range.

2.2.2 What is the "potential" of Overseer to become more "precise", (assuming unlimited resources and time)? i.e., what is its "development limit" and what factors determine this limit?

Given that precision is the measure of **reproducibility** or **repeatability**, for *Overseer*, this translates to the ability of multiple users to produce the same result.

AgResearch has tried to address issue of precision in several ways:

- Developing the model in such a way as to provide consistency of inputs between sectors and also between methods if more than one way for entering data is provided (e.g., entry of animal numbers);
- Developing the model using data, information and support structures (e.g., labels) that the farmer or consultant know.
- Making the model relevant to as wide a range of potential applications as possible and encouraging accurate reporting of information.

The major limitation to enhancing precision in some situations is the potential differences in inputs between users, hence the need for protocols for data entry and farm set-up. As we understand better how users interact and interpret information, the input data systems can be modified.

There is always interplay between information in help systems, labels, input data, and model requirements, along with user understanding of the farm system they are modelling, data requirements and availability, and the modelling skill of the user. The development of industry agreed protocols will be critical for all applications of *Overseer* so that there is confidence in the way a farm is modelled and hence confidence in both absolute and relative terms in the model outputs. The high sensitivity of whole farm nutrient loss outputs to many input choices means that if meaningful whole farm nutrient loss estimates are to be achieved, agreed protocols are essential.

2.2.3 Overseer is not "accurate"/"precise" – "it has a 30% error"….

The assessment by Ledgard and Waller (2001) is the only current published report that has compared measured drainage nitrate nitrogen with modelled farm block drainage nitrate nitrogen estimates. Significant further research would be needed to develop a methodology to collect data that could be used to update the assessment undertaken by Ledgard and Waller (2001) and there would be potentially significant difficulties involved in scaling that up to whole farm nutrient loss estimates.

The current version of *Overseer* reports nitrogen losses on a whole farm rather than a block level (as applied at the time of the Ledgard and Waller (2001) study). Ledgard and Waller (2001) stated “An indication of the imprecision in the long-term estimate of average nitrate leaching for pastoral systems is about ±20%. ... Consequently, an estimate of nitrate-N concentration in drainage will have a greater uncertainty than the estimate of the amount of nitrate-N leached, at approximately ±25-30%.” These conclusions relate to a previous *Overseer* version. However, the range is considered to be very good for a complex biophysical model.

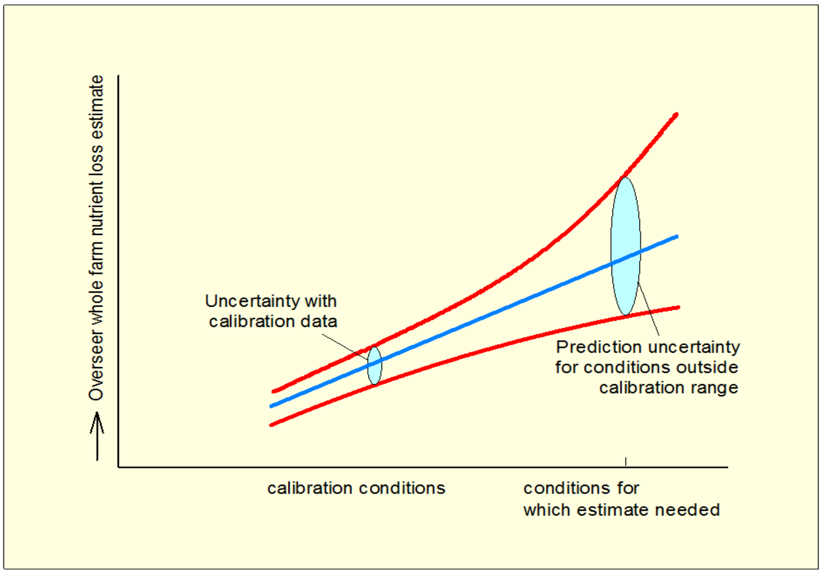
In the meantime, a figure of ±30% uncertainty would be useful only as a conceptual starting point for any discussion about whole farm nitrogen drainage loss estimates modelled with Overseer version 6. This level of uncertainty is considered to be very good for a complex biophysical model. It is important that it is understood that this level of uncertainty is normal in any biophysical modelling, not just *Overseer*. No biophysical model will ever be 100% accurate.

The current relationship between field measured and *Overseer* estimated N leaching loads is considered to likely be similar to that for previous versions. AgResearch scientists who have been involved in the development and application of *Overseer* are confident that the changes have resulted in a scientifically more robust and more broadly applicable model than was the case in 2001.

The current *Overseer* version incorporates a significantly more robust method for estimating N losses than was the case with the *Overseer* version in 2001. As noted in section 2.2.2, the output estimates in any one case will depend on for example, a significant number of input choices that users are beginning to develop protocols for.

It is also important to appreciate that the uncertainty will increase significantly the more a situation moves from the information used to develop and calibrate a model such as Overseer. This is illustrated in the following diagram:

Figure 1. An illustration of the changes to model uncertainty as conditions move from those used for calibration (based on Loucks *et al* 2005)



A critical issue is how uncertainty relating to a whole farm nutrient loss estimates is taken into account, along with other sources of uncertainty, in any catchment nutrient management policy development and/or policy implementation process.

2.2.4 What soil types, climates and farm management practices/systems/land uses are not validated or are poorly validated in the model and why? What are the implications of this?

It is inevitable that because *Overseer* is a model that represents most enterprises across a wide range of environments in NZ, that there will be gaps in data. More calibration and/or validation is required, in particular for:

- Cropping farms
- Beef & sheep
- All farm-types with rainfall >1200 mm /yr
- Clay soils, shallow soils

We can only calibrate and/or validate against measured data where trials have been carried out. This is limited by the range of soils and climates where we can undertake field trials: it would be extremely resource intensive to test all combinations of soils, climate and regional variation. For instance, no N leaching trials have been undertaken in Northland, on peat soils or under high rainfall (>1200mm /yr).

We address these issues by trying to ensure that we have extrapolated and interpolated the available information based on robust scientific principles. However, calibration and validation of a farm system model is not straightforward.

It is also not possible to validate completely a farm system model as you can only validate points where you have data. In farms, this is usually for a subset of the system. For example, validation of the pastoral N model has occurred at the block level for a limited range of grazing trials. It would not appear to be practicable at this stage to validate whole farm losses.

The implications of this is that estimates of whole farm nutrient losses undertaken for situations significantly beyond the calibration/validation range used to develop *Overseer* need to be considered extremely cautiously.

2.2.5 What is the consistency of output among farms, are outputs systematically biased among farms (within and among sectors)?

See notes on precision (question 2.2.2).

The model is designed to maintain as much consistency as possible within and between sectors. When inconsistency has been found, it has been addressed. For example, during the development of *Overseer* 6, considerable work occurred to provide consistency between modelling of fodder crops in the pasture model and the cropping model.

We do not consider that there is any significant bias for or against any one sector. However, because of the complexities of different farming systems it will always be a challenge to ensure that significantly different farming systems are treated equivalently. There is an opportunity to develop documentation and analysis to illustrate the level of consistency between farming sectors.

2.2.6 What is it about irrigation that resulted in concerns about Overseer v 5.4.3 and has this been addressed in v 6.0?

The old model was criticised for not adequately representing the effects of irrigation on nitrogen losses in Canterbury. This was partly due to the irrigation model not responding appropriately, along with insufficient information to model stony shallow soils. Both of these issues have been addressed in *Overseer* 6, and are examples of continuing development following user feedback.

The issue with *Overseer* 6 that has been raised by some users is that N leaching is driven by drainage and that if the model calculates that irrigation is in excess of requirements in the daily water balance model, then this causes calculation of extra drainage and more N leaching. This can be avoided if irrigation inputs are commensurate with the rainfall value used (i.e., do not use irrigation volumes applied in a dry year with rainfall for an average year). A detailed Technical Note (No 4) on this has been placed on the *Overseer* website. If protocols can be developed to ensure that *Overseer* is run in a manner that is consistent with the approach identified in the technical note then the issue will be addressed. This highlights the critical importance of establishing protocols for the operation of *Overseer*.

After discussions with Irrigation NZ, the three main areas for potential further development are:

- the need for data protocols to ensure the rainfall and crop yields are commensurate with irrigation rate;
- the difficulty of estimating irrigation rates and the degree of over-irrigation;
- whether the model includes enough management options so that there is sufficient recognition of the effects of different management practices.

Some additional management options are being considered by Irrigation NZ that could become another phase of model improvement once agreement on the types of changes and funding are made.

2.2.7 What is the sensitivity of the model to specific input errors?

This depends on the input and the output of concern. Sensitivity analyses have been undertaken for the pastoral N model and to a lesser extend for the pastoral P model and the crop N model. Limited information on *Overseer* sensitivity analysis has been published (e.g., Power *et al* 2006). The key conclusions of the sensitivity assessments are listed in the answers to the next question.

2.2.8 What input variables are the model outputs most sensitive to?

These vary between nutrients and systems, and the output being considered. In addition, the influence of some inputs on outputs is dependent on others, for example, wintering pad inputs are only important if one exists.

In general, as would be expected, the main inputs that have the most influence on nutrient loss estimates are:

(a) those that influence the size of **source** of a nutrient (e.g., stocking rate, fertiliser inputs), and

(b) those that influence the **transport** of a nutrient (e.g., soil, drainage, slope for P).

Drainage is a key driver of N (and P) losses and it is therefore important to recognise that this calculation is sensitive to:

- climate inputs, predominately rainfall, potential evapotranspiration,
- soil characteristics that affect available water capacity such as soil order, texture, sand or stony subsoils, and the depth to those subsoils, and
- irrigation rate and method, and (less important) crop cover.

Power *et al.* (2006) undertook a sensitivity analysis with the previous version of *Overseer*. This is being re-run for version 6, but it is highly unlikely that the input variables that can have a significant influence on whole farm nutrient loss estimates will change:

Dairy

- Stocking rates and animal productivity, which is translated to stock feed intake;
- Temperature for N leaching;
- Supplements, feed pads, effluent management system;
- Fertiliser N timing and rate for N leaching;
- Expert judgement inputs such as N immobilisation status and clover levels;
- Olsen P and topography for P loss; and
- Area, type and timing of fodder crop management, and timing of grazing.

Sheep/beef/deer

- As for dairy except supplements/feed pads normally don't apply.

Horticulture (permanent tree or vine crops)

- Timing of fertiliser and irrigation applications; and
- Yield.

Arable and vegetables crops

- Timing of sowing, type of crop sown and management of the crop;
- Yield;
- Timing of fertiliser and irrigation applications; and
- Time and type of grazing (if any).

Small holders (e.g., outdoor pigs etc.)

- Outdoor pigs - the accumulation of fertility during a rotation;
- Indoor pigs – pig numbers as this influences effluent load applied to pasture; and
- Small block - animal stocking and, if small enough, house (septic tank and house gardens).

2.2.9 For what systems/management regimes would a daily time step model give more "accurate" answers?

Model outputs depend on the data available, the nature of the daily time step model and the methods of initiation of the model. Most daily time step models are not full farm system models. They can be more accurate when calibrated against a site but do not necessarily work any better, and frequently worse, when applied across a wide range of sites, i.e., as *Overseer is used for*.

As *Overseer* is an integrated model, it is important to maintain a high level of consistency across farm management options, including different block types. Although it is possible to model one component process more accurately with a shorter time scale, it is important to not introduce 'errors' or credibility issues elsewhere.

2.2.10 What mitigation options are included in each farm system and what current and upcoming management options are not (yet) incorporated into the model?

Most current mitigations in the farm systems are covered by the model. These include, but are not limited to:

- Varying timing and amount of N fertiliser applications
- Changing pasture quality (metabolic energy (ME) content and N content)
- Varying timing and amount of supplements feed to animals
- Varying stock type, animal numbers and stock performance, including grazing off
- Use of wintering pads, animals shelters
- Use of DCD
- Adding wetlands or riparian strips
- Changing effluent application area or methods and timing of application

For pastoral systems, the commonly suggested methods of using the nitrification inhibitor DCD (dicyandiamide) use or the use of grazing off or wintering pads are separate inputs. When using the model in reporting mode, it is not always obvious that a mitigation strategy has been used, such as variation in timing of N fertiliser applications, or manipulation of stock system. Many other possible mitigation options can also be modelled, for example the use of a high ME low N pasture can be modelled manually.

Many of the mitigation options are based around aspects of farm management. Therefore, it would not normally be a simple single change, but a suite of possible changes depending on farm, climate and the farmer's ambitions and abilities. The model can deal with this, but the user has to understand the system and the consequences of the changes – *Overseer* does not automatically adjust the system for these changes unless a scenario tool is used.

The scenario tool that was in version 5.4 is being amalgamated with a 'toolbox' for inclusion in a later release. In the meantime, version 6 does not have a scenario tool.

Mitigation options not covered include mitigation options required to achieve good management practice, the application of strategic management practices to 'critical source areas' and the application of DCD on fodder crops. The new N model has seen the critical period, in terms of N losses, for grazing shift from May, June and July back to April, May and June. This has important implications for mitigation options.

2.2.11 In arable situations, can the model be operated to model the use of deep rooting plants following shallow rooting in up to 3 cycles in a year, high efficiency irrigation (i.e. precision based on weekly moisture monitoring, variable rate applications to less than field capacity), timing and manipulation of cultivation practices, and various grazing practices?

Partially, and is an example of the widening expectations placed on the model. The model structure for this is there, but more scientific understanding of the effects of these practices is required and then that understanding would need to be implemented in the model. As *Overseer* is a strategic management model rather than an operational management model, *Overseer* currently includes these crop management options at a coarser scale than many growers are used to.

The model can include multiple crops within a rotation, timing and method of cultivation practices, and grazing and cut and carry options. High efficiency irrigation is handled via an 'Active management' option. It is recognised that there is a need for improved usability for some of these features.

Overseer can generally take into account the other items outlined in the question and further refinement of arable options could be developed but would need to be considered alongside other development options and priorities. However, as noted above there is need for improved usability for some features.

2.2.12 *In pastoral systems, can stock feeding regimes cope with many different stock classes and feed crop types on the same part of a farm over the annual cycle?*

Yes. The combination of sex, weight and/or age and breeding status allow all known stock classes to be covered for dairy, sheep, beef, deer, and dairy goats. Supplements and crops can be fed to specific animals in-shed, on feed pads or wintering pads/animal shelters/animal barns, or to specific blocks or animal types when fed on pasture. Crops can also be grazed in-situ by defined animal types. The timing of this feeding can be varied. There is scope for updating and enhancing the user interface to improve the input of timing information.

2.2.13 *To what degree are Overseer outputs sensitive to the mitigation options available (i.e., short of dramatic changes in land use what % reduction in output is possible)?*

It is usually possible to model up to 30% reduction in N and P losses, although if 'conditions' are just right, higher reductions are possible. A number of organisations are investigating the potential that Overseer provides to highlight opportunities for increasing nutrient use efficiencies and decreasing nutrient losses. However, it is important to understand that unless such mitigation measures are implemented appropriately, the actual nutrient loss reductions could be effectively zero. The size of a given mitigation varies depending on farm, location, management systems, and other mitigation options already employed i.e., it is farm specific.

Users are sometimes confused by what seem to be small effects. However, this is often because the research is done at a component scale (e.g., individual urine patches) and *Overseer* works at the farm scale, which means that what may appear to be significant effects can be reduced once integrated into the whole farm system.

Mitigation options for N, P and greenhouse gas emissions are modelled within a farm system. Some options may reduce one output e.g., N leaching, but increase another e.g., N_2O emissions.

2.2.14 *What is the science behind the mitigation options?*

Robust available science information and procedures have been incorporated into *Overseer*. Most of the data used in *Overseer* can be sourced back to a published reference, although not always peer-reviewed. The initial sub-models have been developed by expert scientists in the field. A list of references used in the development of Overseer is included on the website. The integration process provides another check on the science as the model outputs are tested against a wide range of realistic situations. There is also peer-review of the completed sub-model, and of the output once integrated into the model. This review is now entering a more formal process, starting with the creation of a formal Agresearch Technical Advisory Group. Some sub-models (e.g., DCD sub-model) have also had extensive industry peer review. The Technical Manual and references provide more detailed information.

2.3 Model performance for different sectors

2.3.1 Overseer is not equally robust among sectors - not all sectors are modelled to the same level of "accuracy" leading to systematic bias among sectors. How significant is any bias? Is there a way to manage/limit this through the model?

The main difference between sectors is the extent of relevant scientific research available and its incorporation into *Overseer*.

For example, the pastoral sector has more field trial data, particular for nutrients other than nitrogen, which has not been available in other sectors, e.g., horticulture and arable. Within these limits, the sector models have been kept, as far as possible, at the same level of scientific robustness. However, where data is limited, we have had to extrapolate based on scientific principles that will introduce additional factors that need to be considered when assessing uncertainty. For example, the greenhouse gas model for crops is not as advanced as for the pastoral model.

It is not possible to provide an absolute guarantee that all sectors are treated equivalently. However, cross-sector comparability has been, and will continue to be, a critical goal of the Overseer programme. Future work on uncertainty analysis and sensitivity analysis should help to highlight any significant differences and may point to future work needed to address any inconsistencies.

2.3.2 Overseer was developed for non-irrigated pasture systems. Is this correct?

Originally, yes, but its evolution has responded to the wider range of farm systems now in NZ. All significant pasture systems can be modelled, including fully housed animals (e.g., dairy goats). More work is required to provide better modelling of low rainfall systems (< 900 mm annual precipitation) and areas with high annual variability in rainfall or drainage, for example, where drainage only occurring in 3 out of 10 years. Issues around irrigation have been discussed earlier (see question 2.2.6).

2.3.3 Overseer is not suited to irrigated soil. Is this correct?

No. This was a limitation for version 5, but not for version 6 (one reason for the upgrade).

See response, above, on irrigation (question 2.2.6).

2.3.4 Overseer is more suited to pastoral land use than arable land use. Is this correct?

If the question refers to *Overseer's* suitability to estimate annual whole farm N leaching load, then the answer is "no".

For N leaching, the arable crop model was developed using process-crop models that had been calibrated against field trials. Investigations by Agresearch scientists indicated that the crop model behaviour is consistent with expected behaviour based on international research publications. It is accepted that the model components that relate to nutrient losses from crops are based on a less comprehensive body of New Zealand research than those used for example, for land used for dairying. The international and New Zealand research indicates that some crops have relatively low nitrogen leaching rates. The crops that have high nitrogen leaching rates tend to be those:

- growing in land that was just in pasture, particularly if additional N is applied;
- systems with high N inputs such as vegetable growing, where N inputs are used as a risk management tool to assist in meeting tight crop production requirements); and
- systems with no crop uptake over winter.

These are known risks and that are recognised in the international literature. There are possible improvements to *Overseer*, including additional research information on mineralisation rates.

Currently the Overseer data capture method can be slow for cropping systems, and laborious when long rotations are used. It is accepted that there is a need to improve the methods for entering crop rotations into the model.

2.3.5 *Some people argue that there are better performing models (e.g., APSIM). What makes them better, if they are? Is there scope to bring these improvements under the Overseer banner?*

A review of models used to estimate nutrient losses to water was undertaken by Cichota & Snow (2009) and one of the conclusions of that review was:

> *"Although overlaps do happen, in general most of the models presented in this review are best applicable to a limited set of problems and at differing scales. Knowing their strengths and deficiencies will help to select models properly and understand better their results."*

Typically process based models perform well when good data is available, and they are 'trained' to the site. Very few of these models have been tested in the broad range of conditions under which *Overseer* is used, i.e., limited specific site data, over a wide range of sites and management options, and run primarily by consultants. The converse is true – *Overseer* would not be used to improve understanding of complex science principles whereas a process model would.

The *Overseer* modelling process has used process models to help formulate N leaching sub-models (APSIM, *Overseer* Technical Note No 5 2012) and the cropping model (Chicota *et al* 2010). Interesting, as part of the N leaching modelling process, integration into *Overseer* identified weakness in the APSIM model.

Models should be 'fit for purpose'. APSIM is not a 'better performing' model, it is a different model used for a different purpose. 'Fit for purpose' should be a user assessment – it is actually a key part about selecting a model. the assessment should include not only the model capabilities, but also the system it is to be integrated into, the availability of the model, and an assessment of the capability required and available to use the model.

2.3.6 *Overseer does not capture short-term management actions to mitigate nutrient loss. Is this correct?*

This question is difficult to answer without a clear definition of what constitutes "short-term".

Overseer estimates nutrient losses on a long-term **annual** average basis and assumes the adoption of best/good management practices. It has been developed this way so assume quasi-equilibrium can be assumed between inputs, system production and outputs. This also allows reduced reliance on parts of the system that are notoriously difficult to estimate over shorter time scales, such as N immobilisation, N fixation, and denitrification. It also allows organic systems, or slow release products to be included in the same model.

There are options to capture 'short-term' actions, such as active management options already incorporated into the irrigation and effluent components of the model. The main issue in capturing additional 'short-term' management actions is how these are assessed, for example, how is daily management associated with good management practice assessed for effluent management.

Daily management options are captured within the assumptions of good management practices.

Overseer does not capture changes that can occur during transition from one system to another.

2.3.7 Overseer cannot deal with dairy cow wintering if this is on greater than 30% of a farm's area. Is this correct?

Not strictly true. The months that animals are on a block can now be selected, and a farm can be set up with all animals in the winter month on one block.

There is a limit on the area of fodder crops, which is 25% of the pastoral block area the fodder crop rotates around. Most farm systems with greater than 25% of the farm taken up with wintering dairy cows on a fodder crop can be captured using the crop model, which also includes fodder crops and forages.

2.3.8 The numbers for winter cropping and other arable operations are quite uncertain for Overseer 6. Is this correct?

Winter grazing of forage crops is a relatively new research area so there is not a lot of data. However, the model is built in such a way that it captures the main principles (balances between time of grazing, urinary return, leaching risk and capture of N by the following crop). This model is, in effect an integration of the crop model and the urine N leaching model. The risk of leaching from fodder crops can be high from early grazing due to low or no N uptake over winter, and large amounts of N consumed and returned to the block during winter. Refer to sections 2.2.1 – 2.2.7 above.

2.4 Policy development and application issues

2.4.1 How important is user error and protocols in gaining a representative estimate of nutrient losses? What level of training is needed to run the model to get representative estimates?

Very important. *Overseer* is an Expert User System, and the outputs are dependent on many inputs that rely on expert judgement. As stated earlier, an understanding of nutrient cycling and farm systems is essential for the correct use of *Overseer*. Even then, there will be some inputs that are 'open to interpretation' which could have significant impacts on the final results.

This highlights the critical importance of developing appropriate protocols for critical input choices. Protocols are about identifying the main input variables of interest and specifying methods for undertaking some analysis e.g., whether runoff blocks are included, methods for estimating precipitation, pasture status estimates, etc. They can also include methods when data is missing, or a farm management system is not included in *Overseer*. Protocol development would be essential for the implementation of *Overseer* in a regional rule or in a resource consent, otherwise users could produce a wide range of whole farm nutrient loss estimates by using different approaches.

Good understanding of farm systems, the features included in the model and protocols would be required to get representative estimates from the model. If undertaking 'what-if' analyses, a high level of understanding of farm systems and the implication of changes mitigation options may have is required.

As a minimum, we consider that the Massey University Advanced Sustainable Nutrient Management Certificate or an equivalent qualification is needed enable someone to produce meaningful results. This training needs to be combined with significant experience and understanding of New Zealand's farm systems, particularly the interdependence of components of these systems.

2.4.2 What can Overseer outputs tell us about water quality in groundwater and/or surface water?

By itself - nothing. Losses are calculated at the farm boundary and bottom of root zone, i.e., *Overseer* does not deal with any possible attenuation, dispersion or dilution between leaving the farm and reaching a receiving water body.

Catchment scale GIS based models such as CLUES (Catchment Land Use for Environmental Sustainability, a NIWA developed model that assesses the effects of land use change on water quality,) can be used with *Overseer* to develop an understanding of the receiving water quality that would result from specific land use in a catchment.

2.4.3 It takes too long to enter the data, especially for complex systems such as horticulture/cropping.

Currently this is an issue, but is not insoluble, with a change in the design/methods of data entry.

A similar issue has arisen with dairy systems – there is a tension between simplicity of inputs versus being able to accurately represent a farm. In many cases, farmer confidence occurs if they see the farm being modelled as they see it. For some farms, the inputs can be relatively simple. However, some farm systems are relatively complex, and the variation in management systems between farms, result in lots of options to consider. Over time, if *Overseer* is applied to the cropping systems, the same pathway is likely to be followed.

The Foundation for Arable Research is considering linkages to other software options to improve this situation. In addition, Fonterra and DairyNZ are investigating ways to provide some standardised inputs. The Agresearch *Overseer* team is also looking to redesign some model input pages to make data entry easier. However, ultimately this is an issue of balance – enhancements to *Overseer* that enable the model to more appropriately represent farm systems will generally result in more input complexity.

2.4.4 What other approaches are needed to "wrap around" the use of Overseer to optimise its usefulness, given the limitations?

All models have limitations, perhaps the key consideration is ensuring that those limitations are understood by all users and appropriately taken into account in the application of *Overseer*, for example, in both the development and implementation of catchment nutrient management policies. There is an ongoing challenge to enhance the understanding of *Overseer* and to clearly distinguish between for examples, uncertainties involved in a process of determining, allocating and implementing catchment nutrient limits.

The following approaches should be considered by appropriate agencies:

- Developing and maintaining communication between all parties with an interest in developing and applying *Overseer*.
- Maintenance and enhancement of training in the use of *Overseer*.
- Development of nationally agreed protocols for model inputs.

- Identifying and linking multiple users of input data to help improve accuracy of data inputs.

2.4.5 What degree of precision do we need Overseer to be, given that the other variables that contribute to water quality outcomes are also numerous and complex, but for which we don't have tools even as precise as Overseer?

Given the earlier discussion that identified uncertainty as the most relevant term, it is assumed that this question is actually about the uncertainties associated with model outputs rather than precision *per se.*

The uncertainties associated with estimates of whole farm nutrient losses do need to be considered both in the context of the complex biophysical model that is *Overseer* and the complex processes, also with uncertainties, that are involved in the establishment and implementation of catchment nutrient limits. In the context of this the current uncertainties associated with whole farm nutrient loss estimates appear to be acceptable. However, it is accepted that as our understanding of the wider processes involved in water quality management improves, so too will pressure increase to reduce the uncertainties involved in each part of the process. That will include pressure on *Overseer* modelling to minimise uncertainties and to do that in a manner that is transparent.

It is not appropriate at this stage to attempt to identify a specific uncertainty target. With information obtained from a detailed uncertainty analysis and sensitivity analysis, a more quantitative approach should be possible.

It is important to appreciate that *Overseer* will not be the only tool used to assist in meeting water quality objectives. Many complex processes contribute to water quality outcomes. It is important to model catchment and land use processes in a balanced way, and to take uncertainties into account in determining an appropriate catchment nutrient management framework.

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