# Nutrient Management with the OVERSEER® model

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## Introduction

A nutrient budget provides average estimates of the fate of the nutrients nitrogen (N), phosphorus (P), potassium (K), sulphur (S), calcium (Ca), magnesium (Mg), sodium (Na) in kg/ha/year as well as hydrogen ions ($H^+$), for different nutrient inputs and management practices (e.g., stocking rate, supplementary feed inputs). Nutrient balances are valuable indicators of the long-term sustainability of farm systems. They indicate where inputs of nutrients are inadequate relative to outputs, thereby leading to a decline in the soil nutrient status. Conversely, they can indicate where excessive inputs result in nutrient surplus and give an estimate of potential nutrient losses to the environment. Nutrient budgets also provide a method for comparing nutrient flows associated with different management practices on a farm. Fertiliser nutrients represent an important resource input on farms. High efficiency of nutrient use through conversion into agricultural produce is beneficial for profitable production and to reduce the nutrient surplus or potential for loss into the environment.

OVERSEER® is not an environmental management tool as it does not assess the effect of farms on the receiving environment. However, OVERSEER® does estimate N loss (from below the root zone) and P loss risk (to the farm boundary) but users of the tool need to fully understand how to operate the model properly, its limitations across the range of farming activities and what the outputs actually mean. OVERSEER® is owned jointly by the Ministry for Primary Industries, the Fertiliser Association of New Zealand and AgResearch.

## What is OVERSEER®?

OVERSEER® is a world class Decision Support System farm model which allows nutrient budgets to be constructed for many enterprises including dairy, sheep, beef, deer, dairy goats, fruit, vegetables and arable crops. OVERSEER® nutrient budgets allow farms to comprise one or more management blocks (defined as an area of the farm that has common physical and management attributes). Nine separate types of management block are available: pastoral, fodder crop, cut and carry, fruit, vegetable/arable cropping, trees and scrub, riparian, wetland and house. AgResearch, the lead science provider for the model, advises that up to 30 different blocks may be specified.

OVERSEER® differs from other farm models in that it aims to be a practical tool relying on input data that are readily obtained, and aims to model most major farm systems across all regions of New Zealand. This broad scope is both a strength and a weakness of the model. OVERSEER® is an annual time step, long term equilibrium model. As such it currently does not reflect year to year or within year variability accurately and should not be used for this purpose.

**What does OVERSEER® do?**

The pastoral model calculates budgets (inputs and outputs) for each separate management block and a whole farm, giving a weighted average for each of the nutrients N, P, K, S, Ca, Mg, Na and $H^+$ (acidity - pastoral block only). Additionally, the model estimates animal pasture intake, pasture production, calculates maintenance fertiliser nutrient and lime requirements and estimates losses to the environment from the boundary of the farm system e.g., N loss to water (leaching), P run-off risk and greenhouse gas emissions. The OVERSEER® boundary is defined as the actual farm boundary, the bottom of the root zone, and the edge of second order waterways. The model does not include losses due to poor management practices (good management practice or best management practice is assumed), direct discharges into waterways (e.g., runoff from raceways, bridges, roads or stock crossings), or losses due to catastrophic events (e.g., earthquakes, storms or volcanic eruptions).

In terms of the pastoral agricultural model (dairy, sheep, beef, deer etc.) the centrepiece model is not based on a pasture growth or soil fertility driven model but is actually an animal intake model. The model calculates the energy requirements of the block/farm based on the livestock information (milk production, stock numbers and classes, management etc.) provided by the user. With this information plus an energy calculation from any supplementary feed used, the model then estimates the amount of pasture dry matter (taking into account pasture quality i.e., its energy content) that must have been consumed.

Once the pasture intake has been calculated the model can estimate pasture grown (by using assumed or entered pasture utilization). Further to this, because pastoral farms are complex in nature many of the other data input requirements are required to understand nutrient transfers around the farm, mainly but not exclusively by the animals depositing dung and urine, but also effluent applications and so on. The information generated around how much nutrient is deposited when and where is then also used elsewhere, such as in the N leaching and P run off sub models.

**What does a long term N loss actually mean?**

OVERSEER® has been picked up by a number of Regional Councils as a useful tool to inform and assist the regulatory processes around managing ground and surface water quality with respect to leaching losses of nitrogen (N) from grazed farm systems. The 'Loss to water' component of an OVERSEER nutrient budget can be made up a number of 'component' losses. By way of example, a nutrient budget for a South Island dairy farm (Figure 1) demonstrates these components which may be found by opening up the 'To water' line on the nutrient budget report (Figure 1).

| (kg/ha/yr) | N | P | K | S | Ca | Mg | Na |
|---|---|---|---|---|---|---|---|
| **Nutrients added** | | | | | | | |
| Fertiliser, lime & other | 132 | 35 | 28 | 43 | 103 | 0 | 1 |
| Rain/clover N fixation | 107 | 0 | 2 | 5 | 3 | 6 | 32 |
| Irrigation | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Supplements | 27 | 4 | 21 | 3 | 5 | 2 | 1 |
| **Nutrients removed** | | | | | | | |
| As products | 88 | 15 | 20 | 5 | 21 | 2 | 6 |
| Exported effluent | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| As supplements and crop residues | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| To atmosphere | 57 | 0 | 0 | 0 | 0 | 0 | 0 |
| **To water** | **26** | **1.2** | **17** | **40** | **63** | **8** | **19** |
| Leaching - urine patches | 20 | 0.0 | 7 | 0 | 16 | 0 | 0 |
| Leaching - other | 5 | 0.4 | 9 | 40 | 47 | 7 | 19 |
| Runoff | 0 | 0.9 | 1 | 0 | 0 | 0 | 0 |
| Direct (animals, drains) | 0 | 0.0 | 0 | 0 | 0 | 0 | 0 |
| Direct pond discharge | 0 | 0.0 | 0 | 0 | 0 | 0 | 0 |
| Border dyke outwash | 0 | 0.0 | 0 | 0 | 0 | 0 | 0 |
| Septic tank outflow | 0 | 0.0 | 0 | 0 | 0 | 0 | 0 |
| **Change in farm pools** | | | | | | | |
| Standing plant material | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Organic pool | 94 | 12 | 3 | 5 | 1 | 0 | 0 |
| Inorganic mineral | 0 | 3 | -21 | 0 | -2 | -3 | -3 |
| Inorganic soil pool | 0 | 7 | 34 | 0 | 28 | 2 | 12 |

**Figure 1**: Expanded nutrient budget report for a flat South Island dairy farm

This report shows the relative proportions of the amount of N lost by leaching from urine patches and other sources (e.g., N fertiliser, non-urine patch soil) runoff, direct losses to water, outwash and so on.

The example (Figure 1) is typical of most grazed pastoral systems whereby the greatest proportion of N lost by leaching is derived from urine deposition. While the above Figure 1 shows N loss to water as a load (i.e., kg N/ha) the programme also reports N loss as a concentration. OVERSEER® estimates drainage water concentration from the load of N which is able to be leached and the amount of drainage calculated using a NIWA drainage model. However, OVERSEER® only calculates N concentration in drainage water for farms on flat land.

In OVERSEER®, N lost to water is more correctly an estimate of the N that enters the area of soil and parent material beneath the root zone but above the water table – sometimes referred to as the vadose zone.

Given that the N loss estimate is what is leaving the root zone, it is inappropriate to use OVERSEER® loss estimates to determine N loss limits that are designed to protect ground or surface water quality. This is because between the end of the root zone and the receiving water there are mixing, assimilation and attenuation processes that may increase or decrease the concentration of N in those receiving waters. In Waikato Regional Council's Variation 5 dealing with the Western Taupo catchment and in the Horizons One Plan, an attenuation factor of 0.5 was used although there is no way of knowing how accurate this might be. Using the OVERSEER N loss estimate together with an attenuation factor could allow OVERSEER to assist determining N loss limits.

A strength of OVERSEER® is that it is able to demonstrate the impact of changing management, inputs or mitigations on nutrient cycling (scenarios) from a farm or block. However, the user of OVERSEER® must be conversant with its operating principles to ensure that the consequences of any changes made are consistent with all the other input parameters used to set up the original nutrient budget. For example, scenario testing provides the farmer with valuable information to assess what management changes he/she could make and to reduce N loss if that is required. Further analysis of the costs associated with changes to management and indeed the practical feasibility of changes also need to be completed outside of the OVERSEER® analysis.

Again the outputs, such as the N loss figure, of the scenario testing referred to above is the long term N loss from the system at equilibrium and should be generated using expected long term average input data for production, fertiliser and feed use. Annually these inputs can and will vary on farm as farmers respond to within year climatic and financial challenges but the model was not designed to model short term (i.e., weekly, monthly or even year to year) changes.

### Limitations of OVERSEER 6

OVERSEER® is a model. It is a mathematical expression of complex biological systems and therefore may not always accurately reflect what is actually occurring with respect to nutrient cycling in the real world. However, many of the useful outputs of the model are the best available estimates that are possible because the model is constructed with the best available scientific information at the time the current version is produced. There is and has been a series of regular updates of the model to keep pace with evolving farm systems, user requirements and new science.

With respect to N loss estimates, it is neither practical nor cost effective for individual farmers to measure N loss, either as total load (i.e., kg N/ha) or concentration (e.g. mg N/L) from their properties nor in the short term is it useful given the biological variability associated with N loss processes in the real world. This is one of the reasons for having long term equilibrium models such as OVERSEER®.

#### *Errors associated with N loss estimates*

Questions have been raised over the accuracy of the OVERSEER® estimates. The following explanations of the bold terms are drawn from information provided by AgResearch, the lead science provider for OVERSEER®. **Accuracy** of a measurement is the closeness of this to the quantity's actual (true) value. This concept has limited applicability to the estimate of whole farm nutrient loss where it is not practical to measure this directly e.g., the whole farm annual N loss to water.

The **precision** (or repeatability) of the measurement is the degree to which repeated measurements under unchanged conditions show the same results. With respect to OVERSEER®, as a model repeatability between measurements and operators will be excellent provided exactly the same input parameters are used. The creation of industry agreed user protocols for choice of assignable default parameters in particular will assist in this.

**Errors** are the level of disagreement between a measured value i.e., in this case an OVERSEER® estimated value and the true (or accepted) value. The concept of error clearly has limited application where actual measurement is not practicable e.g., whole farm nutrient losses. **Uncertainty** in the context of a model like OVERSEER® can be defined as a potential limitation in some part of the modelling process that is a result of incomplete knowledge. This concept is most applicable to the use of OVERSEER® given the number of assumptions and errors in the model produces a level of uncertainty about the estimate of nutrient losses.

OVERSEER 5 and earlier versions clearly stated on the Block N report that the error (or uncertainty) associated with the estimate of N in drainage water was ± 30%. It is unclear at present whether or not this applies to OVERSEER 6 estimates. Nevertheless, the estimate of error reflects what actually happens when attempting to measure N loss in the field.

OVERSEER® requires an annual rainfall number (generally the long term average).The model then uses a set of 'typical' average regional distributions of that rainfall to calculate daily rainfall in a typical year. Thus, it doesn't deal with years where the rainfall pattern is different to the long-term average (Figure 2) **and this is, in part, why the model is considered a long-term average model.**

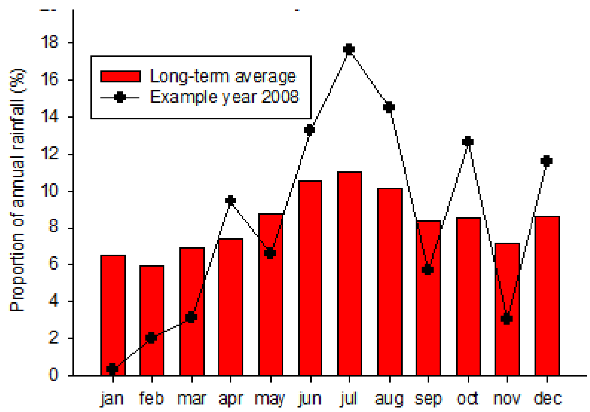


**Figure 2:** Difference between the distribution of long term average rainfall and individual years.

Validation/calibration of the drainage model and hence the N loss estimates, at least for dairy farm systems, using OVERSEER® is shown in the graph below (Figure 3).

The validation data (Figure 3) has been derived from measured N loss data from dairy farmlet studies in the Waikato, Manawatu and Southland where rainfall has been less than 1400mm annually and less than 200 kg N/ha as fertiliser has been applied annually. Certainly, at the lower end of the N loss range (i.e., less than 60 kg N/ha) the correlation ($r^2$=0.83) with measured and OVERSEER® N losses is considered very good for a biological model.

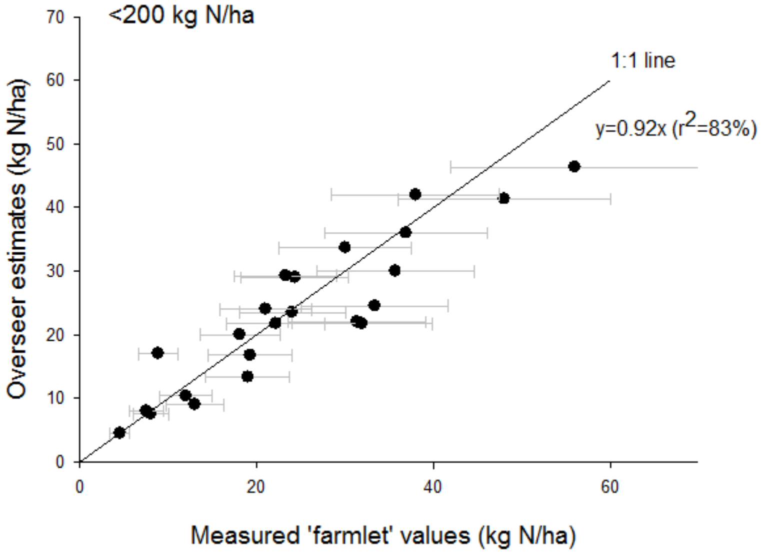


**Figure 3**: Calibration data for farmlet measured and modelled N loss estimates

Notwithstanding this good correlation, the errors associated with measuring N loss are depicted by the horizontal bars. However, there is also a degree of uncertainty around the OVERSEER® estimates which, if known, could be depicted by vertical error bars on the data displayed in Figure 3.

It must also be remembered that actual N loss (where measured) can vary to a much greater extent than for the farmlet studies above. In higher rainfall, free draining soils measured N loss may vary by more than 100% from one year to the next.

The use of the OVERSEER® programme to **estimate** the trend in long term equilibrium N losses, rather than within and between year N loss fluctuations, from pastoral and other farm types is valid. An N loss estimate from OVERSEER® may be used to assist farmers to determine how their farm is performing over the long term relative to any imposed N loss limit and may be used to test the effectiveness of management practices and technologies which will assist in achieving N loss reductions over time.

***OVERSEER® treatment of irrigation and soil drainage***

OVERSEER 6 has a completely reworked drainage sub model provided by NIWA scientists that has assisted in giving much better estimates of the impact of water movement through soils, whether by rain or irrigation and accounts for important soil properties which bear on this.

As rainfall increases, the estimate of N loss increases because total drainage is higher and there is an increase in the number of months in which drainage occurs (Figure 4).

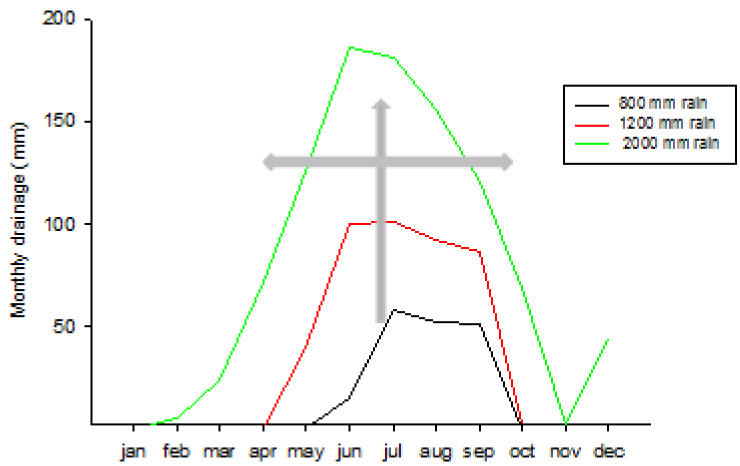


**Figure 4:** The effect of annual rainfall on monthly drainage

Where irrigation is used, this effectively increases the amount of water added to the soil and hence irrigated soils could result in more drainage over more months, especially on the 'shoulders' of the drainage season. This will likely result in higher N loss estimates.

An important component of the interaction between rainfall/irrigation and N loss estimates is related to soil properties. In particular, the available water holding capacity (AWC) of the soil. Deep, fine textured soils generally have considerably greater AWCs than shallow, stony soils. The lower the AWC the more water 'washes' through the soil because the soil cannot store or hold the water and hence the proportion of N lost will be correspondingly higher.

For example, if we have two soils, one with an AWC of 120mm and one with an AWC of 40mm and we have 160mm of drainage, the soil with the higher AWC will only be 'flushed' 1.3 times compared to 4 times for the soil with the low AWC (Figure 5). This increase in 'flushing' will increase the proportion of total N leached.

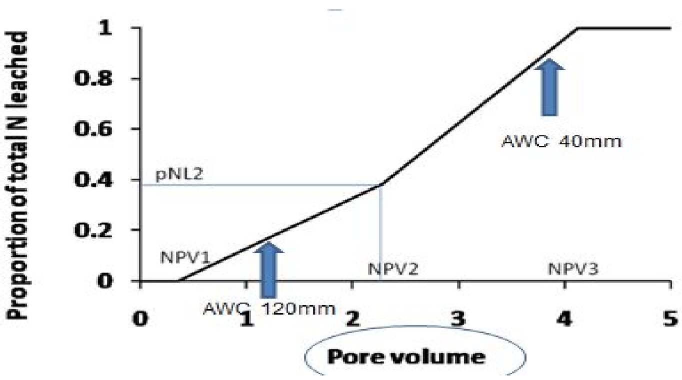


**Figure 5:** The importance of soil properties on drainage and N loss

In terms of irrigation, the model requires the method of irrigation as an input with the choices being pivot, rotorainer or border dyke. Both method and amount of irrigation water used by month can make a significant difference to the estimated N loss.

***Use of OVERSEER® by trained persons***

Given the complexity of the current model, OVERSEER® should be used by properly trained and qualified people using long term average data appropriate to the regional or sub-regional area in which the farm lies. University graduates in agriculture will have had an introduction to the theory behind and use of OVERSEER® but further training is provided by the Massey University professional development courses including the Intermediate and Advanced Sustainable Nutrient Management courses. These courses are open to anyone who wishes to gain knowledge and experience with the tool and the wider issues of nutrient cycling on grazed pastoral farms. Completion of the two courses above alone does not mean that a user of OVERSEER® would be necessarily competent. The ability to actually use the model is a pre-requisite before completing these courses. Knowledge of farm systems and the implications of how to collect and interpret the appropriate data about the farm system and the relevant default parameters to use all take considerable time to learn and understand.

The development of input parameter protocols is one way of standardising the creation of nutrient budgets and the Dairy Industry has produced one under their Audited Nutrient Management programme. Fonterra, Miraka, Open Country Dairy, Westland Milk and Synlait are all signatories to the Sustainable Dairying : Water Accord and as parting of the reporting requirements are to provide N loss and nitrogen conversion efficiency (NCE) at end of each season by having nutrient budgets produced using the protocol.

Subsequent to the Dairy NZ protocol, a set of Overseer Best Practice Data Input Standards has been produced which expands on the protocol to include all land uses and nutrients which OVERSEER® deals with.

An independently run nutrient management accreditation scheme has been developed by Dairy NZ, the Fertiliser Industry and other stakeholders to give assurance of the credibility of ‘nutrient management advisors’ who prepare OVERSEER® analyses of farm businesses. Attendance at and qualification in the two Sustainable Nutrient Management courses forms part of the necessary requirements, as well as consideration of the advisors past experience and current activities including continued professional development, for accreditation as a ‘nutrient management advisor’. Around 30 advisors are now qualified with many more in the process of applying for accreditation.

**Summary**

The nutrient budget model, OVERSEER®, is world class and designed to estimate major nutrient flows into, around and out of a considerable range of different pastoral, arable and horticultural land uses. Traditionally, the model has been used by fertiliser industry personnel to inform fertiliser nutrient recommendations which may be amended because of nutrient deficit or excess, farm dairy effluent and supplementary feed inputs. Latterly, the industry has also used the model to run ‘what if’ scenarios e.g., changing land management practices and determining the effect on N loss, for resource consent applications or in regions where N loss limits are present or imminent.

Losses of N from the root zone and the risk of P loss through overland flow have also been estimated and used to discuss mitigation strategies with farmers. In recent times OVERSEER® has been used in a regulatory context to inform the limit setting process to protect water quality and as part of industry audited self-management processes. There is on-going debate as to whether OVERSEER® is fit for purpose in these activities.

Whatever use the model is put to, while any one can use the model an in depth knowledge of how the model works and the consequences of selecting and then modifying input parameters must be well understood.