OVERSEER® Technical Manual

Technical Manual for the description of the OVERSEER® Nutrient Budgets engine

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Introduction

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Preface

OVERSEER® Nutrient Budgets

OVERSEER® Nutrient Budgets (OVERSEER) is a strategic management tool that supports optimal nutrient use on farm for increased profitability and managing within environmental limits.

OVERSEER provides users with information to examine the impact of nutrient use and flows within a farm and off-farm losses of nutrients and greenhouse gases. An OVERSEER nutrient budget takes into account inputs and outputs and the key internal recycling of nutrients around the farm.

See the OVERSEER website for more detailed information: http://www.overseer.org.nz

This technical manual

OVERSEER is made up of a user interface and an engine. These two components work together to enable users to generate nutrient budget reports. The Technical Manual provides details of the calculation methods used in the OVERSEER engine

If readers have feedback or further technical information that they consider could contribute to the future development of the model, please provide feedback via the website http://www.overseer.org.nz.

Contents

1. Introduction

1.1. What is OVERSEER?

OVERSEER® Nutrient Budgets (OVERSEER) is an agricultural management tool which assists in examining nutrient use and movements within a farm. 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 website www.overseer.org.nz.

The core of the model is a nutrient budget. A nutrient budget is a table of inputs and outputs for a nutrient, for a particular physical identity. The identity can be a farm, blocks, or paddocks within a farm. The types of items (individual input and outputs) in the nutrient budget vary with the processes that are occurring in the identity of interest. A diagrammatic example of a nutrient budget is shown in Figure 1 for a pastoral block.

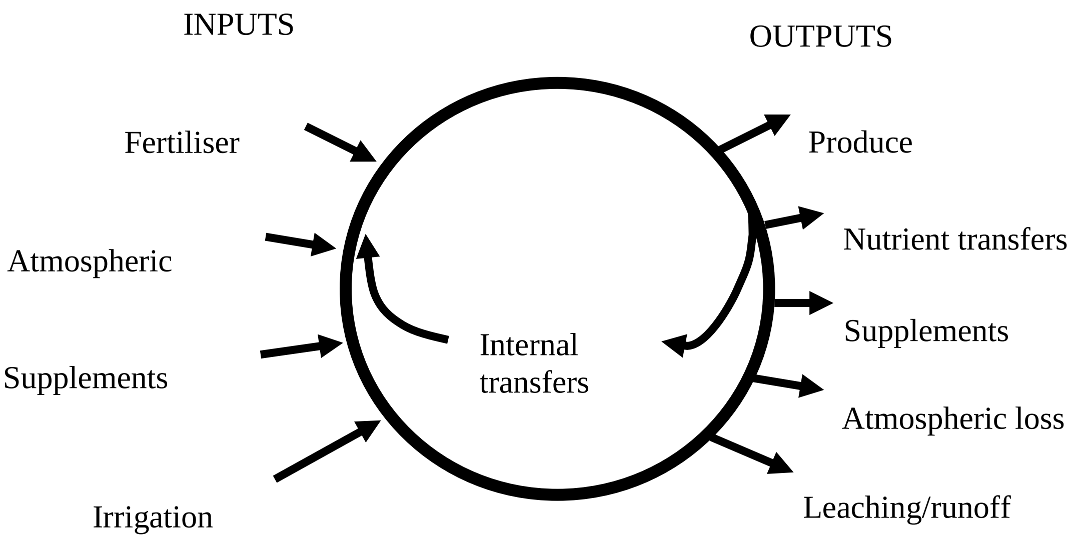


Figure 1. Schematic diagram of a sub-block nutrient budget.

Internal transfers are also included in a nutrient budget. Transfers in and out of internal pools are not losses from the block or farm. They represent the movement of nutrients between plant available or 'readily available' pools and pools where nutrients are very slowly available.

From the nutrient budget, or calculations performed to obtain the nutrient budget, a range of reports and indices, for example, N conversion efficiency or greenhouse gas emissions, can be extracted.

2. Technical manual

This chapter of the Technical Manual is designed to provide the background on the principles the model development has followed, and an outline of the model. This section defines the objectives of the technical manual.

2.1. Objectives

OVERSEER is made up of a user interface and an engine. These two components work together to enable users to generate nutrient budget reports. The Technical Manual provides details of the calculation methods used in the OVERSEER engine

The aim of the Technical Manual is to provide a transparent description of the underlying principles and methods used in the model. The technical manual aims to include the equations used with the model along with sources of data used, data analysis methods, and assumptions made in analyses and model development.

Within the Technical Manual, the preferred method of documenting a procedure is to reference the initial source. Not all of the referenced work can be made publicly available because of copyright limitations. The Technical Manual will record any variation from the reference used. If no suitable references are available, then the Technical Manual will describe the methods in more detail.

The Technical Manual is not intended to be a help file, textbook or training manual. The reader is expected to have an understanding of the field of work described in the chapter. It is also not intended to provide background information, justification for selecting one method over another or separate information such as sensitivity analysis, case studies or uncertainty analysis. This information will be included in the references to the initial source, or included in additional documents as the information becomes available.

The Technical Manual consists of a series of separate chapters for the sub-models within OVERSEER. These will be released periodically on the OVERSEER website. The versions on the website will be updated for each release as required. Hence, they will reflect the current version of the model.

2.2. Conventions used

Subscripts to variables are used within equations to refer to the following:

nut	N, P, K, S, Ca, Mg, Na, and acidity or chloride (Cl).
soil	indicates a soil group, soil order or soil type based parameter.
antype	dairy, dairy replacements, sheep, beef, deer, dairy goats or other.
mon	month.

Summation across indexes is indicated by sigma, with the indexes summed over indicated by a subscript between sigma and the variable name:

$\sum_{mon}$Variable

When describing equations in this manual, units are shown using ( ) and cross-references to other equations and sections within this chapter or to other chapters of the technical manual are shown using [ ]. Equations with multiple '=' options are cascading alternatives in the order they are considered. The condition for each option is shown on the right hand side. Multiplication is depicted by a '*'. The variable and parameter names used are generally shortened names of the model property, and this naming convention is similar to the convention used in the OVERSEER engine model.

Error messages that are generated are shown in italics, and insertions into the error message text are shown between angle brackets < >.

Within equations, units are shown using ( ) and cross-references to other chapters of the technical manual or sections within this document are shown using [ ]. Equations with multiple '=' options are cascading alternatives in the order they are considered. The condition is shown on the right hand side. The variable and parameter names are generally shortened names of the property, and this naming convention is similar to the convention used in the OVERSEER engine.

3. Operational guidelines for OVERSEER development

3.1. Development objectives

The primary development objectives for OVERSEER are to develop and maintain a New Zealand wide strategic farm-specific tool that is able to:

- Produce nutrient budgets to identify nutrient flows through a farm system,
- Determine fertiliser nutrient maintenance requirements,
- Tabulate greenhouse gas and energy emissions, and
- Produce indices of production and/or environmental impacts.

OVERSEER is a long-term strategic tool that takes account of 'long-term' rather than 'short-term' management effects. Thus, it is not intended to be used as a day-to-day management tool.

The tool aims to represent 'fairly and equitably' differences between farms and farm types. This is defined as capturing differences in site characteristics or management practices that result in differences in outputs, modelling the impact of these site characteristics or management practices using a robust science process using the guiding principles outlined in section 3.6, and allowing this to happen in a manner that every user has equal access to data and information. This has been done by endeavouring to:

- Capture paths of nutrient transfers within a farm system.
- Model processes where paths change using the science process and science reviews, and guiding principles outlined in section 3.6.
- Use data that the farmer knows is readily available, or suitable defaults are available as outlined in section 3.4.
- Maintain consistency between farm systems.
- Maintain a focus on mitigation options.

OVERSEER also assumes some good management practices (GMPs) are followed. See section 6.2 for more details.

3.2. Modes of operation

OVERSEER is capable of operating as a:

- Reporting tool that captures key inputs that affect nutrient management and nutrient flows.
- Strategic tool with a focus on forward-predicting annual average nutrient flows for a given set of farm conditions and management.
- Benchmarking tool that captures current (or past) management systems and estimates annual average losses.

OVERSEER is not considered to be an operational tool for managing day-to-day operations.

3.3. Operational scales

OVERSEER is a farm-scale model.

- A farm is defined as a land area (e.g., excluding land under urban, industrial and conservation estate land use) encompassed within a management unit as defined by the user. This is defined further in section 4.1.
- The land area need not be contiguous; rather it should be under the same management structure.
- Within OVERSEER, the models operate at two scales – whole farm and block scale. A block is defined as an area of land with similar physical and management options within the farm. This area need not be contiguous. A block is defined further in section 4.2.

3.3.1. Temporal Scale

For a given farm system, the nutrient budget estimates the annual average outputs for the farm and management system described. Site data inputs such as soils and topography are considered effectively fixed. Annual inputs for rainfall, temperature, and PET can be user defined, or suitable defaults for temperature and PET can be used. The monthly patterns for rainfall, temperature, and PET are built into OVERSEER and are based on 30-year averages (see Climate chapter of the Technical Manual).

For farm management data and annual rainfall, a user usually chooses between:

a) an average annual derived from many years' data, or

b) actual or estimated specific annual data.

The choice of inputs is normally determined by the purpose of the OVERSEER modelling, e.g., estimating long-term annual nutrient losses versus estimating losses for a specific one year period.

It is important to appreciate these different types of inputs and the potential implications of choosing specific annual or long-term average inputs. For example, there will be implications for nutrient loss estimates of using actual annual rainfall versus using long-term average rainfall.

Further work is needed to clarify the implications of these different approaches for nutrient loss estimates.

3.3.2. Physical boundary

OVERSEER operates within the physical farm boundary except as noted below. Thus:

- Losses in water are calculated to the ‘edge of field’, i.e. from the bottom of the root zone for leaching, from the end of the tile drain in drained soils and from the paddock in surface run-off.
- Attenuation processes in water bodies within the farm are not generally included. The exception is that attenuation in wetlands and riparian strips up to the stream bank edge are considered within the farm boundary if the user includes these inputs.
- OVERSEER has an upper limit of 2m above the soil surface for gaseous losses.

The exceptions to the above are:

- Catchment areas for wetland and riparian strips can be outside the farm boundary
- Nitrous oxide (N_2O) emissions include N_2O emissions subsequently generated from leached NO_3 or volatilised ammonia (NH_3).
- Greenhouse footprint model includes embodied carbon dioxide (CO_2) emissions in farm inputs. Embodied emissions are the CO_2 equivalents required to produce and use a product within the farm.

3.4. Data inputs

In the development of OVERSEER, data inputs are used for sub models that conform to the following criteria:

- Data can be reasonably expected to be known to the farmer or consultant,
- Data can be obtained (at reasonable cost) from a commercial laboratory, or
- Suitable default values are available, and
- Data inputs are verifiable, i.e. they come from a documented source such as stock trading records for animal numbers, climate data sets, or fertiliser records.

3.5. Users

OVERSEER needs to accommodate use by the following groups:

- Farmers and their consultants, including fertiliser company staff to provide farm specific advice on nutrient management.
- Education establishments for training in nutrient management and the use of OVERSEER.

- Policy developers and policy implementers (e.g., MPI and regional councils).
- Scientists applying it to farm nutrient investigations and research projects, including testing and validating the model.

3.6. Guiding principles for sub-model development

The key questions when developing a sub-model have been:

- Has the sub-model captured the significance of a process properly?
- Is there a farm set-up where this process is important?
- Is the inclusion of this process important for user confidence?
- Is the data input or sub-model included for educational purposes, for example, the use of active management to illustrate what an exceptional system may achieve?
- Is there is greater error in including a process conservatively, or ignoring it?

The following guidelines have been followed in the use of data:

- Lack of data is 'not a reason' for omitting something – rather a probable effect assessment is made using science principles and/or any relevant research results. This assessment should consider the impact of including a process based on first principles as opposed to not including a process.
- Data preferences for model development, validation, and testing follow the order: NZ-specific data whenever available; overseas data from climates and farming systems similar to NZ; otherwise, develop from first principles.
- Model parameters should reflect farm conditions and management options – they should not be nationally integrated or averaged values.

4. Model definitions

The model has been split into inputs that relate to management decisions made at a farm scale, and those that are made at a block scale. The definition of a block is covered in section 4.2.

Animal information such as productivity (numbers and amount of product), imported supplements, and how farm structures (feed pads, farm dairy, effluent management) are used, is usually known at the farm scale rather than block scale. Site and soil characteristics, fertiliser inputs, irrigation, cropping, supplement removal, and crop rotation operate at a block level. Hence, data inputs and output reports are aligned with each scale.

The use of multiple scales means that farm scale inputs and calculated variables are sometimes required to be distributed down to blocks, where the inputs and outputs for the block nutrient budgets are determined. The reporting part of the model scales sub-block outputs up to block and farm scale, adding in specific block and farm scale inputs or outputs as required.

4.1. Definition of a farm

Typically, the farm is the area of land managed by a single person such as a farm manager, owner, or sharemilker. This farm usually consists of one or more legal titles. However, an

OVERSEER farm can be part of a farm operation, or be multiple ‘farms’ brought together, provided the data can be sensibly entered and outputs interpreted.

The land units making up the farm need not be continuous. For example, for a dairy operation, the dairy milking platform and runoff block can be analysed as two separate farms, or as a single farm with two different blocks (blocks are defined in section 4.2). The land units need not be in a single water system catchment.

4.2. Definition of a block

A block is defined as an area of the farm that has common physical and management attributes. Within the model, a block does not have a spatial component (is not geo-referenced) and hence need not be continuous, although the user’s perception of a block is that it is a discrete spatial component. A block usually comprises more than one paddock.

There are a range of block types that define the basic farm anatomy and types of management that occur on specific areas of land (see section 5). Block types should be added to reflect the management systems on farm. Multiple blocks of the same type are allowed.

Common reasons for setting up multiple blocks of the same type include differences in:

- Block site characteristics such as topography, rainfall, or irrigation.
- Soil groups, soil test values.
- Development status, for example if a block has recently been purchased and is being developed, or if a block is recently cultivated.
- Fertiliser management (application rates, and type or timing of application).
- Effluent management (application rates, and type or timing of application).
- Stock type(s) between blocks. Examples would include a separate deer block on a sheep and cattle property, or different sheep/cattle ratios between blocks (e.g., between flats and hills). On dairy farms, dairy replacements can be allocated to a separate block from the milking herd.
- Crop rotation or cropping system.

4.3. Sub-blocks

A sub-block is part of a block. Currently the model only recognises camp and non-camp sub-blocks when estimating maintenance fertiliser nutrient requirements for a pastoral block, headlands and uncultivated areas in a crop block, and sward area in fruit crop blocks. The sub-block level essentially uses block level data, with some modification to soil test values and internal transfer rates.

A spatially explicit model (if and when developed) would operate at the sub-block level.

4.4. Farm structures

Farms structures are buildings or construction that is used on the farm. Farm structures include

- Farm dairy – milking shed and associated yards.

- Effluent system - sumps, ponds, storage systems, application systems.
- Feed pads, loafing pads, wintering pads, or animal shelters.
- Lanes or raceways.

Lanes or raceways are modelled so that no additional information is required. Although other structures are used on the farm such as hay barns, silage pits, water reticulation systems, etc., these structures are either not included in the model, or a captured via supplements inputs for silage. Hence, they are not included in the input requirements.

4.4.1. Farm dairy

The milking shed and associated yards. It is assumed that excreta dung and urine deposited on the yard are directly transferred to the effluent management system.

4.4.2. Standoff or loafing pad (dairy only)

A standoff pad is a specially built area where stock can be withheld from grazing during wet periods to minimise damage to pasture. These pads are typically constructed of free-draining materials such as sawdust, bark, wood chips, lime, or a soft metal (rock) mix. Since cows may be withheld for extended periods (20 hours/day) an area of about 8-10 m^2 per cow is recommended (Dexcel 2005). There is no provision for stock feeding while the animals are on the pad.

4.4.3. In-shed feeding (dairy)

In-shed feeding is the feeding of supplement during milking. In-shed feeding assumes that there is no additional effluent added to the effluent management system because the animals are fed while milking.

4.4.4. Feed pad (dairy only)

A feed pad is normally a hard surface area (usually concrete) sited adjacent to the farm dairy where stock can be held for some time (1-2 hours), either prior to or after milking, and provided with supplementary feed. Feed pads are usually included in a farm system to improve supplementary feed use compared to paddock feeding.

4.4.5. Wintering pads/animal shelters

A wintering pad is a specially built area where animals are withheld from pasture for extended periods and supplementary feeds are brought to them on the wintering pad. As the herd may spend several months on the pad, the cows require a similar sized area to lie down as stand-off pads, as well as additional space for feeding. In some cases, rather than supplements being brought to the animals, or in addition to supplements, animals are allowed to graze pastures for a limited time (e.g. 3-6 hours) each day.

A wintering barn or animal shelter is similar to the wintering pad, except that it is covered. The animals are usually withheld from pasture for extended periods and supplementary feeds are brought to them in the wintering barn.

4.5. Example conceptual farms

4.5.1. Dairy farm

A schematic representation of the scales and components of the model for a dairy farm is shown in Figure 2.

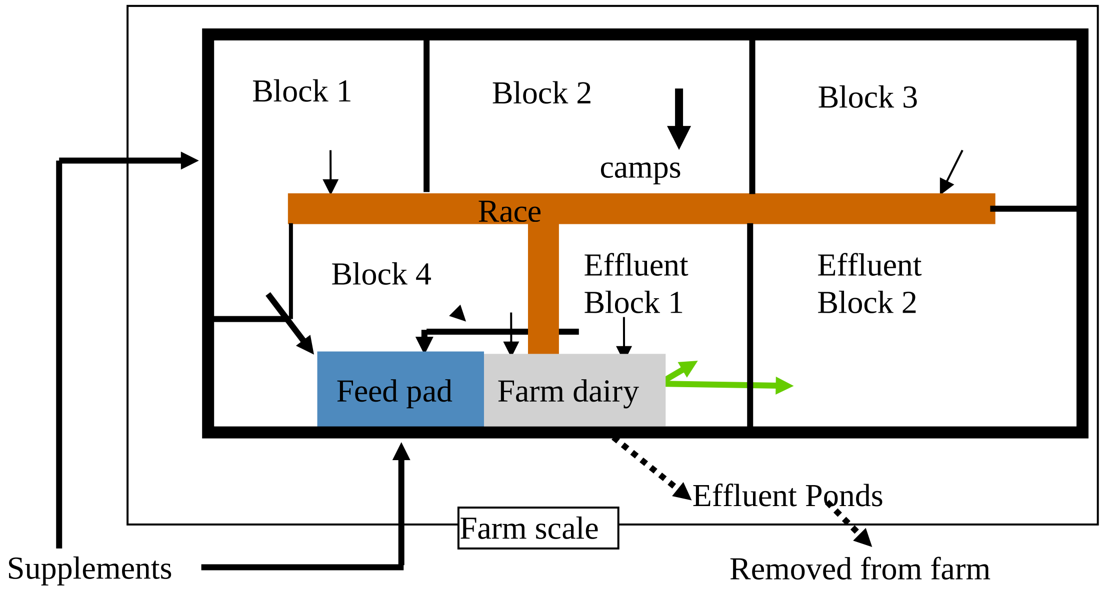


Figure 2. Schematic representation of a dairy farm within the model. Arrows indicate nutrient transfer pathways, with only some of them shown for clarity.

In the above, the farm has four farm structures (raceway or lanes, feed pad, farm dairy and effluent ponds) and six pastoral blocks, including two that receive effluent.

4.5.2. Cropping farm

A cropping farm, consisting of individual blocks, is shown in Figure 3. There are no nutrient transfers between blocks. However, there is nutrient transfer when crops are harvested and removed.

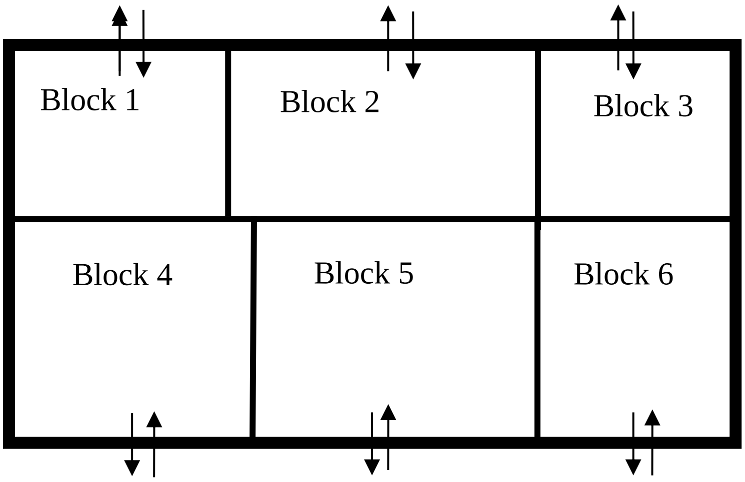


Figure 3. Schematic representation of a cropping farm within the model. Each block is a separate crop rotation. Arrows indicate nutrient transfer pathways, with only some of them shown for clarity.

4.5.3. Catchment areas for riparian buffers and wetlands

The catchment for riparian buffers and wetlands is separate from the farm and block scales. Catchment areas can be spread across many blocks, and can include areas outside of the farm (Figure 4). The effectiveness of a wetland is dependent on the whole catchment inputs, but the model only includes the estimated effect for the farm area within the catchment.

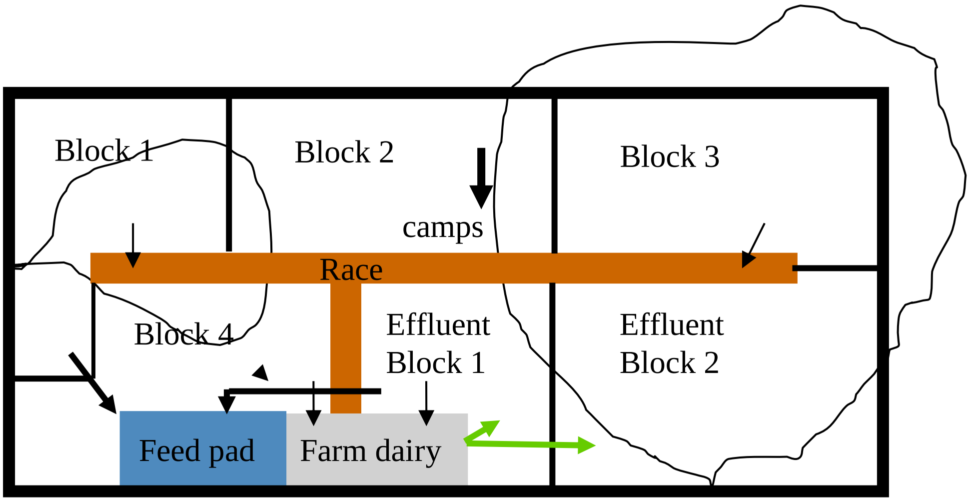


Figure 4. Schematic representation of a dairy farm within two wetland catchments, one entirely within a farm, and the second with areas outside the farm.

5. Model coverage

5.1. Animal types

The model caters for dairy, dairy replacements, sheep, beef, deer, and dairy goats systems. Other animal types can be added as stock units. These are modelled as sheep unless animal type specific data is available. Dairy replacements were separated out so that runoff blocks could be modelled.

5.2. Block types

A block type defines the basic farm anatomy and types of management that occur on an area of land within the farm. Allowable block types are:

5.2.1. Pastoral block

A pastoral block is a block growing pasture or lucerne and with animals grazing. Some pasture can be removed for animal supplements. There are two types of pastoral blocks:

- permanent pasture blocks, and
- pasture blocks through which a fodder crop or pasture fallow block rotates.

5.2.2. Fodder crop block

A fodder crop area is an area of pasture that is cultivated, sown with a fodder crop, and resown back into pasture, or is put into pasture fallow. The range of fodder crops is shown in section 5.2.4.

The area under cultivation or in fallow is similar each year. The fodder crop area rotates through the selected pasture blocks, that is, each year a different set of paddocks within the pasture blocks is sown in fodder crops or fallowed.

Multiple fodder crop areas can be set up, but all areas are assumed to rotate through the same pastoral blocks. Fodder blocks can be up to 25% of the area of pasture blocks that the fodder crops rotates through, i.e., within the pastoral blocks the crop rotates through, a given area is cropped every four years.

5.2.3. Cut and carry block

A cut and carry block is a block with a perennial crop (typically pasture or lucerne) where all forage grown is removed. The forage can be fed to animals on other blocks or on farm structures, or exported. Cut and carry blocks are assumed to have a flat topography.

5.2.4. Crop block

A crop block is a block that is cultivated and sown in vegetable, arable or fodder crops. Although animals may graze the block during a pasture phase, or as part of the crop management, the primary focus of the block is the crop. The range of crops is shown in Table 1. Crop blocks are assumed to have a flat topography.

Table 1. Crop categories and types in the model.

Category	Crop
Grain crops	Barley (spring)[1]
	Maize (short, medium and long)[2]
	Oats (spring and autumn)[1]
	Wheat (spring and autumn)[1]
Vegetables: greens	Broccoli (winter/spring and summer)[1]
	Brussels Sprouts
	Cabbage (winter/spring and summer)[1]
	Cauliflower (winter/spring and summer)[1]
	Lettuce
	Spinach
Vegetables: legumes	Beans (green and dried)
	Lentils
	Peas (green and dried)
Vegetables: root crops	Kumara
	Potato (short, medium and long)[2]
	Beets
	Carrots
	Parsnips
Seed crops	Clover seed
	Ryegrass seed
Vegetables: other	Onions
	Sweetcorn
	Squash
	Tomato
Green manure	Brassica
	Lupins
	Mustard
	Oats and rye
	Phacelia
Forages	Annual ryegrass
	Forage barley (spring) [1]
	Forage oats (spring and autumn) [1]
	Maize silage
	Rye corn (spring and autumn) [1]
	Triticale (spring and autumn) [1]
Fodder crops	Fodder beets
	Kale
	Rape
	Swedes
	Turnips bulb
	Turnips leafy
Permanent pasture	Grazed
	Pasture fallow
	Cut and carry

[1] Sowing time; [2] Growing period

5.2.5. Fruit crop block

A fruit crop block is a block that has a permanent fruit crop grown on it. Currently five fruit crops (kiwifruit, apples, grapes, avocadoes, and peaches) can be modelled. Fruit crop blocks are assumed to have a flat topography.

5.2.6. Tree/scrub block

Trees and scrub blocks typically have lower nutrient inputs and outputs than other block types. The effect of trees on greenhouse gas emissions is currently not included in the model.

5.2.7. Riparian blocks and strips

A riparian block or strip is an area fenced off such that runoff water passes through it before reaching a water body such as a stream. A riparian block is the fenced areas around streams. A riparian strip or filter is an area fenced off to intercept runoff within a block.

Riparian strips are used for a number of reasons including:

- Excluding stock from waterways, stabilising stream banks,
- Reducing the amount of sediment reaching streams,
- Reducing particulate nutrients reaching streams,
- Controlling stream temperatures, and
- The provision of habitat.

OVERSEER is only concerned with the effect of a riparian strip in reducing particulate nutrients (phosphorus (P)) from reaching streams. In New Zealand, P in runoff is generally present in very fine particle sizes, which is the particle size range that riparian strips are least effective at removing. Hence, the impact of riparian strips on reducing P loss in runoff is not always high. Riparian strips are effective at removing sediment and in the other benefits they provide.

Defining the effectiveness of a riparian strip requires observation of how the strip operates during a runoff event.

The effectiveness of riparian blocks or strips in decreasing P loss is currently not included in block or farm nutrient budgets but is reported separately.

5.2.8. Wetland block

Wetland block are wetland areas that have been fenced off to all grazing. These may include natural or artificial wetlands. Wetlands can also be listed as a farm input or artificial wetlands entered as treating outlets of mole/tile drainage systems - it is important that the same wetland areas are not included in both sections.

The effectiveness of wetlands in decreasing N loss is currently not included in block or farm nutrient budgets but is reported separately.

5.2.9. House block

House blocks can discharge nutrients via septic tanks, cultivated areas (gardens) or runoff from hard surfaces. On larger (takes account of land use intensity) farms, the contribution from the house block can be a non-significant proportion of total property losses and hence can be ignored. However, on small blocks, the contribution from the house block may be a significant part of whole property losses

Multiple house blocks can be added together into one block.

5.3. Nutrients

Calculations are performed for the following nutrients:

- All models: N, P, K, S, Ca, Mg, Na for all block models and the farm model
- Pastoral block model only: acidity/Cl. The change in acidity is modelled to determine lime maintenance requirements. Plant and supplement Cl levels are used to access the amount of net acidity intake.

5.4. Greenhouse gas and energy emissions

The model reports greenhouse and energy emissions at a farm scale only, although some of these emissions are calculated at a block scale.

Although greenhouse gas emissions are included, the change in carbon stock is not included except for the acidity model.

6. Underlying assumptions

In constructing the nutrient budgets, the model is based on the following assumptions:

- Quasi-equilibrium: The model assumes that inputs and farm management practices described are in quasi-equilibrium with the farm productivity (see section 6.1 for more details).
- Good Management Practices (GMPs): the model assumes that some specific good GMPs are followed. See section 6.2 for more details.

There are also assumptions about each sub-model and these are listed in the relevant Technical Manual chapter.

6.1. Quasi-equilibrium state

The quasi-equilibrium state implies that the inputs (for example, fertiliser, irrigation, and supplements) are in equilibrium with the described management practices (for example, timing, presence or absence of a practice) and production (for example, number of animals, crop yield, and milk solids production).

The benefit of the quasi-equilibrium model is that it reduces the number of inputs that are required and there is no need to estimate the effect of changes in soil characteristics on changes in productivity during a transition period. Thus, the model can be applied to systems such as organic systems, or those using slow release fertiliser (reactive rock phosphate (RPR), elemental S). For slow release fertiliser, the model assumes that the rate of release from the product or source is the same as the rate of input, and that production from the farm is in equilibrium with this rate of release. However, direct effects of fertiliser form on other processes (e.g., P runoff risk, acidification) are modelled. Effects of transition periods for slow release fertiliser or changing the underlying soil fertility levels are not included.

Limitations in using a quasi-equilibrium modelling approach include not being able to construct a nutrient budget for the transition period when management changes are imposed. The model also assumes that inputs are in equilibrium with production irrespective of whether the system is viable or not. Hence actual farm management data should be used for the current or base farm when changes in management are been considered. This has been condensed to the **actual and reasonable** assumption.

In addition, the model does not automatically change one set of inputs if another input is changed, for example, animal production does not increase if irrigation is applied as it breaks the quasi-equilibrium assumption. Thus, an additional limitation is that if an input parameter is changed from what actually occurred on a farm, then all associated parameters also need to be changed to reasonable values.

It should be noted that the quasi-equilibrium rule is not applied everywhere and the exceptions are noted in the following chapters of the technical Manual where appropriate.

6.2. Good management practices

OVERSEER assumes some specific GMPs are used because not all processes can be adequately captured by a model, poor management is difficult to quantify, and a model like OVERSEER is not necessarily the best option to capture poor management practices. In general, if GMPs are not followed, environmental losses are higher.

All the assumed GMPs are not defined in a single document. For example, if fertiliser or effluent is 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. The key documents are:

- 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).
- For fertiliser in the Fertmark and Spreadmark codes of practice (New Zealand Fertiliser Quality Council, 2012a, b).

The model also 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, OVERSEER can model some instances of ‘bad practice’, for example applying large amounts of nitrogen fertiliser in the winter or applying more than is required for the level of production, over-stocking, and over-irrigating causing extra drainage.

7. Model outline

7.1. No animals (crop farm)

On farms with no animals the information to undertake nutrient budget calculations for a block is contained within the block. There are no inter-block or block-farm transfers as occurs when animals are present. Thus, on farms with no animals, the farm nutrient budget is the average of the area weighted nutrient budget for each block, as illustrated in Figure 5.

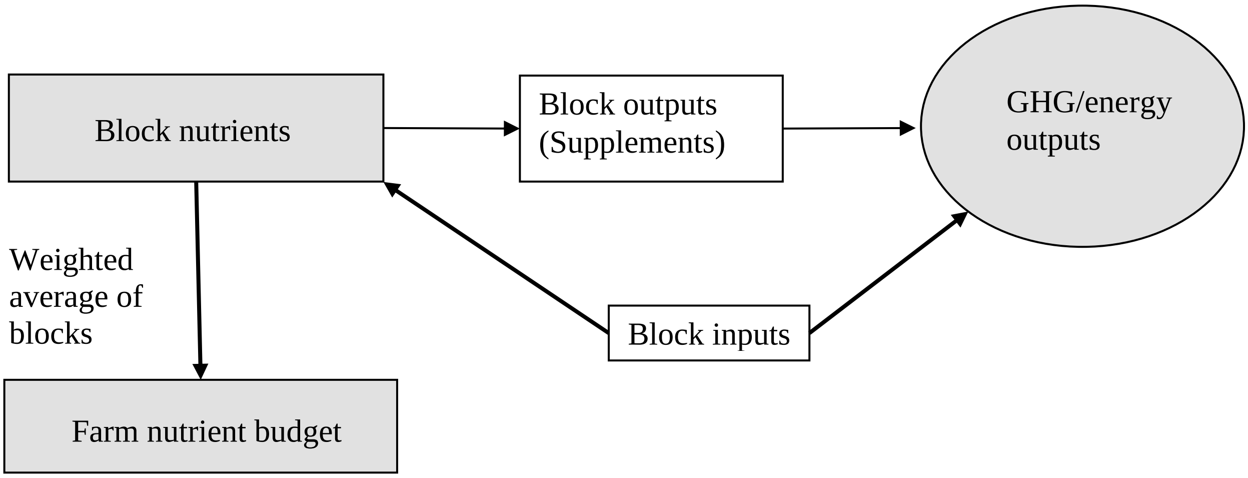


Figure 5. Schematic diagram showing the generalised structure of the model for a system with no animals.

7.2. Farm model with animals

The inter-relationship between the animal model, and block and farm nutrient budgets is shown in Figure 6. On farms with animals, animal intake of energy and nutrients are estimated at a farm scale. However, the calculation of intake is also dependent on block scale outputs of pasture and supplements or crops grown on blocks. The method for estimating block pasture production is briefly described in section 7.2.2. The ingested nutrients are then distributed around the farm. Thus, there are interactions between farms and blocks, and between blocks as described in section 7.2.3 and 7.2.4.

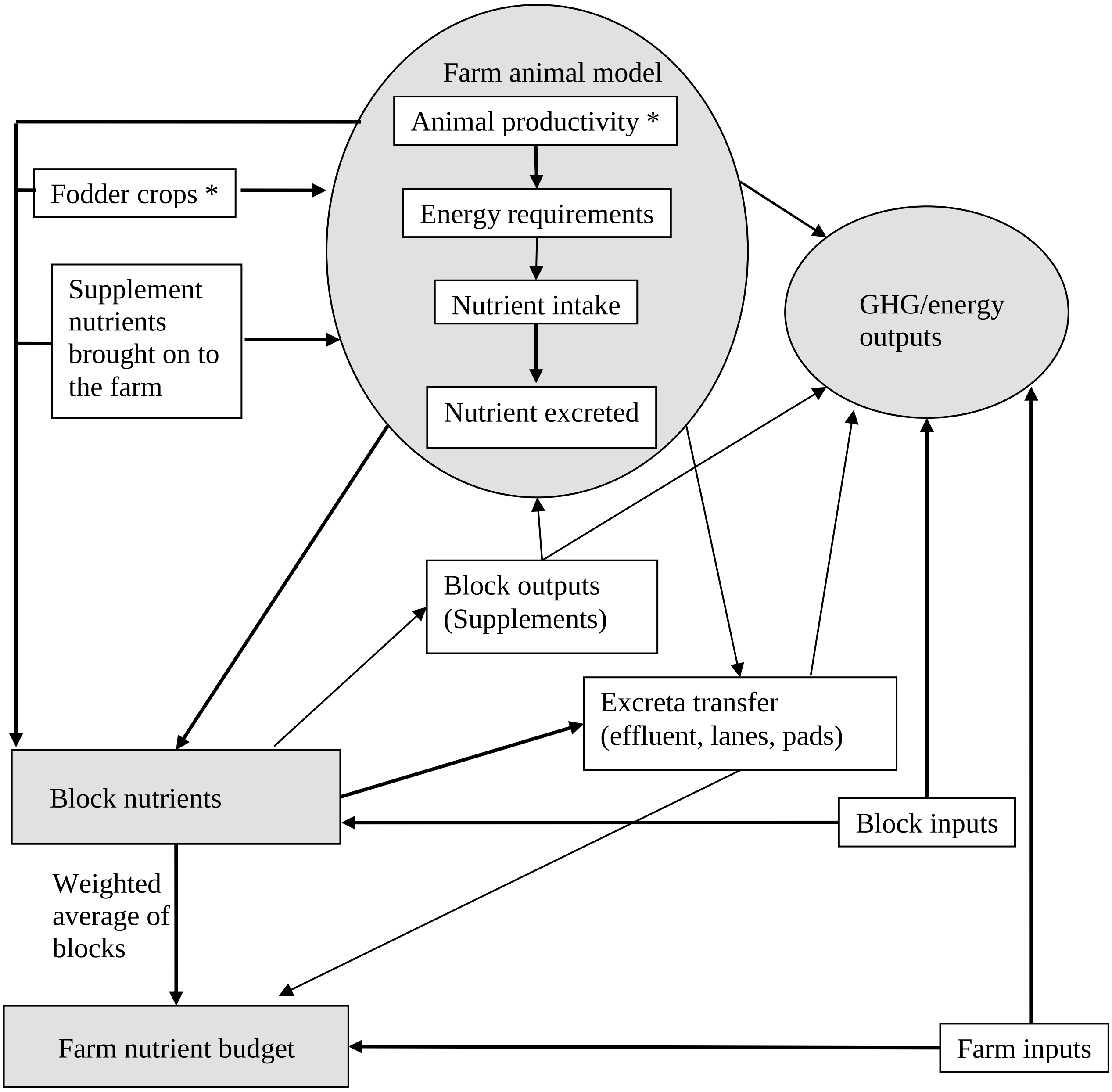


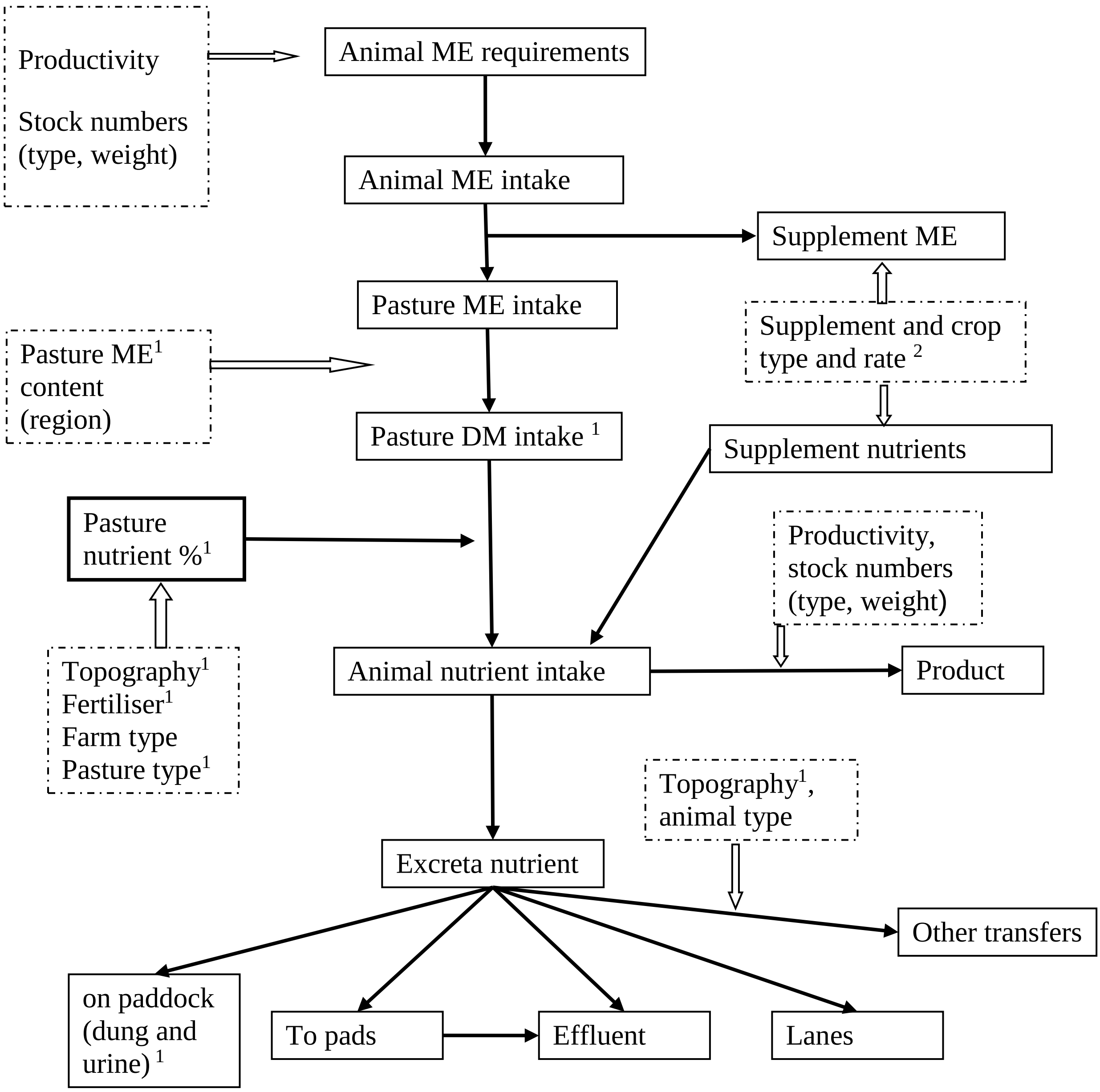
Figure 6. Schematic diagram showing the generalised structure of the model for a pastoral system.

7.2.1. Animal model

The farm animal model estimates animal dry matter (DM) and nutrient intake for each animal type for each month. Figure 7 provides a simplified representation of the elements that constitute the animal model framework.

Animal nutrient intake (see Figure 7) is then estimated from supplement nutrient levels, fodder crop nutrient levels, and pasture nutrient levels. It is assumed that excreta production is animal nutrient intake less product removed.

Excreta is then partitioned and distributed to various parts of the farm such as feed pads, laneways, and effluent systems, with the remainder returning to the paddocks as dung and urine.



ME = metabolisable energy 1 = block scale, 2 = block and farm scale

Figure 7. Generalised animal model. Dotted box indicate inputs that affect calculations.

The disadvantage of the developed approach shown in Figure 7 is that any modelled management or mitigation changes should also consider any consequential change in animal productivity. These consequential changes are not always well known. In addition, on many farms, adopting mitigation changes frequently result in multiple changes to farm management systems, which when added together can either enhance the mitigation or result in higher emissions than if looking at the mitigation option in isolation. Thus, it is critical that scenario analysis is undertaken by a professional with an in-depth understanding of farm systems.

7.2.2. Block pasture dry matter intake

Pasture DM intake could be estimated as pasture growth multiplied by utilisation for each block, or from ME requirements of the animals, based on animal productivity, and pasture ME content. In the former, total pasture growth must be commensurate with farm animal numbers. In the latter, farm animal distribution must be commensurate with block pasture production so that quasi-equilibrium requirement is met.

Estimation of pasture production and utilisation to obtain animal intake is difficult, is open to interpretation differences, and is difficult to validate. Animal production is usually better known and easier to validate, although pasture ME content is not always easily obtained. On balance, it was decided that pasture nutrient intake would be estimated from animal productivity. This was fortuitous as the national inventory methodology for methane and nitrous oxide uses animal productivity to estimate ME intake. Thus, similar base models could be used for estimating animal nutrient intake and methane emissions.

This methodology does require estimated animal DM and nutrient intakes to be distributed to each block. In the original 'Outlook' model, it was required that stocking rates appropriate to each block were entered to make the model run correctly. However, a survey indicated that this generally didn't happen – rather the whole farm value was applied irrespective of whether there were block differences or not. Second, when different production levels between blocks, different stock classes between blocks, supplement movement, grazing off and feed pads are included, then these calculations quickly became difficult for a quick assessment. A method was developed to distribute pasture DM production, nutrient intakes and excreta return to blocks, taking these factors into account.

7.2.3. Between farm and block interactions

If farm animals are present on a block, then block nutrient budget calculations require:

- An estimation of pasture DM intake from a block, which is based on farm animal numbers and productivity and block animal distributions.
- Pasture nutrient concentrations so that animal nutrient intake from a block and nutrient transfer rates out of a block to a farm structure can be estimated.
- The distribution of farm based inputs to blocks, e.g., supplements brought in which are fed on blocks, or farm stocking rate to a block stocking rate.
- Redistribution of block outputs (supplements or crops) to farm structures, e.g., supplements removed from one block and fed on a feed pad.
- The distribution of calculated farm based inputs to blocks, such as nutrients removed in products sold, or nutrients added as urine and dung excreta, or effluent.

7.2.4. Between block interactions

Common interactions between blocks include:

- Redistribution of supplements or crops between blocks, e.g., supplements removed from one block and fed on another.
- The impact of a fodder crop block on the parent pastoral block.
- Riparian and wetlands blocks requiring information of the hydrology and nutrient concentrations in water from blocks that contribute to their catchment areas.

8. Units

The model uses units of metres (m), kilograms (kg), hectares (ha), and seconds or year for length, weight, area, and time respectively unless otherwise stated.

Within the model, block inputs and outputs are calculated on a per ha basis whereas farm inputs and outputs are calculated as totals.

9. References

DairyNZ 2012. Environment: Managing/Operating Effluent Systems. http://www.dairynz.co.nz/page/pageid/2145874053/Managing_Operating_Effluent_Systems

Dexcel 2005 Minimising muck, maximising money. Standoff and feed pads design and management guidelines. 44 pp.

New Zealand Fertiliser Quality Council (2012a). Fertmark Code of Practice. http://www.fertqual.co.nz/download.php?view.1

New Zealand Fertiliser Quality Council (2012b). Spreadmark. http://www.fertqual.co.nz/page.php?11http://www.fertqual.co.nz/page.php?11