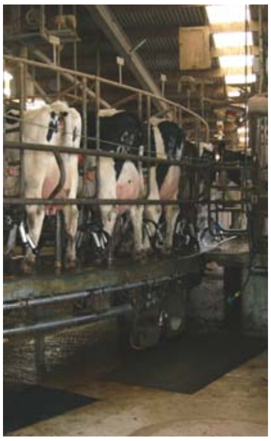
Nutrient Budgeting for Land Spreading

Guideline No 13.



A Nutrient Budget allows you to check the amount of nitrogen, phosphorus or potassium that is applied in dairy effluent with what is being removed through products such as milk, silage, hay, live weight etc.

Allowances must be made for the amount of nitrogen carried over in the soil from previous applications, and the amount of nitrogen that is lost in a gaseous form when it is applied to the land.

This guideline aims to assist in understanding the elements that make up the Nutrient Budget, using the Excel computer program that has been developed as part of these Dairy Effluent Guidelines.

Recycling your Dairy Waste

Manure nutrients and decaying organic matter are natural components of the environment that ultimately contribute to the production of more plant and animal tissue. Although dairy shed effluent is often called a waste, it is in fact a resource when recycled through new plant growth.

Applying manure to supply fertiliser nutrients to plants is the oldest and most used method of recycling. However, if the nutrients are applied in excess of pasture requirements they will be wasted and those not used by the plants are at risk of entering water resources or even degrading the soil.

The composition of dairy effluent differs from farm to farm and from season to season. The amount of nutrients which are in the dairy shed effluent will depend on a number of factors, such as:-

- The number of cows milked.
- How long the cows spend in the dairy and yards.
- How much wash water is used to clean the dairy and yards.
- Whether rainwater from the dairy roof and yards is diverted away from the effluent stream.
- Whether solids separation is used and the type of solids separation.
- Whether the effluent is conveyed direct to the pasture or is held in storage or treatment ponds before spreading.
- Whether some yard wash water is recycled from the second pond.

Manage your Nutrient Levels in your Dairy Effluent

The best way to know what is in your dairy effluent is to have it tested. Effluent should be tested for nutrient content at several times throughout the year. Any laboratory, which carries out soil, plant and fertility analysis should be are able to carry out an effluent nutrient analysis. See Guideline 19 for some suitable laboratories.

There are three major nutrients which should be managed in dairy effluent. These are

- Nitrogen
- Phosphorus
- Potassium

Nitrogen

Nitrogen is an essential plant nutrient which is incorporated into plant protein. Nitrogen in effluent is present as ammonium, ammonia, organic nitrogen, nitrate and nitrite. Plants, however, can take up nitrogen in only the ammonium and nitrate forms. The other forms can become available as the organic nitrogen (in the form of proteins) is mineralised into forms available to plants.

To avoid nitrogen in the form of nitrate passing below the root zone and entering the groundwater, or being carried by surface water into streams, it is important that the nitrogen application rate from all sources does not exceed the capacity of the pasture to assimilate it. Once assimilated in the pasture it can be removed by grazing to produce milk or live-weight gain or harvested as green chop, silage or hay.

Reducing the excess nitrogen excreted by the cows can play an important role in managing the nitrogen in dairy shed effluent. Dairy cow rations should be balanced so that the correct amounts of protein and energy are supplied daily. When the protein in a cow's diet exceeds her needs the extra protein is largely excreted as nitrogenous compounds and increases the amount of nitrogen which needs to be managed in the dairy shed effluent.

Phosphorus

Phosphorus, like nitrogen, is an essential plant nutrient. However, in conjunction with high nitrogen levels, high phosphorus concentrations in streams, lakes and dams can cause eutrophication and excessive algal growths. In particular, high phosphorus levels have been linked to the occurrence of potentially toxic cyanobacteria (blue-green algae) blooms throughout Australia over the past decade.

Phosphorus is much less mobile than nitrogen and is therefore less likely to enter water resources. Most soils have the ability to bind or adsorb phosphorus and retain it in the root zone until it can be used by plants. The ability of soils to adsorb phosphorus generally increases with the amount of clay and free lime in the soils. Sandy soils have a low capacity to store phosphorus, and are much more likely to leach phosphorus or allow phosphorus to move.

Most phosphorus is lost from soils by erosion as phosphorus adsorbed on soil particles.

The application of phosphorus in effluent should not exceed the capacity of the pasture or crop to assimilate it, plus a small allowance to increase soil phosphorus fertility levels according to the ability of the soil to store phosphorus. The number of years that the soil fertility build-up can occur will depend on your soil type.

Where phosphorus is the nutrient which seriously limits the rate at which the effluent can be spread, reducing the amount of phosphorus excreted by the cows can play an important role in managing your dairy effluent. Up to 70% of the phosphorus in the cows' ration could be excreted.

The phosphorus to calcium ratio in the ration should be checked to ensure that there is no imbalance. The inclusion of phosphorus supplements which are more available to the cows will reduce the amount of un-utilised phosphorus excreted.

The phosphorus levels in liquid effluent can be influenced by storage. In storage ponds 50–85% of phosphorus in effluent settles to the bottom. It is not available for land application by irrigation unless it is agitated for sludge removal.

Talk with your nutritionist about some means of reducing the amount of phosphorus excreted by your cows.

Potassium

Potassium is excreted mostly in an inorganic form in urine. It is soluble in water and immediately available to plants. In effluent storage ponds most potassium is found in the sludge layer.

Potassium is also an essential nutrient for plant growth and helps plants take up nitrogen. However, high levels of potassium, especially in combination with high nitrogen, can induce magnesium and calcium deficiencies in grass pastures. This can cause hypo-magnesia (grass tetany) in cattle and germination difficulties with crops.

Potassium can be lost by leaching. Excess potassium may also result in luxury uptake by plants. To avoid leaching and luxury uptake, applications of potassium should not exceed the amount which is required for the growth of pastures and crops. Frequent light applications are preferable to a single heavy application.

High levels of free potassium in soils have an effect similar to high salinity. High levels of potassium in soils can also degrade soil structure.

Nutrient Budgeting

A Nutrient Budget can be used to check the amounts of nitrogen, phosphorus and potassium applied to the land in effluent with what is being removed from the soil/plant environment through the removal of products e.g silage, hay, cereal grain, milk, or live weight gain.

So that a complete nitrogen budget is taken in to account, it is also necessary to consider the amount of nitrogen that is already stored in the soil profile and any nitrogen that may be lost in a gaseous form during the effluent application process. Once these amounts are determined, the amount of nitrogen added per hectare per year from all sources including effluent, can be calculated.

The maximum amount of phosphorus which should be applied in effluent should not exceed the amount which can be assimilated by the pasture or crop, with a small addition a amount to increase soil phosphorus levels according to the ability of the soil to store phosphorus.

Applications of potassium should not exceed the amount which is required for the growth of pastures and crops.

The Amount of Nutrients Removed in Products

Table 13.1 below shows the amount of nitrogen, phosphorus and potassium removed per tonne of dry matter for a range of agricultural products.

Table 13.1 Nutrients Removed in Agricultural Products

Product removed	Average DM	Nutrients removed (kg/tonne DM)		
		P	N	K
Cut Forage, Fescue	25%	3.7	24.0	22.0
Cut Forage, Lucerne	25%	2.9	28.8	25.0
Cut Forage, Oats	25%	2.0	27.2	20.0
Cut Forage, Ryegrass	21%	3.0	28.8	20.0
Hay, Barley	87%	2.7	14.4	14.0
Hay, Clover Dominant Pasture	88%	2.2	25.6	12.0
Hay, Grass Dominant Pasture	85%	3.0	22.4	16.0
Hay, Lucerne, early flower	88%	3.0	35.2	22.0
Hay, Lucerne, late flower	85%	2.0	24.0	25.0
Hay, Oaten	86%	3.2	15.2	16.7
Hay, Oats & Vetch	88%	3.0	22.6	16.7
Hay, Peas	90%	2.2	25.6	12.0
Hay, Ryegrass & Clover	83%	3.0	15.2	22.0
Livestock, Cow's Milk (per 1000 litres, at 3% protein)	#	1.1	6	1.9
Livestock, Cattle Liveweight Gain (per tonne)	#	8	60	4
Livestock, Sheep Liveweight Gain (per tonne)	#	5	20	2.5
Livestock, Wool (per tonne)	#	4	200	20
Lupins	92%	3.1	56.0	8.2
Potato tops	30%	0.2	3.0	2.0
Potato, tubers	23%	2.4	15.2	21.7
Silage, Grass Dominant Pasture	40%	3.0	22.4	16.0
Silage, Lucerne	40%	2.2	27.2	25.6
Silage, Maize	30%	3.1	12.8	15.4
Silage, Rye & Clover Pasture	35%	3.0	22.4	16.0

The Amount of Nitrogen Stored in the Soil.

Not all nitrogen is available to plants in the year of application. Some nitrogen is held in un-decomposed organic matter which needs to break down before it can be used by plants.

Approximately 60% of the nitrogen in effluent is available to plants in the first year. The remainder is carried over into year 2 (30% is available) and year 3 (the final 10% is available).

The amount of nitrogen carried over from these previous years needs to be accounted for in the nitrogen budget.

The amount of Nitrogen Lost as Gas

During and After Spreading

The amount of nitrogen lost as gas will depend on the method used to spread the effluent and whether it is incorporated into the soil quickly by additional irrigation or rainfall.

Effluent applied through a sprinkler system will lose approximately 25% of its N content by volatilisation. Losses when spreading by manure cart will be around 18% of total N.

About 25% of applied nitrogen can be lost after spreading unless it is immediately incorporated into the soil.

By Grazing Animals

Nitrogen is lost in the form of ammonia by grazing cattle. A dairy cow of 600 kg live-weight will emit around 0.120 kg of ammonia nitrogen per day.

The Amount of Phosphorus Stored in Soil

The ability of soils to store phosphorus is called the "Phosphorus Sorption Capacity" of the soil. The capacity of the soil to adsorb phosphorus depends on the concentration of iron and aluminium oxides. Soils with high clay content or high free-lime content tend to have the highest Sorption Capacities. For most soils, application of phosphorus up to $^{1}/_{3}$ of the Sorption Capacity for the soil will result in the soil sorption immobilising the phosphorus and preventing movement of phosphorus through the soil. Applications in excess of $^{1}/_{3}$ Sorption Capacity can exceed the capability of the soil to immobilise all the additional phosphorus and result in phosphorus movement in the soil. It is important not to exceed this level.

Table 13.2 shows the Phosphorus Sorption capacity for soil classes in South Australia.

Table 13.2 Phosphorus sorption of soil classes in South Australia

Class	P Sorption Capacity mg/kg soil	Soils
LOW	0–200	Deep sand, some podsols, sandy mallee, solodised solonetz
MODERATE	200–1000	Loamy mallee, sandy red brown earth, clay loams (most cereal-growing soils)
HIGH	1000–2000	Clayey red brown earth, dark brown cracking clay, calcareous loams, lateritic podsolic.
VERY HIGH	2000–4000	Kraznosems, peats, acid swamp soils, highly calcareous soils.

Table 13.2 provides a general guide to the range of Phosphorus Sorption Capacity of South Australian soils. More accurate estimation of the soil's Phosphorus Sorption Capacity can be made from table 13.3, which shows values for soils at a range of sites within South Australia.

Soil Phosphorus Sorption Capacity will change over time as a result of the use of phosphatic fertilisers or effluent containing phosphorus. Having the soil tested is the only means of determining what Phosphorus Sorption Capacity remains in the soil.

Table 13.3: Phosphorus sorption capacity of some South Australian soils

Soil Type	District	Texture	P Sorption Capacity mg/kg
Deep sand	Tintinara	Sand	5–14
Podsols: Ground-water Yellow Yellow Red Lateritic	 Wattle Range Mt Compass Myponga Flaxley Parndana	 Sand Drift sand Valley sand	 2 11 130–200 750–800 1000–1200
Solodised Solonetz	Cleve Lameroo Kybybolite Mt Compass Mt Compass	Sand Sand Sand Sand Clay Subsoil	22 9 130-370 210-250 2000-4000
Sandy Mallee	Wanbi Napperby	Sand Sand	30 140
Loamy mallee	Kimba Minnipa Roseworthy Caltowie Narridy Maitland	Loamy sand Loamy Sand Sandy Loam Sandy Loam Sandy Loam Loam	270 560 440-550 675 710 900
Grey calcareous mallee	Central Yorke Peninsula	Calcareous Loam	1670
Grey calcareous sand	Lower Yorke Peninsula	Calcareous Sand	3575
Red Brown Earth Sandy Sandy Sandy Loamy Lateritic Clayey	 Cleve Ungarra Riverton Booleroo Cockaleechie Turretfield	 Gravelly sand Sandy Loam Sandy Loam Loam Loamy Sand Clay Loam	 175 310 445 401 800 1670
Dark Brown Cracking Clay	Manoora Salter Springs	Clay Loam Clay Loam	1000 1120
Ground-water rendzina	Furner Struan	Clay Clay	670 1000
Alluvial Clay	Long Flat	Clay	3330
Volcanic	Mt. Gambier	Silty Loam	1330
Terra Rossa	Coonawarra	Loam	1160
Krasnozem	Glencoe	Clay Loam	4000
Peat	Eight Mile Creek	Peat	2860

(From Primary Industries & Resources SA)

Developing the Nutrient Budget

A nutrient budget spreadsheet model is available from the Technical Service Consultant for the Dairy Effluent Project, or your milk company field officer. Refer to Guideline 19 for contact details.

If you are unable to access or run the model for yourself they will be able to run your data for you.

To run the Nutrient Budget Model

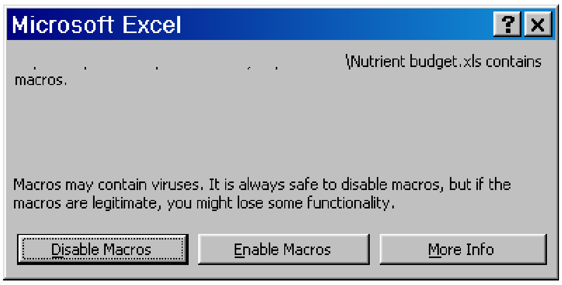
The spreadsheet model is written in Excel and requires Microsoft® Windows 2000, XP or later running Microsoft® Excel 2000 or later.

The model is supplied on CD-ROM. You should create a folder called "Nutrient Budget" on the hard drive of your computer, and copy the model to this folder. There are two ways in which to run the Nitrogen Budget Model on your computer. Choose the method that you are most familiar with.

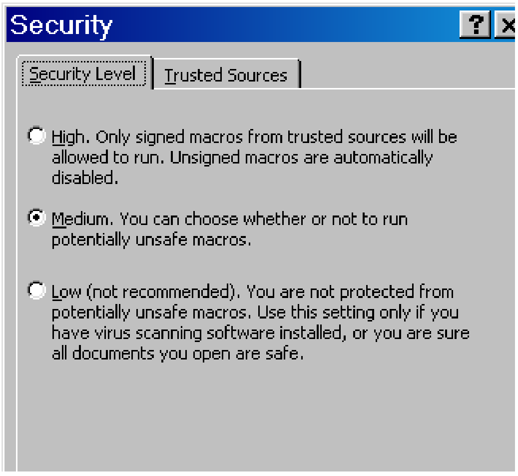
You can either:-

1. Navigate in Microsoft Explorer to the "Nutrient Budget" folder, and double click the ***"Nutrient budget.xls"*** file **OR**
2. Select File, then Open, ***"Nitrogen budget.xls"*** in Excel to open the model.

As the program is opening, a message will appear.



You must click **"Enable Macros"** (or the model will not run). If the model opens without giving you the option to enabled macros you probably need to set your macro security level to medium. Close the Nutrient Budget model, and in Excel click on "Tools", "Macro", "Security", and click the bullet button against "Medium".



Re-open the Nutrient Budget model.

The model should open at the menu screen.

The menu is used to select the aspects that need to be calculated for your effluent management system.

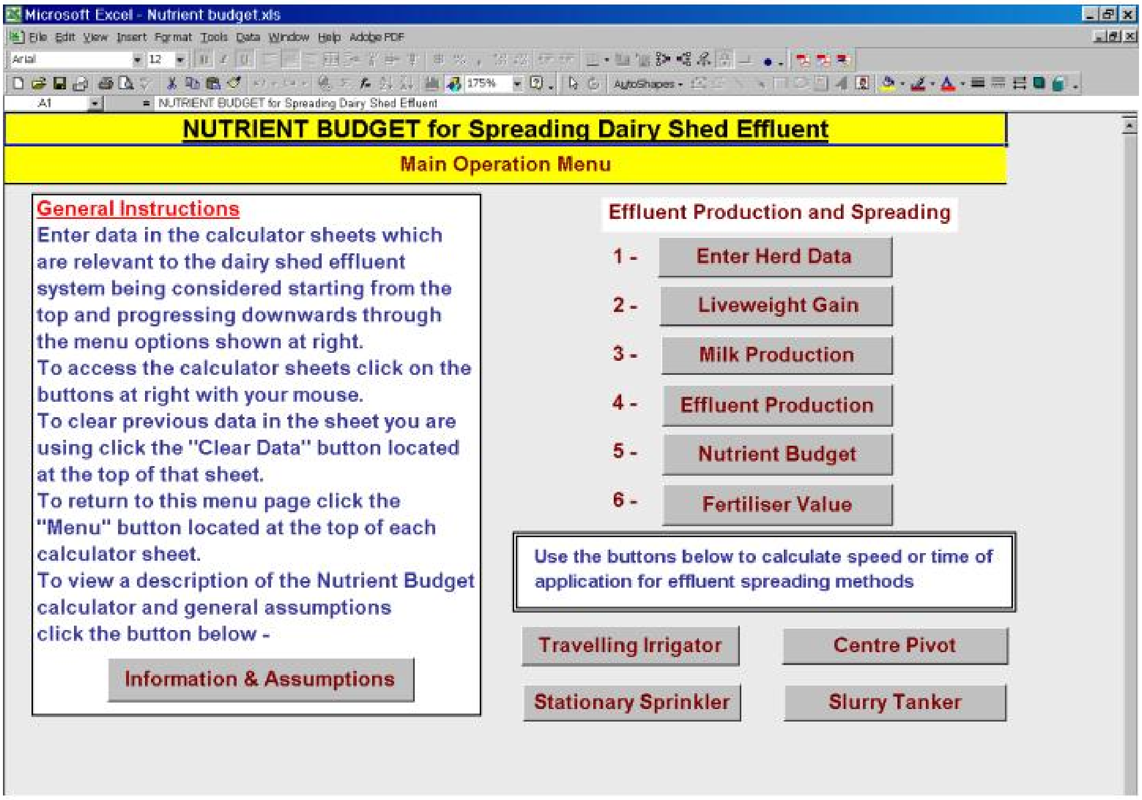
The options include calculating the amount of:-

- Live weight gain from your effluent utilisation area and milk produced.
- The nutrient budget, including maximum application rates.
- The estimated composition of effluent leaving the dairy shed (This can be used by the model where the actual composition of effluent is not known).
- The value of the nutrients as fertiliser.

- The speed at which a travelling irrigator needs to move to apply the target application.
- How long a stationary sprinkler should say on one spot to reach the target application.
- How long a run is required by a slurry tanker/waste spreader to apply the target application.
- The speed of rotation of a centre pivot irrigator and the number of rotations, to apply the target application.

The main menu screen layout is shown below. To make a selection, click on the button of choice.

You will be prompted on each screen for the information required to calculate the various aspects of the Nitrogen Budget. For more information on the data required for each input sheet click the "Details" button.



The Main Menu Screen Layout for the Nutrient Budget Model.

Assistance with the calculations

If you are unable to run this spreadsheet model, contact the Technical Service consultant for the Dairy Effluent project, your dairy field officer, or your dairy consultant who may be able to assist with processing your data. Refer to Guideline 19 for contact details.