Effluent Technical Note

Dairy Effluent Treatment Systems

Farm dairy effluent is a valuable resource which, when managed well, can increase pasture production and reduce fertiliser costs. There are a range of storage and irrigation options for farmers which can be tailored to suit farm topography, soil type and the management system operating on-farm.

However, there are several companies developing dairy effluent treatment systems that they believe will offer options for farmers, but these need to be carefully evaluated. These systems may employ a range of different technologies to remove the nutrients from the dairy effluent with the intention to reuse the 'treated' effluent back into the farming system or possibly discharge it to waterways.

1. In brief

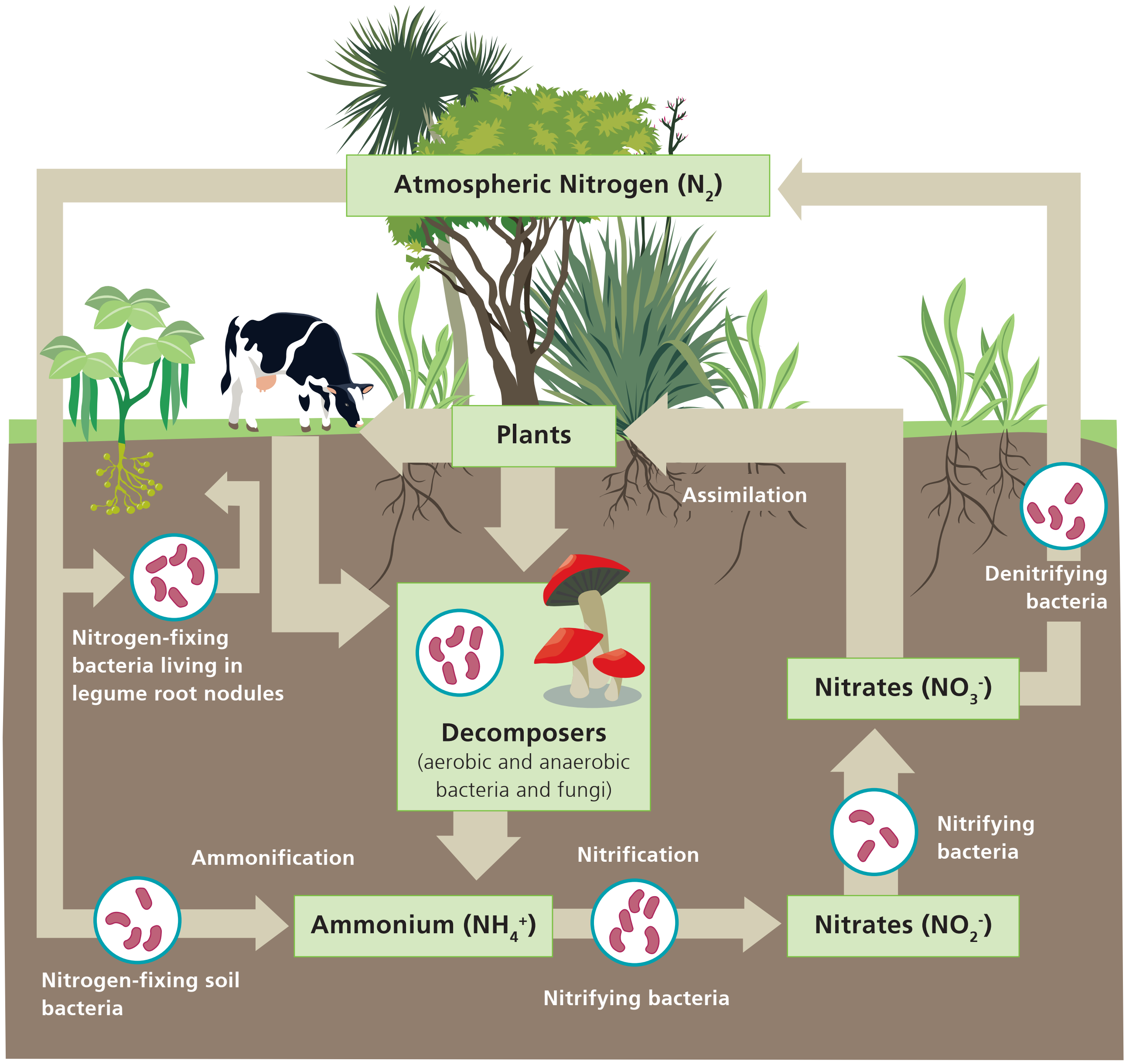
This document provides a summary of relevant technical information as well as regulatory requirements that all parties need to consider before embarking on such a system. Topics include:

- Treatment processes
- Getting a discharge consent
- Regulatory information for food safety
- Stock drinking water
- Spreading treated material onto grazing paddocks
- Dairy effluent volumes on a farm
- Nutrients from farm dairy effluent
- Barriers to new technology
- Comparison in costs to municipal treatment processes
- Validation methodology
- Decision processes around new dairy effluent treatment technologies.

2. Treatment processes

The dairy industry is increasingly moving away from two-pond 'treatment' systems which do little more than settle solids (remove carbon) and enhance gaseous removal of nitrogen. These two-pond systems often discharge nutrients to waterways in regions where this practice is accepted by the regional authority. They do not require detailed discharge testing to the level required by a town municipal system and/or they discharge into river systems that transfer the nutrients to the sea.

When dairy effluent is applied to land, a series of processes occur in the soil when bacteria and fungi produce nitrogen compounds including nitrates which plants absorb as shown below.



Wastewater treatment plants effectively mimic these biological systems to methodically remove nutrients from the influent coming into the treatment plant and enable the discharge of treated water to a standard consented by the regional authority. The extent of nutrient removal depends upon the type of treatment process selected, its configuration, and stability of operation.

Nutrient removal involves a series of transformations and higher rate treatment plants (more sophisticated than simple two-pond systems) which are designed to provide environmental conditions to enable the selection of the right microbes which need a lot of air and energy. These often cycle between anoxic and aerobic phases with clarification systems towards the end of the process. For the removal of phosphorus, biological or chemical processes may be used.

3. New dairy effluent treatment technology – getting it right

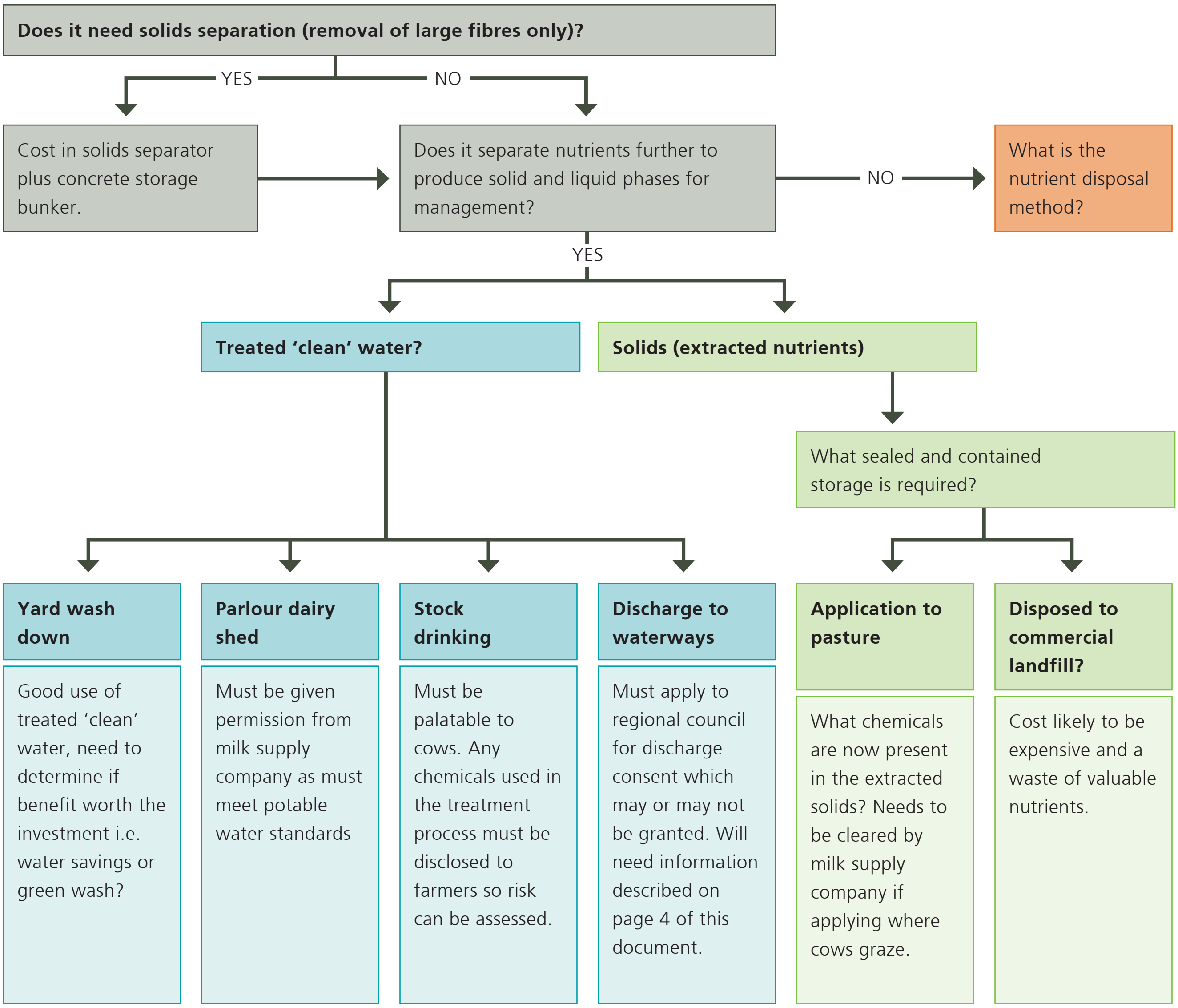
When making such a major financial decision, it's important to carefully weigh up all the available information before choosing a dairy effluent treatment system. Treated 'clean' water and extracted solids have more regulatory requirements than stored and land applied effluent.

The effluent treatment system must have been validated for at least one full dairy season as dairy effluent has some challenging properties related to fibrous material (digested grass and hair) that can block filters - plus it has a nutrient loading generally much higher than human sewage. It also can be quite variable throughout the year in volume and nutrient loading due to pasture growth and the timing of supplementary feeding.

It's important that the target technology is proven in the context in which you want to use it, and that various other expenses like staffing levels and operational costs are considered before purchase.

Farmers may be keen to try/buy this new technology but it is important to remember that there are other parties who have an interest in what happens on-farm, such as regional councils and milk supply companies.

Follow the decision tree below for a summary of considerations:



**Note this figure does not include the liquid irrigation to land as there is little value in stripping nutrients from dairy effluent only to irrigate the 'treated' water with its associated energy and staff costs.*

4. Regulatory requirements for discharging treated effluent

Getting a discharge consent

Operators of a wastewater treatment plant (whatever the size of the town or industry) must apply to their regional authority for a discharge consent if they wish to discharge treated water from the plant. Discharging 'treated' effluent to waterways in most council regions is a discretionary activity which allows consent conditions to be set on a case-by-case basis. Consent may or may not be granted for this activity. The same rules are likely to apply for treated dairy effluent.

The dairy industry is facing some challenging nitrogen limits in some regions. Almost all consents granted will have an on-going requirement for monitoring by the regional council. Self-monitoring or independent monitoring is likely to be determined on the degree of testing already available for the proposed technology.

Note that direct discharges to waterways are generally a less accepted practice, even with high treatment quality, and that national policy is directing regional councils across the country to maintain or improve New Zealand's water quality.

The contaminants of concern (from a fresh water quality perspective) are:

- Nutrients (High concentrations of Nitrogen and Phosphorus cause excess algae growth)
- Pathogens (present in faeces and have health impacts)
- Ammonia (toxic to fish and aquatic animals)
- Suspended solids (solids in waterways block light and increase turbidity)
- Biochemical oxygen demand (BOD) (measure of the level of organic, carbon based pollutant present and hence how much oxygen is needed to break down organic material-hence reduces the dissolved oxygen in the waterway)

An Assessment of environmental effects (AEE) will likely be required as part of the consent applications for dairy treated effluent and includes:

- Design and performance of the treatment system
    - Treated wastewater quality
    - Design parameters
- Receiving environment assessment
    - Current state
    - Values: recreation, cultural, water supplies, fisheries
    - Dilution/assimilative capacity locally and at catchment level
    - Cumulative effects, catchment level
- Mitigation assessment
    - Degree of treatment
    - Land disposal
    - Stream fencing
    - Riparian planting
    - Waste reduction and diversion/recycling measures.

Discharge parameters

An analysis of a range of consents for municipal waste water treatment plants is shown below (these were from 17 consents grouped into three categories; high, medium and low). This table gives an indication of the range of discharge parameters that regional councils have granted for human treated effluent.

	$cBOD_5$	NHs/NH_4+	TN (Total Nitrogen)	TSS (Total suspended solids)	TP (Total Phosphorus)	DRP (Dissolved Reactive Phosphorus)	FC/E.coli
	g/m^3	g/m^3	g/m^3	g/m^3	g/m^3	g/m^3	Cfu/100 ml
High	31-80	16-50	21-35	51+	6-15	4.1-6.5	6001+
Medium	13-30	6-15	8-20	31-50	3-5	1.1-4	101-6,000
Low	2-12	0-5	2-7	15-30	0.5-2	0.06-1	0-100
Raw Municipal*	300	38	55	350	10		10,000,000
Raw Dairy Shed*			250-500	1500	40		

The 'High' category represents the old two-pond municipal systems found in small towns; 'Medium' is where some improvement has been made to the secondary process, and 'Low' is where contemporary treatment plants limits are likely to be set, and available technology employed to the greatest economically sustainable extent.

The 'High' represent roughly a 97% reduction in nutrients and 'Low' roughly a 99.5% reduction.

It is very likely that treated dairy effluent may be required to meet the low levels displayed above.

*Information on the starting material for raw municipal and raw dairy shed effluent is shown in the table above for the few parameters reported. Dairy shed effluent has considerably higher loadings than human sewage. The raw dairy shed figure is based on only a couple of farms so more data is required.

Solids handling

Discharges of sludges from activated sludge processes for municipal waste water treatment plants to land may or may not be a permitted activity (check with regional council) otherwise they are a controlled or discretionary activity depending on the grade of sludge.

Dairy effluent solids from desludging of ponds, feed pad and stand-off material and solid separation in some regions is a permitted activity (as long as less than a particular loading rate eg 150 kg/N/ha/year) or a consent is required which is likely to cover loading rate per hectare and may have other requirements around timing of spreading, area required and placement on the farm.

5. Regulatory information for food safety

Milk supply companies that purchase milk from a farm (as part of their supply agreement) are increasingly requiring more information around on-farm technologies and chemicals used on-farm that could possibly end up in milk products. With increasingly sophisticated testing technologies used in overseas markets, extra scrutiny will be exercised around any treatment process used to remove nutrients from dairy effluent.

The Ministry of Primary Industries has developed NZCP1: Code of Practice for the Design and Operation of Farm Dairies and milk supply companies must ensure that the dairy farms that they collect from are compliant.

foodsafety.govt.nz/elibrary/industry/dairy-nzcp1-design-code-of-practice/index.htm

This code covers chemical approvals, chemical storage, dairy hygiene and effluent management. Examples for dairy effluent include:

Water recovered from the farm dairy effluent system must not be used within the farm dairy except to clean the dairy yard, in which case:

- the system operates at low pressure, with no detectable mist or aerosol;
- the water recovery system is of a design that will consistently deliver water that does not contain excessive sediment or offensive odours and is acceptable to the farm dairy assessor;
- the system must be of fixed design and must not include hand held hoses;
- if pumped, the delivery outlet is to be fixed at no more than 300mm above the yard surface;
- the system must be completely separate from the fresh water wash down system;
- the yard is of concrete construction with no surface cover, and rinsed with clear water if necessary to remove any residual sediment;
- the activity does not have a negative impact on the hygiene status of the milking plant, milking and milk storage environment, water used in the milking area, the cleanliness of milking animal teats and udders, or any other thing that might to lead to contamination of the milk; the raw milk is not intended for the manufacture of unpasteurised dairy products.

Water used in the farm dairy is usually from bores, surface water take or, in some instances, from town supply. The requirements of water quality from such sources are assessed under

New Zealand Food Safety DPF 201 – *Assessment of Farm Dairy Water Status* which is a systematic risk assessment framework of water quality essentially addressing whether these three parameters have been met:

(a) Does the water meet the turbidity/clarity standard? ie not exceed 5 NTU

(b) Does the water meet the E. coli standard? ie be free of E.coli (absent in 100 ml)

(c) Have any risks to the water supply been identified?

foodsafety.govt.nz/elibrary/industry/201-assessment-farm-forms/

Just because a treatment technology can meet the parameters of the turbity, clarity and E.coli standards does not mean it can be used in the farm dairy. As NZCP1 states:

'Effluent, wastewater and water recovered from the farm dairy effluent system must not be used for any purpose in or near any part of the farm dairy other than the yard unless it has been treated to meet potable water standards'.

Potable water standards are defined as New Zealand Drinking Water Standards.

health.govt.nz/publication/drinking-water-standards-new-zealand-2005-revised-2008

It is essential that a farmer checks with the milk supply company to find out their exact requirements before using treated effluent in the farm dairy.

Storage of goods

Storage of chemicals used in any treatment process must meet the following requirements:

- The milk storage area must be used only for the storage of equipment required for the milking process, milk cooling, refrigeration and cleaning.
- Stores such as those required for the operation, maintenance and cleaning of the milking plant and premises may be kept in the milk receiving room or combined receiving/storage room if an appropriate storage facility is provided.
- Only pesticides registered for use in the farm dairy or for use on milking animals may be kept in the storage area.
- All other goods must be stored in an area separate from the farm dairy.
- Chemical preparation and storage (pesticides and other chemicals not approved for use in the farm dairy) must be greater than 20 metres from the farm dairy.

6. Stock drinking water

There are no real standards for stock drinking water apart from the water being palatable and not causing animal welfare issues. Stock will refuse water and/or reduce intake if they find the water unpalatable.

If planning on using treated 'clean' water for stock drinking water then any chemicals used in the dairy treatment process must be declared to the dairy farmer so they know the risk they are taking. Contingency plans should be in place if a breakdown occurs in the treatment process so this water is not used by stock.

There is also a risk of public perception of cows drinking recycled effluent, especially if going through a recycling process with unknown chemicals and/or unknown monitoring of the stock drinking water quality.

7. Spreading treated material onto grazing paddocks

If spreading any solid effluent material collected after the treatment process onto pasture that is then eaten by cows; then any chemicals used must be declared to the farmer. It is also likely that the milk supply company may request more information on the chemicals used as per the last bullet point below. Even if spread onto a maize paddock (or other crops) or cut and carry operation a farmer must know what chemicals are present in this solid material (eg if aluminium or ferric chloride or other chemicals are used to remove phosphorus).

Dairy farmers are likely to be concerned over potassium loadings in any liquid or solid portion applied back to land as this can have an effect on animal health.

Many of the milk supply companies have supplier handbooks which specify requirements. An example relevant to animal feed is from Fonterra 4.12 which states:

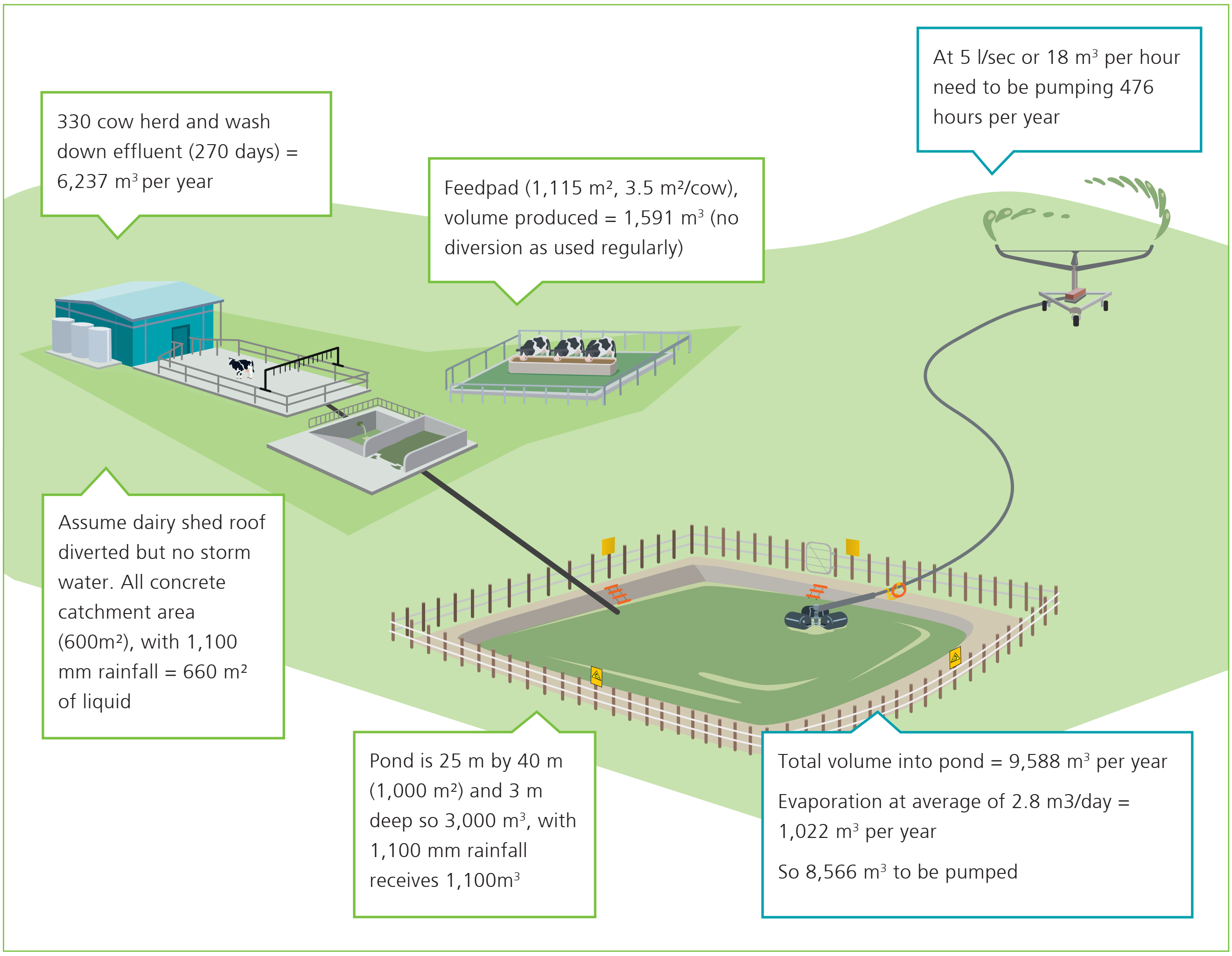
You must not feed any material to your animals that:

- may contaminate milk with toxins, residues or any other harmful substance;
- contains ruminant protein;
- was grown on land irrigated or treated with meat waste;

- was grown on land irrigated or treated with human waste water which has not been treated in accordance with the "Californian Standard – title 22" (available from the Food Safety or Sustainable Dairying Teams);
- was grown on land treated with sewage sludge derived from the treatment of human waste; or
- was grown or harvested on land used for land farming i.e. where petrol chemical exploration drilling waste has been reincorporated into soil.
- any waste applied to land where your animals feed must be declared at the time of your Farm Dairy and Environmental Assessment. Depending on the type of waste, milk supply companies may require, and you must provide, further information in order to assess any food safety risk.

8. Dairy effluent volumes on-farm

It's useful to consider the sources of dairy effluent volumes that are captured, stored and then irrigated. Average volumes from a Waikato dairy farm are shown in the example below.



**Note any additional areas such as drainage from stand-off pad, solid separation and solids bunkers, and tanker apron if draining into the effluent storage must be added to the total volume captured in a year (based on catchment size and the annual rainfall).*

***The farm dairy and the yard wash down (which was based on an average of 70L per cow per day) is around 66% of the total volume captured. Breakdown of this into the parlour and the yard water-use is approximately 35:65 so yard wash is then around 4,054m3 or 43% of 'captured effluent' (includes rainfall on all areas) to storage.*

**** It was assumed that the feed pad was dry-scraped and either green wash or rainfall used to clean feed pad.*

9. Nutrients from farm dairy effluent

The nutrient content of dairy effluent is highly variable therefore any treatment technology must be able to cope with this.

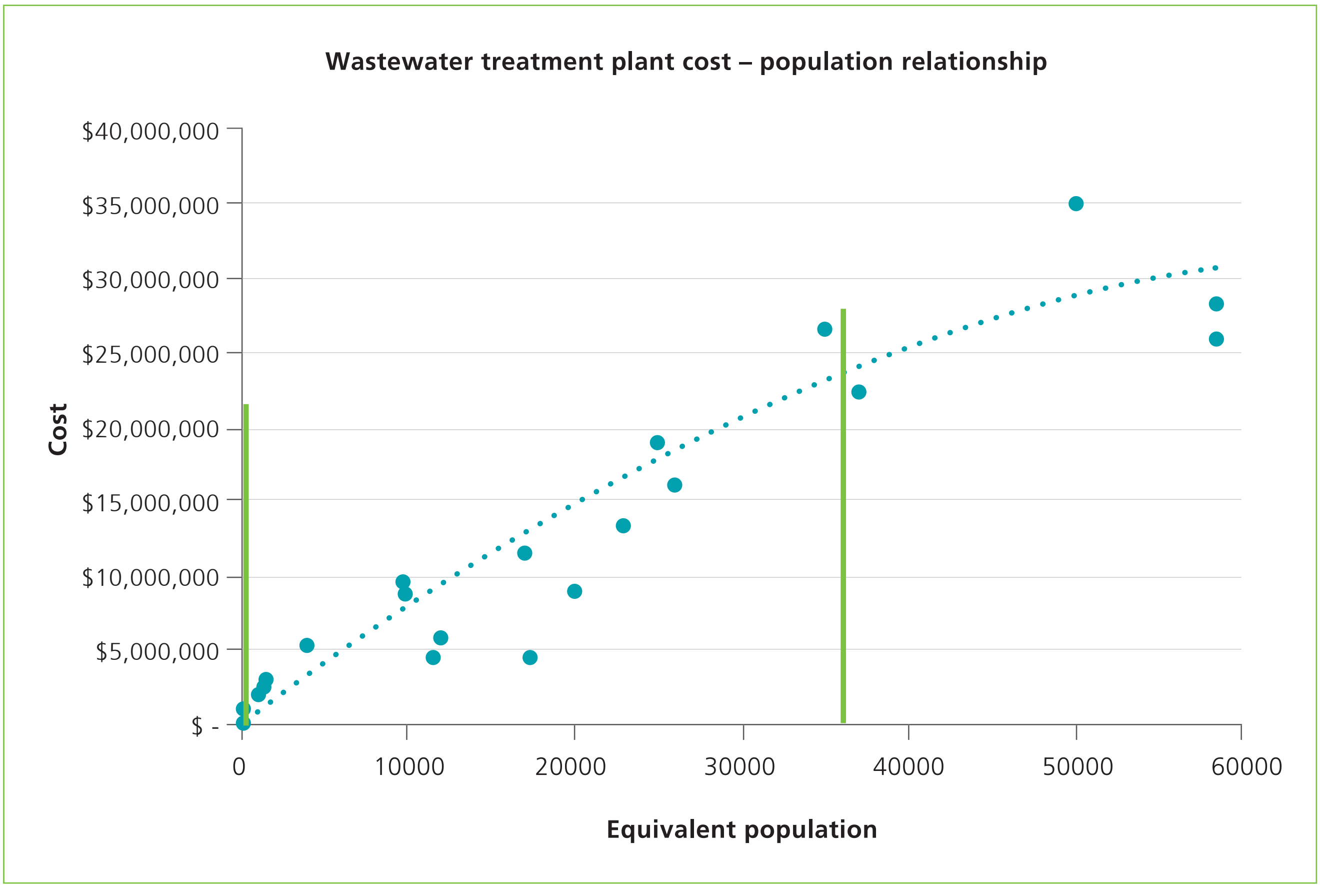
For example a Waikato herd of 328 cows, with imported supplements (1.34 t DM/ha), some silage (30 t DM), 268 days in milk and 929 kg MS/ha produced and just capturing yard wash down; the effluent captured has a nutrient value content of around 2,240 kg Nitrogen and 224 kg Phosphorus per year.

If using a Canterbury example of a 775 cow herd with two hours a day on a feed pad plus increased supplementary feed, the figure is now heading towards 12,000 kg Nitrogen captured per year which must be managed. This is approaching the equivalent of a small town municipal system in terms of nutrient loading.

10. Comparison in costs to municipal treatment processes

Companies may claim they can produce treated 'clean' water from dairy effluent but it's useful to consider the comparison with the costs of municipal treatment processes and what they spend to get to this same water quality.

As shown below, a treatment plant to cater for a very large 3,000 cow herd with all effluent captured would cost around $22 million in capital and design costs for a waste water treatment process of a similar standard to a municipal system. A system for a 300 cow herd with just 10% of effluent captured, would probably cost around $800K.



One cow is generally equivalent to around 12-13 people (in terms of N & P content in effluent) or 1.2–1.3 persons if just considering the yard (ie just 10% of effluent captured and rest of the time on pasture).

Therefore it's useful to compare the likely costs of treatment systems especially if herd sizes increase and if it becomes necessary to capture increasing amounts of dairy effluent with off-paddock infrastructure.

11. Barriers to new technology

New technologies often have a high bar to get over to be accepted in the market, so a commercial company often needs to make a significant investment in research and development. In particular, it is essential that the company exercises considerable effort carrying out validation trials over a reasonable period to prove that the technology works.

The information that should be considered is:

- Proof of concept; what science is there to show how it works (published science papers, pilot trial data)
- Proof of robustness (where has it been used, scale of operation and for how long)
- Level of complexity (instrumentation, trained operator cost)
- Legal constraints of consent compliance
- Cost
  - Capital costs
  - Energy costs to run the system
  - Staffing and skill level required to operate
  - Consumables and supply times
  - Guarantees/warranties
  - Servicing and equipment repairs
  - Emergency call outs
  - Ease of disposal of consumables eg filter cartridges
  - Ease and cost of disposal of residuals such as sludge

12. Validation methodology

Ideally a new technology should have been tested over 2-3 dairy seasons but at least one year's worth of data is a minimum requirement to validate a new technology.

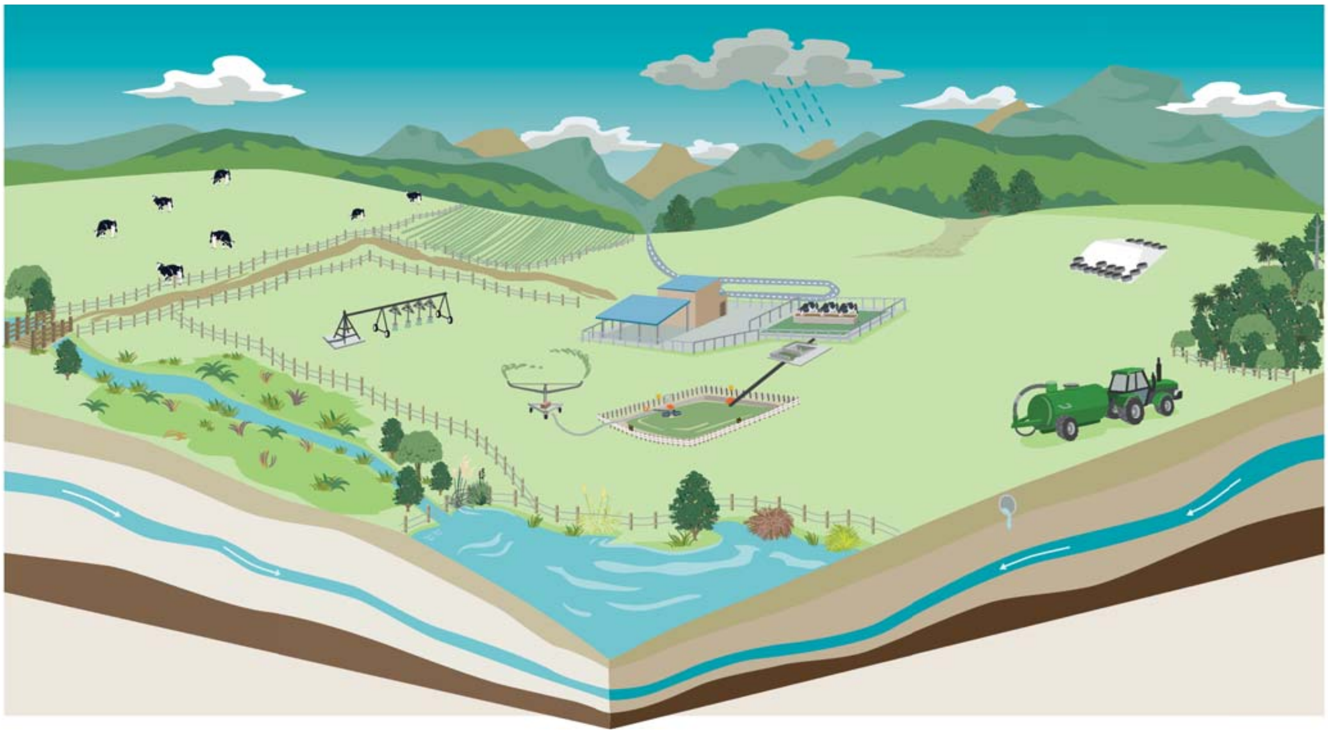
- Information should be collected for the parameters of Biochemical Oxygen Demand (BOD5), Total Suspended Solids (TSS), Total Nitrogen (TN), Ammonia, Total Phosphorus (TP), Dissolved Reactive Phosphorus (DRP) and E.coli
- Samples of treated effluent should be collected weekly (and there should be independent third parties collecting samples on some occasions)
- Validation process should include the period of stop and start for dairy season (ie from drying off to calving)
- The validation process should include one milk contamination dumped into the system (minimum amount of one milking) to assess its ability to manage this. Expect farmers to have one incidence per year where 'bad' milk must be disposed of
- Also include one week breakdown test mid-season (ie stop for one week and then start up again to simulate an equipment failure)
- Tests also need to measure the ability (speed and size) of the system to respond to peak loading conditions.

13. To summarise

The dairy industry is facing some challenging nitrogen limits in some regions of New Zealand and exploration of nutrient reduction technology may be of interest, particularly for intensive systems or larger herds.

It is worth noting that any nitrogen stripping from effluent using a new technology must then be incorporated into Overseer Nutrient Budgets (the national applied farm systems model used for assessing nitrogen leaching). This is likely to require significant research validation trials before Overseer would be amended to include such a new technology as a Nitrogen reduction tool.

It's also important to note that farm dairy effluent, although very visible and can be a point source discharge to waterways if not managed well, is only part of the whole farm nutrient loss so it's important to look at effluent management in the context of the whole farm.



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