

Effluent Management for Large Herds

Guideline No 14.



Effluent systems that are designed for small herds cannot simply be made bigger to cater for larger herds. Issues associated with larger cow numbers, length of time the cows are at the dairy and greater volumes of water required to wash down yards and shed cleaning, all contribute to an overall increase in the amount of effluent that is produced at the dairy.

Management of dairy effluent from large herds can be improved by focusing on :-

- 1. Reducing the amount of effluent by reducing water use*
- 2. Reducing the amount of odour produced through solids management*
- 3. Treatment of the effluent so that it can be irrigated through existing irrigation systems*

Compared to smaller herds, large herds deposit more wastes and nutrients at the dairy, yard and shed cleaning use more water, and create a larger waste volume. Setting up to manage the wastes produced is not simply a matter of making things bigger!

Big ponds are more difficult to clean out. If large storages are required consider more than one pond in series, with each pond of a size which is easier to pump out and de-sludge.

The most confronting issue with effluent management of large herds is managing the huge amount of effluent produced. Dairy shed effluent will produce some odour and the more effluent there is, the more odour that is produced. Odours are generated mainly from decomposing solids in the effluent – the so-called volatile solids.

Managing dairy effluent from large herds can be approached by focusing on two main issues:-

1. Reducing the amount of effluent by reducing water use.

Limiting the water use at the dairy and using recycled effluent for yard wash down will reduce the total amount of effluent which has to be handled and reduce the size of the wet weather storage which will be required over the winter period. This can save many thousands of dollars in pond construction costs and reduce the costs of pumping and annual costs associated with spreading the effluent.

2. Reducing the amount of odour produced by:-

- Separating solids from the effluent early in the waste management system, or
- Treatment of solids in a deep properly designed anaerobic pond, or
- Trapping solids in a “solids pond or trench” which operates as an anaerobic sludge pond with a surface crust.

1. Reducing the Amount of Effluent by Reducing Water Use

The first step in reducing the amount of effluent is to try to limit the amount of fresh water that is used at the dairy. It is also important to limit or eliminate the amount of stormwater that enters the effluent stream.

Limiting the use of fresh water and diverting stormwater are both important in minimising the size of the effluent storage ponds that are required for winter storage when it is too wet to irrigate effluent onto pastures.

Most large herds are milked on rotary platforms, with fresh water being used at the dairy for the following:

- Cup sprays
- Platform sprays
- Plate coolers
- Shed wash-down
- Machine wash-down
- Yard wash-down

Reducing the amount of fresh water used in many of these areas in the dairy will have a large impact on the amount of effluent produced.

Reducing Fresh Water Use – Cup Sprays

Although the flow rates for cup sprays are not usually high they are often running for the whole milking. At a flow rate of 30 litres per minute they will keep the cups clean but use 10,800 litres per day, for six hours of milking.

Reducing the flow rate to 10 – 15 litres per minute using a fine spray will prevent manure sticking to the cups and reduce fresh water use to 3,500 – 5,250 litres.

On the last rotation the flow rate can be turned on full to 70–80 litres per minute, which will wash the cups. This rotation is usually about 10 minutes and uses 700–800 litres of water. The net effect is a reduction from 10,800 litres per day to between 4,200 and 6,050 litres. This strategy will reduce water use over six months by at least 855,000 litres.

Reducing Fresh Water Use – Platform Sprays

Platform sprays keep the rotary platform clean during milking. They are often run for the whole milking using about 60 litres per minute, which amounts to 21,600 litres per day for six hours milking. However, unless there is manure that must be removed, the platform sprays can be left off until the last rotation, when they can be turned on full.

They will use about 80 litres per minute for the 10 minutes of the last rotation, or 1600 litres per day, which is a reduction of 20,000 litres per day.

When this saving is combined with the saving from operation of the cup sprays, the reduction in water use over six months is **4.6 megalitres**, which is equivalent to an effluent pond 50x45x3 metres deep.

Reducing Fresh Water Use – Plate Coolers

Plate coolers operate most efficiently at a water to milk ratio of 2.5–3.0:1. A herd producing 20,000 litres per day will use 50,000 litres of water at a ratio of 2.5:1.

The plate cooler water can be used for a number of things after passing through the plate cooler.

- It can be recycled through a water cooling system for re-use in the plate cooler e.g. a cooling tower system.
- It can be stored for wash-down.
- Water in excess of wash-down requirements can be used for a stock water supply.
- It can run direct to the effluent management system.
- Combinations of all of these suggestions can be used.

Plate cooler water must be good quality fresh water and is often sourced from a bore. It is a good idea to keep the amount going into the effluent stream as low as possible. Recycling of pond effluent to a flood wash tank will dramatically reduce the amount of fresh water used for wash-down at the dairy and allow the plate cooler water to be used in other areas.

Plate cooler water can be eliminated. The plate cooler can be replaced by a refrigerated shell and tube heat exchanger which uses refrigeration technology and glycol to rapidly cool milk to 4°C. This will remove all the plate cooler water from the effluent stream. Contact a refrigeration engineer for details of how this system operates.

Reducing Fresh Water Use – Shed Wash-down

Shed wash down is typically done with hand held hoses with high flow rates – about 300 litres per minute. The volume of water applied tends to move the manure by its depth and momentum.

Restricting the hose outlet using twist type nozzles can increase the velocity of the water, which enhances its ability to transport manure. At the same time, it reduces the water flow rate from the hose by one third to one half.

Flow rates of this nature are unlikely to cause excessive spatter during wash down. Provided that the wash-down of the shed takes no longer, there is a potential saving of 3,000 to 4,500 litres per day for a 30-minute per day wash-down.

Reducing Fresh Water Use – Yard Wash-down

Using twist type nozzles on yard hoses can reduce water use in yard wash-down as described in the section on shed wash-down.

A reduction in the amount of water used in yard wash-down can also be achieved through recycling of effluent from the second pond, of a two-pond effluent storage system.

This will reduce the amount of fresh water used at the dairy by as much as 50%. The continual recycling of effluent for wash-down will result in a more concentrated effluent. As the effluent becomes more concentrated a chemical called Struvite may form in pipes and fittings.

Struvite Control

Struvite is a chemical compound called magnesium ammonium phosphate. When it precipitates in pipes and pumps it can cause problems.

If effluent is continually recycled with little input of fresh water the salts in the effluent accumulate and can precipitate if conditions are right. The main factors which promote precipitation are:-

- pH 7 (normal for effluent). Acid conditions (pH 4) prevent the crystals from precipitating.

- Rough interior pipe surfaces
- Metal components. Plastic components are not immune to build up but are less affected than metals.
- Turbulence. Crystals accumulate where there is turbulence in the water flow so this means around valves, joins, bends and the pump. Turbulence is affected by pump size, pipe size and fittings.

Struvite precipitation can be avoided by:-

- Dilution of the effluent with fresh water. The percentage of fresh water which needs to be added is still uncertain. Problems can still occur with 15 – 20% fresh water inflow into the effluent stream. Check the salinity of the final effluent pond and try to keep it below 3000 ppm.
- Empty the final pond each year so that a long term build-up of salt is avoided
- Match the pump to the pipe size and flow velocity to avoid turbulence. Keep the velocity of flow less than 1.5 m/s and keep the number of fittings in the effluent line to a minimum.
- Use PVC or polyethylene piping rather than galvanised steel
- If struvite builds up either recirculate acid to dissolve it, or replace the pipes. Take care with acid. 1 part hydrochloric acid to 9 parts water is effective, but will corrode metal pipes and fittings.

Reducing Water Use And The Effect On Effluent Spreading

Limiting the water use at the dairy and using recycled effluent for yard wash-down will reduce the amount of effluent which has to be handled and also reduce the size of the wet weather storage required over the winter period.

This can save many thousands of dollars in pond construction costs and reduce the annual costs of pumping and spreading the effluent.

The amount of effluent that can be spread per hectare can be checked by running the Nutrient Budget model (**Refer to *Guideline No. 13 – Nutrient Budgeting for Land Spreading***).

Implementing water saving techniques, such as effluent recycling, will result in a reduction in the volume of effluent but will not reduce the area required for effluent spreading. This is due to the effluent becoming more concentrated. If insufficient area is available, removing nutrients from the effluent can reduce the area required for effluent spreading.

How can nutrients be removed from the effluent?

Nutrients can be removed from the effluent by separating solids from the effluent stream, or allowing them to decompose or separate in the storage ponds.

Removal of solids from the effluent can be done by:

- a) **The use of mechanical solids separators, gravity settling systems, and slurry trenches.** The separated solids can be used as fertiliser on other areas of the farm. (**Refer to *Guideline. 7 : Solids Separation Systems***).
- b) **Anaerobic digestion of effluent before passing to an aerobic storage pond.** Anaerobic digestion will reduce the amount of solids, and reduce the amount of nutrients, particularly nitrogen, in the effluent. The sludge and crust will need to be removed from the anaerobic pond after several years, and can be used as fertiliser on other areas of the farm. If necessary it can be moved off-farm.

- c) **Extending storage times to allow breakdown of organic nitrogen and its release as gases.** This process also reduces the number of pathogens in the effluent, but requires a larger storage volume. Extended storage can also decrease the amount of phosphorus and potassium in the liquid effluent as both tend to settle into the sludge layer.

Reduction of nitrogen can also be achieved during spreading by using a spreading system that results in higher volatilisation of nitrogen.

(Refer to section “The Amount of Nitrogen Lost as a Gas” in Guideline No. 13 : Nutrient Budgeting for Land Spreading).

2. Reducing the Amount of Odour Through the Removal Of Solids from Large Herd Effluent

Compared to smaller herds, large herds generally require different management systems to remove solids. Systems that are designed and operate successfully for smaller herds cannot simply be scaled up and used for large herds. This is due to difficulties in handling the increased volumes of effluent and wet solids. Wet solids in particular are difficult to handle in large quantities – and with large herds large quantities are produced daily.

Removal of solids from large herd effluent can be achieved through mechanical or gravity separation, or both.

a) Mechanical Separation

There are many different types of solids separation machines designed to remove solids from effluent streams (**Refer to Guideline 7 – Solids Separation Systems**). The main types which have been used for dairy shed effluent are the **stationary run-down screen** and the **screw press**.

The **stationary screen** is capable of removing up to 65% of solids but has the drawback of becoming clogged with biological slime, which reduces its effectiveness. It requires regular cleaning to maintain its efficiency. More recently self cleaning screens have been developed (the “Wedge Wire” screen and the “Baleen Filter”) which alleviates blockages.

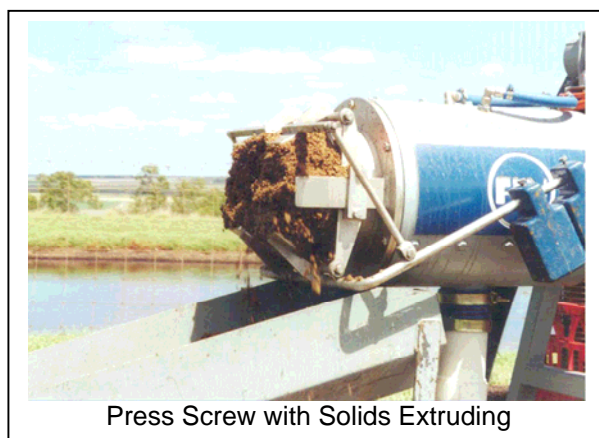
The **screw press** can remove up to 80% of the solids in dairy effluent, depending on the screen aperture size, and requires very little power to operate it.

The screw press can process up to 45 cubic metres of effluent per hour. Throughput of the separator can be adjusted by altering the amount of moisture retained in the separated solids, or changing the screen aperture. The dry matter can be adjusted to as high as 80–90% but the throughput will be reduced. Some down time needs to be built into the system to allow for repairs and maintenance.

The “Wedge Wire” screen can process between 65 and 79 cubic metres of effluent per hour (30 – 43 cubic metres for the smaller model) and produces a product at 65 – 70% dry matter. Very little maintenance is required.



Run Down “Wedge Wire” Screen



Press Screw with Solids Extruding

Sufficient pre-separator effluent storage is required for at least two days in case of breakdowns, or a bypass system needs to be installed which diverts the unprocessed effluent into a gravity solids separator or a pond which can function as a solids pond. An agitation system is required in the pre- separator storage when the effluent is being pumped to the separator. To avoid “dead” pockets during agitation the pre-separator storage should be circular.

b) Gravity Separation

Gravity sedimentation systems rely on gravity to settle the heavier particles. Gravity settling has the potential to remove more solids than most alternatives but requires more management.

In closed ponds or slurry trenches the surface will crust over and the heavier solids will settle to the bottom. The effluent from beneath the crust is drained into a storage lagoon.

During the cleaning process the crust is removed carefully with an excavator, then the settled solids are vigorously agitated so that they can be handled as slurry and removed with a vacuum tanker or manure pump. Cleaning should be done before the settled solids reach more than 50% of the depth of the trench or a solids content of greater than 8% in the agitated slurry. Thick slurries may require the addition of water to dilute them.

To use this system with synthetic liners several slurry take-off points should be installed into the base of the liner at construction with couplings for the effluent tanker located on the bank. This will avoid the tanker having to insert a surface suction pipe into the pond with the risk of puncturing the liner.

Sedimentation systems are usually a basin or terrace system. For basins and terraces settling occurs when the flow of the effluent is slowed as it spreads across the structure and the denser particles settle to the bottom by gravity. Settling basins should be shallow, typically 0.6–1.0 metres deep, long, wide and free draining with the effluent moving on to a storage lagoon. The design flow rate through the basin should be less than 0.3 m/sec with a hydraulic retention time of at least 20–30 minutes.

A front-end loader can be used to remove the solids every 1–2 months. Regular removal is necessary to prevent the development of septic conditions or sludge re-suspension. Two basins or terraces side by side can be used alternately, with one being filled while the other dries out for cleaning.

Anaerobic Digestion

Anaerobic digestion is the breakdown of organic matter by micro-organisms in the absence of oxygen. The end products of anaerobic digestion of effluent include biogas that is comprised of methane, carbon dioxide, some trace gases and stabilized organic matter.

An anaerobic treatment pond is sized to accommodate the volatile solids loading. The pond size depends on herd numbers, cow size and the time cows spend in areas which contribute to the effluent flow into the pond. The design-loading rate is dependent on climate, which affects the biological activity within the pond. This governs the amount of solids that can be loaded into the pond per cubic metre of pond volume.

The engineering details of anaerobic pond design are beyond the scope of these guidelines. For assistance in designing an anaerobic pond you should contact the Dairy Effluent Technical consultant for the project, or a waste management engineer.

When properly designed, managed and not overloaded, the anaerobic pond can function for many years. A low-level musty odour is normal. A foul odour indicates a malfunction which could be caused by events such as overloading, or reduced microbial activity.

Handling Solids

Separated solids can be spread on the dairy farm as a soil conditioner and fertiliser or they can be sold off-farm, particularly if they are low enough in moisture content to handle easily with loaders and trucks.

The method of handling the separated solids will depend on the moisture content of the solids. Vacuum tankers are suitable for slurries up to 20% total solids. Vacuum tankers provide flexibility of distribution, which maximises the nutrient utilisation and value of the waste. However, vacuum tankers have a high labour requirement. When the soils are wet, issues such as soil compaction with machinery wheels and traction problems can occur. Vacuum tankers are more suited to small waste volumes.

Solid manure spreaders are suitable for materials with solids content greater than 20% total solids. They are the only method of getting an even distribution of solid material. The disadvantages are the high labour requirement, soil compaction caused by the machinery wheels and traction problems are common in wet soils.

For more details on general handling of solids refer to Guideline 12 - Management of Solids.

Spreading the Effluent

Spreading the effluent from large herds will generally require a large irrigation system. This could be a centre pivot into which the effluent is injected, big gun travelling irrigators or a permanent sprinkler system.

Injection of dairy effluent into centre pivots and permanent sprinkler systems requires the sprinklers to be set up to handle the type of effluent injected.

Effluent, which is free of solids, either by settling or filtration, can be spread through all types of conventional sprinklers. Effluent, which contains solids, will need to be spread through sprinklers that have been set up to handle solids

Conventional sprinklers will need to be fitted with flow control nozzles to minimise blockages that will occur when solids are present.

Impact sprinklers are able to handle solids that are smaller than the smallest nozzle diameter. These will generally have lower efficiency and uniformity than conventional sprinklers.

Big gun sprinklers are capable of handling larger solids but require higher operating pressures to operate. Both the efficiency and uniformity of irrigation are low. Big gun supply lines can be underslung from conventional centre pivot systems which will allow two separate methods of irrigation – fresh and effluent.



Centre Pivot Irrigator

An example of a system for large herds

The following is a description of an effluent management system which could be suitable for a large herd.

1. Sand and stone trap. This could be constructed similar to a trafficable solids trap. Effluent enters by gravity flow. Heavy particles settle out. Some manure solids will also be captured. Separation of sand and grit is essential because the effluent will need to be pumped at the next stage of processing. Sand and grit, and the accumulated manure solids are removed by loader and stockpiled to drain into the effluent system
2. Effluent flows to an in-ground circular receival sump capable of handling all the wash water for up to two days plus storm capacity if the yard runoff is not diverted. Gravity flow is preferred. The sump is fitted with a mixer to re-suspend any solids which settle out. A by-pass drain to take effluent to the gravity separation system is installed here in the event of long term breakdown of the solids separator, or extreme weather events.
3. Effluent from the sump is pumped to a mechanical solids separation device. The pump and pipe sizes are matched to achieve a velocity in the pipes which prevents settling of solids during transfer. Solids fall to the concrete pad beneath the separator, and runoff from the wet/moist solids is directed either back to the receival tank, or the gravity separation system
4. Liquid from the solids separator gravitates to a gravity separation terrace or pond. A number of designs are possible here, incorporating concrete terraces which control flow rates and settling of solids, or a pond designed to settle out solids over a period of months. Solids will need to be removed from the terraces every couple of weeks, or 6 – 12 monthly from the solids pond.
5. Effluent from the terraces or from beneath the surface of the solids pond is moved by gravity flow to one or more storage ponds depending on area available, and the size and dimensions required for ease of cleaning. The final pond should be relatively shallow to promote aerobic conditions and reduce odours. If odour reduction is important, mechanical



aeration may be an option. Effluent from this pond can be recycled back to yard flood wash systems or in-place yard cleaning systems

6. Effluent from the final pond is suitable for injecting into existing irrigation systems, such as fixed sprinklers and centre pivots. A mixing ratio of between 5 and 8% of effluent in the irrigation mixture is a guide to the proportions required to meet nutrient load parameters and utilise all the effluent in the storage ponds. The actual ratio can be determined by developing an irrigation schedule for the crop or pasture being grown. The effluent pump should be timed to start about 10 minutes after the fresh water pump, and turn off 10 minutes before the end of the irrigation. This allows the fresh water to flush out the pipes of the irrigator and prevent any solids build-up or corrosion.

