2.2 Direct application systems

Effluent management systems that rely on the direct application of effluent to pasture are forced to operate even when conditions don't suit irrigation, such as during periods of rainfall or slow pasture growth. However, direct application may be necessary in situations where storage ponds introduce additional environmental risks.

Direct distribution versus storage

An early and sometimes contentious decision that must be made in designing an effluent management system is the choice between 'direct' application of effluent from the collection sump to the reuse area and storage in an effluent pond before periodic drawdown and distribution. The decision can be contentious because each approach has difficult-to-quantify environmental risks that depend on the specific characteristics of each site. Such characteristics and the limitations they pose are summarised in Table 1.

Table 1. Site characteristics and issues to be addressed.

Characteristic	Direct application of effluent	System including effluent storage
Soil type	Soils with high infiltration rates are needed to minimise runoff following any applications made during wet weather (or when soil moisture deficit is limited)	Site requires *in situ* material suitable for the construction of relatively impermeable clay liner (or a membrane liner must be installed)—see chapter 2.4 'Pond site investigation'
Vulnerable groundwater	Care must be taken to avoid over-application of nutrients resulting from the limited area of coverage and poor uniformity normally associated with such systems	As above
Topography and proximity to watercourses	Runoff resulting from application during periods of wet weather or limited soil moisture deficit must not enter a watercourse	Site may pose some restrictions on the location of a pond, e.g. distance to watercourse, above flood height, availability of site with suitable slope
High-rainfall region	As above	Calculated storage requirement may be impractical
Proximity to neighbours	Runoff resulting from application during periods of wet weather or limited soil moisture deficit must not leave the property boundary	Odours from a poorly sited pond might affect neighbours
Application system	Must be capable of very low application rates and depth to avoid runoff when soil moisture deficit is limited	The ability of the system to handle entrained solids is an issue for single pond systems; application rate is limited by soil infiltration rate
Enterprise viability		The cost of extraordinary measures such as membrane liners may not be justified for small or marginal operations

In general, storage ponds are recommended, unless site-specific conditions prevent their use, as they provide the opportunity to defer effluent application until conditions are suitable for irrigation, which has been shown to almost eliminate nutrient loss from land-applied effluent (Houlbrooke *et al.* 2004).

Regional soil and groundwater considerations

Some dairy regions have hydrogeological settings that are characterised by highly permeable subsoils and vulnerable groundwater resources with a high beneficial use value (for example, the limestone soils of south-eastern South Australia). Direct application systems may need to be retained as an option for small farms that cannot justify a long-term investment in pond liners if the risk of groundwater contamination from an ineffectively sealed pond constitutes a larger risk than applying effluent directly. Provided application rates are well managed, the direct application of effluent to the highly permeable soils represents a smaller nitrogen load than urine patches.

Management of daily application systems

Where a daily application system is currently being used without problems or can be justified as the best alternative for the farm, the following measures should also be adopted:

- Fit rainwater diversion devices and adopt effluent minimisation strategies where possible (see chapter 2.6 ‘Effluent storage requirement’).
- Install an effective solids separation trap to reduce the nutrient loading on the reuse area, the likelihood of equipment blockages and excessive wear.
- Give the sump sufficient buffer storage (see Chapter 1.5 ‘Sump design’) to avoid irrigation during rain. Even following a solids separation trap, the settlement of solids that will occur if storage exceeds 30 min means that agitation equipment will be needed.
- Select the reuse areas with the assistance of a tool such as the farm nutrient loss index (FNLI) (Melland *et al.* 2007). Locate them as far as possible from waters, avoiding steep terrain or topography that concentrates runoff.
- Select irrigation equipment with a low application rate, large irrigated area and high coefficient of uniformity.
- Develop and implement backup or contingency plans in the event of pump failure or equipment breakdown.

Risk of contaminant movement off-site

It is difficult to quantify the risk of nutrient loss in runoff and drainage resulting from direct application systems without detailed monitoring. Fyfe (2004) investigated the export of contaminants from a direct land application system that used a travelling irrigator in the Southern Highlands of NSW and concluded that the system did not provide adequate control of nutrients in wet weather even under recommended nutrient loading rates. Nutrients were exported from the reuse site (unfertilised, grazed) in greater quantities than from the control site (fertilised, grazed): 20.6 $mg \cdot L^{-1}$ TKN, 8.6 $mg \cdot L^{-1}$ NH_3-N, 7.8 $mg \cdot L^{-1}$ TP, 6.4 $mg \cdot L^{-1}$ dissolved reactive phosphorus (DRP) in runoff from the reuse site versus 3.4 $mg \cdot L^{-1}$ TKN, 0.8 $mg \cdot L^{-1}$ NH_3-N, 0.9 $mg \cdot L^{-1}$ TP, 0.7 $mg \cdot L^{-1}$ DRP from the untreated control. Variation in concentrations between sampling events suggested that the ‘nutrient losses were not governed by soil interactions, but were a result of direct wash-off of waste’.

Houlbrooke et al. (2004) reported that nutrient losses from a single badly managed irrigation can be significant. Similarly, Misselbrook et al. (1995) found that ‘losses of nutrients were higher following applications made with the soil at field capacity and rainfall soon after application’.

In general, contaminated runoff is more likely to move off-site on steeply sloping land, less permeable gently sloping land, or land that receives runoff from higher ground (Fyfe 2004). However, it is difficult to set criteria to determine whether a site is suitable

for direct application as, apart from topography, the likelihood of contaminated runoff loss is influenced by dynamic factors such as soil moisture deficit, soil permeability, amount and intensity of rainfall, and amount of effluent applied. As the time interval between the application of effluent and any subsequent rainfall is one of the most important factors governing the concentration of nutrients in runoff (Misselbrook *et al.* 1995), environmental authorities in all states recommend pond systems with sufficient capacity to store effluent during times of limited moisture deficit .

Management plans and monitoring

Farmers adopting direct application systems must therefore be prepared to provide sufficient information to regulatory authorities to justify their choice over a system with wet weather storage. Indeed, farmers in south-eastern SA are required to produce an Irrigation Management Plan (IMP) if effluent is applied during that part of the year when average rainfall exceeds average evaporation (Rural Solutions SA 2005). The intent of the IMP is to prevent nutrients, particularly nitrogen, from leaching past the root zone and entering groundwater, and to monitor for any impacts on ground or surface waters and soil. Although the broader adoption of such requirements is not currently being advocated, the process of thorough planning and follow-up monitoring is commendable.

Farm nutrient loss index

One tool that may offer some assistance in choosing between potential reuse areas is the farm nutrient loss index (FNLI). Although the FNLI is also relevant to selecting reuse areas for systems with storage ponds, the increased risk of runoff under direct application in wet weather or to soils with limited moisture deficit suggests that additional emphasis on site selection issues is warranted.

The FNLI allows a qualitative assessment of the risk of nutrient loss to the environment in all of the dairying regions in Australia (Melland *et al.* 2004). It determines the risk of N and P loss at the paddock scale and allows the user to evaluate the broad effect of different management practices on nutrient use efficiency while minimising environmental impacts. It does not estimate actual loss; rather, it assesses the risk of loss from a paddock or management unit in an average year.

The FNLI uses easily quantifiable inputs grouped into source factors and transport factors. The options for each factor are assigned a rating of 1, 2, 4 or 8, based on their potential to increase the risk of nutrient loss. As the relative importance of each factor varies between grazing regions, the ratings are weighted by a multiplier before being summed to determine overall risk. Risk ranking categories (low, medium, high or very high) are based on validation against field data. For example, Table 2 shows the options for the 'Effluent application and timing' factor. Melland *et al.* (2007) describes all of the other factors that are important when considering the risk of nutrient loss.

Table 2. Factor assessment criteria and ratings—'Effluent application and timing' (Melland et al. 2007)**.**

Rating	1	2	4	8
Effluent application and timing	Summer or autumn surface application or incorporation. Back-up recycle dam captures excess flood-irrigated effluent	Spring application when no heavy rain forecast for 7 days. 'Short watering' used to eliminate runoff from flood irrigation	Effluent applied when soils already waterlogged or heavy rain expected in <7 days	Effluent applied to land during winter, or no effluent storage system. Effluent drains directly off-farm

The FNLI will not provide a determination in the choice between a direct application system and one with a storage pond. However, where a farm has an existing direct

application system or intends to implement one, it will provide some assistance in determining on which paddocks effluent may be applied to minimise risks.

References

Fyfe, J. 2004, 'Performance evaluation of two dairy shed waste management systems in the southern highlands of NSW', Masters of Engineering, Faculty of Engineering, University of Wollongong.

Houlbrooke, D.J., D.J. Horne, M.J. Hedley, J.A. Hanly, D.R. Scotter & V.O. Snow 2004, 'Minimising surface water pollution resulting from farm-dairy effluent application to mole-pipe drained soils - i. An evaluation of the deferred irrigation system for sustainable land treatment in the Manawatu', *New Zealand Journal of Agricultural Research,* 47**,** 405-415.

Melland, A.R., C.J.P. Gourley, A.P. Smith, I.S. Tarbotton & K.I. Peverill 2004, 'Developing a farm nutrient loss index for grazed pastures in Australia', *Supersoil 2004*, University of Sydney, 5 - 9 December 2004, ASSSI.

Melland, A.R., A. Smith & R. Waller 2007, 'Farm Nutrient Loss Index - an index for assessing the risk of nitrogen and phosphorus loss for the Australian grazing industries. User Manual for FNLI Version 1.18', www.asris.csiro.au/downloads/BFD/FNLI%20User%20Manual%20v1.18.pdf, DPI.

Misselbrook, T.H., B.F. Pain, A.C. Stone & D. Scholefield 1995, 'Nutrient run-off following application of livestock wastes to grassland', *Environmental Pollution,* 88(1)**,** 51-56.

Rural Solutions SA 2005, 'Irrigation Management Plans', South East Dairy Effluent Guidelines No. 12, http://www.dairyindustrysa.com.au/__data/assets/pdf_file/0005/4748/guide_12_irrigation_management_plans.pdf, Primary Industries and Resources South Australia, Adelaide.