



Department of Agriculture

Dairynotes



Security of Effluent Storage Ponds

A project in the Dairy and Apiculture Program, supported by the National Landcare Program

Background

Good management of effluent is critical on dairy farms. The effluent that collects around the dairy and associated feed sheds and laneways has the potential to contaminate surface and ground water with nutrients and bacteria. It can also create a serious image problem for the dairy industry - even though it is only about 10% of the effluent produced on the farm. Effluent management is an essential part of the quality assurance programs that are increasingly being demanded by customers.

Dairy effluent should be regarded as a resource to be used, not as a waste product to be disposed of.

The most effective way of using effluent on most farms is to apply it to actively growing pasture so that the nutrients and organic matter it contains can be recycled.

On most farms, effluent will need to be stored for several months so that it can be applied to pasture at the optimum time. It is important that storage ponds do not leak nutrients or bacteria to groundwater. It is also important that authorities who can regulate effluent management are satisfied that properly designed and constructed storage ponds won't leak.

Because information on effluent storage had not been collected in Western Australia, National Landcare agreed to support an Department of Agriculture project to monitor a number of effluent storage ponds between Wokalup and Margaret River.

The Project

The sites selected for evaluation (see the table below) were located according to four main criteria:

- trial sites drilled before this project starting,
- new sites on representative soil-landforms of the region,
- new sites on representative groundwater vulnerability mapping units,
- geographic spread for rapid communication of results.

**Year
built**

**Pond
material**

Description of system

Wokalup	1995	Clay	Single facultative* pond
Brunswick	1975	Clay	Single facultative pond
Roelands	1994	Clay	Single facultative pond
Wonnerup	1991	Sand	Single anaerobic** pond with 'biological filter'
Yoongarillup	1991	Sand	Single anaerobic pond with 'biological filter'
Vasse	1985	Sand	Anaerobic and aerobic# ponds with 'biological filter'
Warner Glen	1995	Sand	Anaerobic and aerobic ponds
Scott Plain	1994	Sand	Anaerobic and aerobic ponds
Yoongarillup	1998	Sand	Single facultative pond

** Deeper (4 metres) ponds that crust over and exclude oxygen are **anaerobic**.

Shallow (1.2 metre) ponds that have oxygen right through the water column are **aerobic**.

* Deeper ponds that don't crust over and have oxygen in the top layers are generally **facultative**.

At each site, between four and ten piezometers were drilled, typically on a 'crucifix' type design. The primary transect was orientated in the direction of inferred groundwater flow and sites were drilled wherever topography and site access allowed. Holes were typically drilled between 5 and 100 metres upslope, adjacent and down gradient from the ponds. At all sites, control bores were located over 100 metres upslope from the effluent ponds.

All sites were monitored for three years from December 1994 until February 1998, except for the ponds constructed in 1997 and later. No record of any monitoring conducted before December 1994 was available. Monitoring was conducted quarterly to measure changes brought about by seasonal conditions. On each visit, water levels were recorded and samples collected for analysis.

The 'biological filters' were all of the same basic design - convoluted earthen drains constructed by excavation which receive overflow from the pond or ponds. Two of the filters monitored were lined with waste material from mineral sands mining, which has a high capacity to retain phosphorus. The banks of all three filters were covered with kikuyu.

The concept underlying these 'biological filters' was that the vegetation would remove nutrients from the effluent as it flowed through the drain and the lining material would strip out phosphorus from effluent leaching through the floor of the drain. Outflow from the filters varied from minimal during summer and autumn, when the effluent leached through the floor of the drains, to virtually a straight through-flow in winter, when the ponds and drains were full from rainfall and high watertables.

What did we find?

In the ponds and filters

There was a reduction in the concentration of soluble reactive phosphorus and bacterial contaminants (*E. coli*) from the raw waste to pond outflow. No trend in total nitrogen was observed (mean of all sites).

	Nitrogen (mg/L)	Phosphorus (mg/L)	E. coli (per mL)
Supply water	1.51	Not detected	Not detected
Raw waste	445	23.31	80 063
Single pond	438	21.36	4 000
Anaerobic pond	685	24.04	6 700
Aerobic pond	230	11.87	2 800
Inflow to filter	633	11.09	5 333
End of filter outflow	410	9.81	1 500

The levels of nitrogen and phosphorus in water leaving the ponds and filters were too high for discharge into any waterbody, so the water needs to be contained and used on the farm.

Salinity levels (measured as conductivity in mS/m) in the single storage ponds and the first pond of two pond systems generally rose over summer and dropped back over winter.

	Conductivity
February	445 mS/m
March/April	529 mS/m
Sept/Oct/Nov	397 mS/m

As a comparison, irrigation water from Stirling Dam runs about 55 mS/m, while Wellington Dam runs about 200 mS/m.

Mixing effluent with large volumes of irrigation water will reduce the overall salinity to a manageable level but there could be problems applying it direct and undiluted to pasture, especially germinating pasture. Ponds need to be emptied regularly to prevent salinity building up to unacceptable levels.

Nutrient concentrations in single ponds generally showed the same trend as salinity - lower concentrations in spring following dilution with winter rain - but there were big differences between farms.

Concentrations of nitrogen, phosphorus and potassium in single storage ponds on the three irrigation farms are shown in the following table.

	Nitrogen	Phosphorus	Potassium
March/April	512 mg/L	79 mg/L	434 mg/L
Sept/Oct/Nov	365 mg/L	52 mg/L	197 mg/L

Concentrations in anaerobic ponds on five dryland farms are shown in the next table. These ponds were either the first pond in two pond systems or had 'biological filters' attached.

	Nitrogen	Phosphorus	Potassium
March/April	565 mg/L	73 mg/L	603 mg/L
Sept/Oct/Nov	806 mg/L	101 mg/L	289 mg/L

Concentrations in aerobic ponds on two dryland farms are:

	Nitrogen	Phosphorus	Potassium
March/April	198 mg/L	42 mg/L	263 mg/L
Sept/Oct/Nov	318 mg/L	10 mg/L	248 mg/L

The main message from these tables is that the concentration of each of the three major nutrients is very variable, both between farms and between seasons. Concentrations will depend on whether or not solids are put into the pond, how much 'clean' water gets into the system and, to some extent, what the cows are fed. This makes it very difficult to work out how much of each nutrient is being applied to pasture in effluent.

You can sample the pond before application, but the contents will need to be well mixed for the figures to mean anything. A simpler option may be to soil sample, at the appropriate time of the year, paddocks that have received effluent, then adjust the fertiliser program accordingly.

In the groundwater

Extremely high levels of nitrogen were observed at Wonnerup, Yoongarillup and Vasse. High phosphorus levels were observed in several monitoring bores at Yoongarillup and Vasse. At Warner Glen, one bore located at the foot of the pond also had extremely high levels of nitrogen. This bore received leakage directly from overflow from the pond. All these ponds were constructed in sandy material.

At all other clay sites, nutrient and bacterial levels in groundwater adjacent to the ponds were low, including the Brunswick pond, which had been in continual use for over 20 years.

At most sites, high nitrogen and bacterial levels in the groundwater were noted at sites of 'intensive use', such as near gateways, laneways, feed or resting areas or watering points. At these sites, phosphorus levels were typically low.

Iodine concentrations were measured as another determinant of contamination of groundwater. Apart from regional patterns attributed to geology, no significant relationships in iodine concentrations were determined.

Placement and construction of ponds

Soil type and clay content

The results show that the sites monitored in deep sands, deep sandy duplex soils or sandy gravelly soils overlying sandy clay or gravelly clays (Wonnerup, Yoongarillup, Vasse and, to a lesser extent, Warner Glen and Scott River) are unsuitable for the construction of dairy effluent ponds, **using the construction techniques used to date**. These profiles usually contain less than 15% clay.

Ponds constructed in clays of alluvial and colluvial, sandy duplex, loamy duplex and heavy cracking clay soils are suitable for the construction of ponds. These soils typically contain more than 35% clay. There is potential for ponds situated on these soil types to leak if sandy layers are intersected. Site assessment before installation should include excavation of test holes using a backhoe to one metre below pond depth to ensure these layers are not encountered. This should be done at each of the corners and in the middle of the intended pond site.

Watertable depth

At sandy sites where watertables are within 2 metres of the soil surface, there is a significantly higher risk of leakage. Sites that have watertables shallower than 1 metre below the depth of the intended pond floor should be avoided in all except the lowest permeability sites, such as those in the heavy clays of the irrigation area.

Construction method

While construction method was not specifically tested, two factors may significantly increase the risk of less suitable sites leaking - batter slope and soil compaction.

- Building ponds with steep batter walls (1:1 or more), especially when using excavators and backhoes, prevents mechanical compaction and mixing of the soil layers while the pond is being constructed. Steep batters also prevent the accumulation of sludge on the batters and hence reduce 'biological sealing'.
- Construction using bulldozers with subsequent additional compaction using wheeled tractors, vibrating rollers or similar machines that create significant soil disturbance and compaction, and reducing batter slopes (3:1 or less), will reduce leakage.

Clay and plastic lining

Lining ponds with tough 'plastic' membranes or clay (or both) can be undertaken at sites where excessive leakage and groundwater contamination are likely. Experience at one site indicated that polypropylene liners are relatively simple to install but they are expensive. The cost of synthetic liners can be reduced by minimising the size of storage ponds so that the liners can be fabricated and supplied in one piece, rather than being welded together on-site.

Pond size can be reduced by preventing storm water from dairy yards and roofs entering ponds and by more frequent irrigation of pond effluent on to actively growing pasture on drier sites during winter and spring.

Clay lining was not undertaken during the study period but it is only likely to be practical where a readily accessible supply of clay is available on-farm or very close to the pond. Large quantities of clay are required to line a typical pond. For example, 1 350 cubic metres of clay are required for a pond of final volume 4 500 cubic metres with 3:1 wall batter, at 500 mm liner thickness (minimum acceptable thickness).

Conclusions

- This project has provided evidence that effluent storage ponds constructed in clay soils do not contaminate groundwater, but there is evidence of contamination from ponds constructed in sandy or coarse grained soils.
- Groundwater contamination is evident from three of the monitored sites.
- Groundwater contamination from such things as stock camps warrants further study.

More information:

Ian Bell

AGWEST Bunbury
Phone: 9780 6290
Email: ibell@agric.wa.gov.au

Richard George

AGWEST, Bunbury
Phone: 9780 6296
Email: rgeorge@agric.wa.gov.au

Don Bennett

AGWEST, Bunbury
Phone: 9780 6298
Email: dbennett@agric.wa.gov.au

Bill Russell

AGWEST, Bunbury
Phone: 9780 6264
Email: brussell@agric.wa.gov.au

See also [Bulletin 4336 *Environmental management for animal-based industries - Dairy farm effluent*](#)