Leaky water storages – What are the options?

By Jenelle Hare and Graham Harris

Seepage losses can be as high as 10 per cent – that's valuable water you can't afford to lose. A group of proactive growers on the Darling Downs of Queensland have bitten the bullet and put up their hands to actively find working solutions to seepage losses – a sleeping giant for the industry.

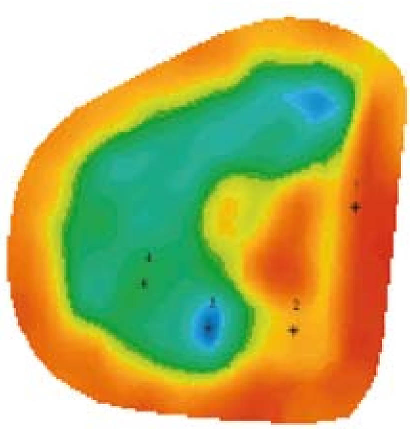
Some growers had identified seepage from ring tanks as a significant issue but others were uncertain of their losses. A project was developed around this issue through funding secured by Cotton Australia from Condamine Alliance.

The continuing drought, failures in filling storages and increased rainfall variability have seen irrigators try to minimise potential losses from their storages through infrastructure protection and management strategies. Their investment will, in the long term, ensure the productivity and efficiency of irrigated cropping, as well as relieve pressure on the water resource.

BACKGROUND

Previous investigations in the Macintyre Valley (straddling the NSW–Qld border) by Paul Dalton indicated storage seepage losses of between two and 10 per cent and evaporation losses of between 14 and 40 per cent. These losses were from storages on soil types suitable for storage construction and minimal seepage losses. But even greater seepage losses are possible from poorly constructed storages and those sited on inappropriate soils.

FIGURE 1: EM38 and soil test sites in Storage 1



Applying the compaction treatment before installing the ring infiltrometer.

Growers doing their bit

In the 2005–06 season, the Darling Downs Cotton Growers Inc asked the Central Downs Irrigators Limited (CDIL) to investigate how monies could be invested for the benefit of all irrigators after Cotton Australia secured funding of $50,000 from Condamine Alliance for water use efficiency work.

In the first stage of the project, Total Ag Services (TAGS) Dalby and FSA Consulting Toowoomba were contracted to identify the cause of seepage problems from on-farm storages and demonstrate the cost-benefit of alternative repair strategies. In addition the CDIL members funded the use of ground penetrating radar to locate possible storage wall weaknesses on 50 storages. Companies involved with this procedure were TAGS, Precision Cropping Technologies and Baigent Geosciences.

HOW IT WAS DONE

Assessment

Seepage losses from three storages in the project area were quantified by FSA Consulting and found to range from 0 to 14 mm per day. The results obtained agreed with previous work by FSA Consulting where seepage losses from on-farm water storages varied between zero and three mm per day.

Four storages known to have excessive seepage losses – and geographically spread to have the greatest impact in demonstrating the benefits of minimising these losses – were selected.

TAGS used EM38 surveys and soil core analysis in the chosen storages to identify seepage locations. Data was collated and interpreted using spatial analysis software to indicate zones of higher and lower EM38 values (see Figure 1). Soil test cores were taken at representative sites within the main zones at three depths (0–30 cm, 30–60 cm and 60–90 cm) (see Figure 2).

The soil samples were analysed for moisture, particle size, macro and micro nutrients as well as EC, cation exchange capacity and organic matter. The information that had the greatest influence on the siting of the seepage trials were EM38 values, soil moisture and sand percentage trends going down the profile.

A characteristic site had low EM, higher sand content as a percentage and often had declining soil moisture content down the profile, indicating stored water was declining at depth (see Figure 2). These sites also tended to have lower chloride levels and lower cation exchange.

Treatments

Single ring infiltrometers were used to

evaluate seepage losses in the dry storages. These measured 1527 mm in diameter (4800 mm circumference) and 600 mm height rolled from 2.5 mm flat steel (in 1200 mm x 2400 mm sheets) with a 50 mm x 4 mm strengthening band rolled around the top edge.

Mitigation treatments used in these infiltrometers were:

- **Compaction** – 150 mm of topsoil was removed, the subsoil wet to ideal moisture content then compacted with a 50 kg Whacker Packer with a 28 cm foot. Topsoil was then replaced, and also wet to the ideal moisture content and compacted. The aim was to compact 300 mm of soil to 95 per cent of maximum compaction at optimum moisture. Once compacted the ring was placed on top of the site and knocked in 150–200 mm to seal. A clear plastic 30 cm ruler was attached vertically to the inside wall of the ring with silicon, with the zero at ground level. The ring was filled with water 300 mm above the soil surface using a deflector so the soil surface was not disturbed.
- **Natural** – the infiltrometer ring was placed on the ground and knocked in 200–300 mm without disturbing the internal soil surface. The ring was marked and filled as per the compaction treatment.
- **SoilPAM** – set up as per the natural site initially. This ring was allowed to settle for 7–10 days before being treated with the equivalent of 60 kg per hectare SoilPAM as a surface application.
- **Bentonite** – again, set up identically to the natural and SoilPAM rings. After settling the water surface was treated with an application of 10 kg per m^2 of bentonite granules.

The water depth in each treatment was then checked regularly (if not daily), the depth recorded, then the ring was topped back up to the 300 mm mark.

Although readings were ‘actual’ mm per day lost from the rings, they are not to be construed as equivalent to mm per day seepage losses from that particular storage. This is because:

- We measured a small and targeted area of the floor;
- Not all of the seepage loss could be expected to be straight down in a saturated hydraulic flow; and,
- Sites were operated with a head of only 300 mm whereas storages often contain 1000 to 5000 mm of standing head.

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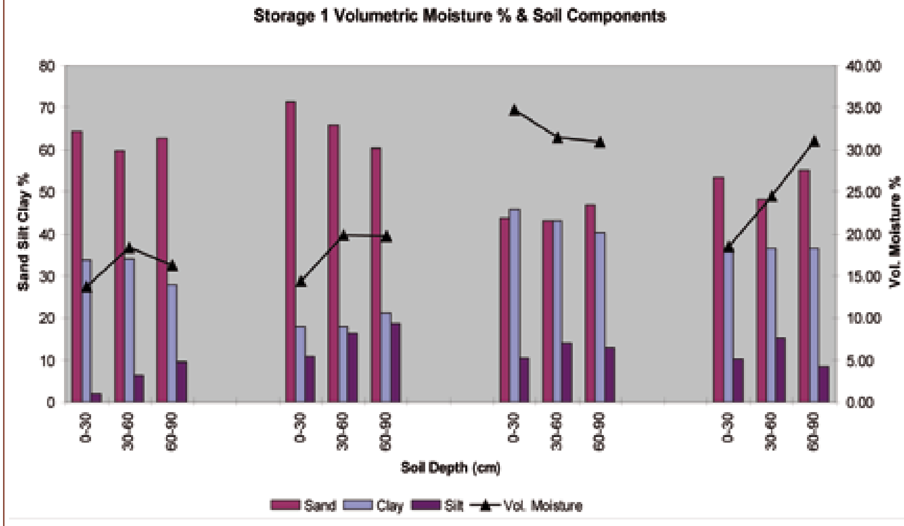
FIGURE 2: Storage 1 – moisture content and soil components



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Results

Table 1 reports the effect of the four treatments on the seepage rate in each of the storages.

In three of the storages compaction has the greatest impact on seepage losses. Similarly the 60 kg PAM per hectare treatment reduced seepage losses more then bentonite at 100 kg per hectare in three of the storages.

Conclusions

Use of EM38 and targeted soil testing aids in pinpointing seepage loss locations in the storage floor.

Longevity of the remedial treatments and their cost must be considered. For example, bentonite deposits vary greatly in the content of montmorillonite clay and thus their expansion properties. Care should be exercised in the evaluation of local clays for their suitability to seal storages – in particular, the effect of their properties on the best thickness as a compaction layer and their response to other remedial treatments.

Compaction was identified as the most effective treatment in reducing seepage losses. But how can it be practically implemented and at what cost? How long will the compaction treatment last? Alternative methods of batter stabilisation to vegetation are required to minimise erosion losses and reduce repair costs.

Vegetation in storages must be controlled to prevent degradation of remedial treatments and breakdown in the structural integrity of storage walls.

Following this work, Stage 2 of the project is investigating these issues and the cost:benefit of alternative remedial treatments.

TABLE 1: Results of seepage trials – ring infiltrometer

Treatment		Storage 1	Storage 2	Storage 3	Storage 4
Natural seepage	mm/day	3.54	6.03	102.83	12.02
Compaction (300mm)	Before mm/day After mm/day **% Reduction**	4.65 2.67 **43**	6.21 0.88 **86**	73.31 13.8 **81**	24.3 0 **100**
Soil PAM (60 kg/ha)	Before mm/day After mm/day **% Reduction**	6.72 3.14 **53**	6.64 3.05 **54**	58.33 39.35 **33**	27.51 6.74 **76**
Bentonite 100 t/ha	Before mm/day After mm/day **% Reduction**	3.29 2.3 **30**	6.02 3.17 **47**	58.77 31.83 **46**	33.37 19.73 **41**
Soil PAM High rate (4 x 60 kg/ha)	Before mm/day After mm/day% **Reduction**	193.75 52.75 **73**			

Although some outstanding results were achieved in the project, it should be remembered that these remedial treatments have been trialled for one season only. Ring infiltrometer studies showed natural seepage rates of 3.5 to 103 mm per day – these are relative figures and should not be considered the real seepage rate loss from these storages due to the technique used.

We greatly appreciate the input by irrigators and consultants on the Darling Downs who have used funding from Condamine Alliance to proactively address the issue of seepage losses.

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WHAT A DARLING DOWNS GROWER HAD TO SAY

Q. What was the most important thing you learned from this work?

A. Trying to identify the leaking area is more difficult than first thought. You need the dam to be dry to work in it – we have done EM surveys, dug holes and had a high resolution resistivity survey done. EM surveys give an overall view of sand clay content but soil moisture content can hide some information. Backhoe pits are hit and miss without survey information. The high resolution resistivity survey gave a deep profile of the dam floor and appeared to identify suspect areas. Once suspect areas are identified, selecting the best repair method is challenging because its hard to know which method will give the best long term control. Compaction – your access to good material and long term management of the compacted zone is essential. Polyacrylamide (PAM) is expensive short term control if the dam empties, hard to apply and not as efficient as we had hoped when applied commercially. For small areas, plastic liners may be an option.

Q. What will you do because of these results?

A. We compacted the suspect area with a square impact roller and tested the compaction with a penetrometer which did not indicate any increase in compaction. This was disappointing. We then dug through the compacted area and uncompacted area and found a massive change in soil structure – the compacted area had no air spaces and was solid, similar to plasticine. This encouraged us to continue compacting. We then covered the compacted area with 300 mm of soil in order to prevent drying out of the compacted area.

Q. What was the most challenging aspect of this work?

A. The most challenging part of the trial was to get the infiltration rings to represent what happens in the dam – water from the rings tend to leak sideways as well as down. Identifying the leaking area so that you are confident that the repair will work is challenging. The cost can be high and you don't know if you have been successful until the dam is full, by which time it is too late to repair it any further until the dam is empty again.

WHAT A PARTICIPATING CONSULTANT HAD TO SAY

Q. What was the most important thing you learned from this work?

A. Just how much of a problem seepage can be and the chance to evaluate some technologies that assist in identifying seepage problems. For example, the use of EM surveys in the bottom of a storage.

Q. What will you do because of these results?

A. We have used different methods to try and rectify these problems. For example, on one storage dam where some polyacrilamide has been applied we have also used more clay compacted over the suspect areas.

Q. What was the most challenging aspect of this work?

A. Trying to find the location in a dam that is seeping the worst and then evaluating the success of remediation.

It is hoped that outcomes from this project will continue to lead to an increased adoption of management practices that improve the efficiency and effectiveness of water use.