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Drainage of sandplain seeps for salinity control and stock water supplies

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Constructing drains in deep yellow sand at Doodlakine was difficult and the walls had to be terraced to prevent them collapsing.

In this trench, gravel and drainage pipe had to be installed quickly. The water-level in the drain can be seen at the base of a steel picket in the foreground.

The drain was backfilled immediately after it was completed.

This article is best read in conjunction with the article 'Reclaiming sandplain seeps by planting trees' in Journal of Agriculture, Western Australia Volume 32 (4th Series), pages 18-23. That article outlines an alternative option for reclaiming sandplain seeps.

By Richard George, Research Officer, Bunbury and Peter Frantom, formerly Technical Officer, Merredin

Sandplain seeps are derived from a shallow groundwater system which flows from the deep sandplain soils upslope.

Seeps result in small areas of salinity and waterlogging, which can be the focus of soil erosion. Sandplain seeps may represent as much as 10 per cent of Western Australia’s salt problem in the drier agricultural area.

Several drainage experiments conducted between 1986 and 1989 determined the best methods of reclaiming sandplain seeps.

Buried and open interceptor drains constructed by backhoes or excavators were tested at Doodlakine and Bencubbin. Tube drains installed using laser-controlled, slotted pipe layers attached to bulldozers were tested at Holleton.

This article discusses the results of these drainage experiments. It comments on the most suitable method for reclaiming sandplain seeps and developing them for stock water supplies.

Initial investigations

Many sandplain seeps throughout the eastern wheatbelt were drilled and the water within them and adjacent sandplain areas tested for salinity. All the sites investigated had stock quality groundwater (dry adult sheep), with a conductivity less than 2200 millisiemens per metre (mS/m), in the area upslope from the seep. (Drinking water has a conductivity about 100 mS/m and sea water about 6000 mS/m.)

Sandplain soils are more permeable than the underlying clay rich hardpan upon which the aquifer develops. Under these conditions, we expected that adequate drainage systems could be constructed to reclaim the seeps and to provide a valuable supplementary water supply.

1 Now at Murdoch University
UNITS OF SALINITY

The Department of Agriculture uses a standard international metric system when reporting soil and water salinity.

Water and soil salinities are expressed in milliSiemens per metre (mS/m), a unit of electrical conductivity. To convert mS/m to other expressions of salinity, the following relationships exist:

- mS/m to mg/L or ppm (milligrams per litre or parts per million): mS/m x 5.5* = ......
- mg/L to grains per gallon: mg/L ÷ 14.3 = ......

* For waters less than 2000 mS/m multiply by a factor of 5.5. Over this conductivity, the factor of 5.5 does not apply. The factor increases from 5.5 to 14 for waters up to 25,000 mS/m (salt lakes).

These conversion factors are printed at the end of all reports of water analyses done by the Department of Agriculture.

supply for stock. This is important, particularly in areas not serviced by a reticulated water scheme. Many farmers are already using sandplain groundwaters for stock water supplies.

The aim of these investigations was to improve the methods available for water harvesting, and to study the role that different drainage systems could play in seep reclamation. Drainage systems had to be cheap to construct, the equipment easily obtained, and the method used had to be cost effective. Buried and open interceptor drains, and tube drains were investigated.

Interceptor drains

Construction details

Interceptor drains suit sandplain seeps in the eastern wheatbelt because the drains can be constructed with local equipment. The aquifers that cause the seeps are shallow and are generally located on gently sloping ground.

Backhoe-built drains were installed on a grade at sites at Doodlakine and Bencubbin in May 1986 (Figure 1). Drains were dug to between one and three metres deep onto the hardpan (a naturally-cemented subsoil clay) and the water conveyed to existing dams (Figure 2). Each drain was surveyed carefully. The survey investigated the topography of both the surface and sub-surface (hardpan) layers.

Drains were designed to intercept the shallow aquifer waters coming into the salt-affected area from the deep sandplain upslope. Drains were located as close as possible to the seep to reduce the depth of digging needed to get to the hardpan, and to intercept the water before the salts were concentrated by evaporation.

At Doodlakine, the drain was first lined with three to five millimetre diameter coarse stone (bluemetal). One hundred metres of 65 mm diameter slotted pipe was laid and covered with more bluemetal to a depth of 0.5 m. The trench was backfilled with soil removed from the drain and the area sown to wheat.
At Bencubbin, the drain was left open and has remained open since. No bluemetal or slotted pipe was used. Seepage rates were measured at both sites.

Results

Flow began immediately after the interceptor drains were installed in May 1986, and ranged between zero and 30 kL per day (1 kilolitre = 1000 litres) over the following seven months. Flow rates were higher after significant rainfall.

The flow had stopped by December 1986, by which time the drains had removed 2800 kL at Doodlakine and 1900 kL at Bencubbin. Water conductivities were less than 100 mS/m at Doodlakine and less than 1000 mS/m at Bencubbin.

The measurements of water levels in the boreholes installed near the drains at Doodlakine over the monitoring period are shown in Figure 3. The water level in borehole BD08 (see Figure 2 for its location) declined rapidly and completely by December 1986. Shallow wells installed at the Doodlakine site have been predominantly dry since. Only a thin saturated layer develops above the hardpan after winter rain.

Flows were recorded at Doodlakine in 1988, and again in 1989 after about 180 mm of rain in May, June and July in both years. In 1989, the flow at Doodlakine was about 2500 kL. The dam also filled (more than 3000 kL) in 1990 due to seepage.

Though the drains at Doodlakine flowed in 1989, the water-tables remained low throughout the previously salt-affected area.

At Bencubbin, only about 250 kL of water flowed into the dam during 1987, while 1000 kL flowed into the dam in 1988 and over 1800 kL in 1989.

The irregularities of the annual flow rates observed between the Doodlakine and Bencubbin sites are due to the poorer grade control on the hardpan at Bencubbin, the lack of maintenance of the open drains, and the inability of the backhoe to cope with saturated sandplain soils deeper than 2.5 m.

Water drained from the sandplain groundwater was stored in dams for use by stock the following summer. This practice worked successfully at Doodlakine because of the low groundwater conductivity (100 mS/m). However, at Bencubbin, the more saline waters with a conductivity of 1000 mS/m were concentrated by evaporation to nearly 5000 mS/m by March each year, making the water unsuitable for stock.

Reclamation

At the Doodlakine site the area below the drain was cropped to wheat in 1987, the first winter after the drains were constructed. This first successful crop on the five hectare site since 1963 yielded 0.8 tonnes per hectare. A 1988 lupin crop produced 1.8 t/ha, about the paddock average. In 1989, the wheat yield was similar, at 1.8 t/ha, with over 2500 kL of water entering the dam in both 1988 and 1989. The site is now reclaimed.

Reclamation at the Bencubbin site has been poorer than at the Doodlakine site where water levels and soil salinities were quickly lowered. A three-hectare area upslope from the drain, which previously produced poor crops, yielded 0.8 t/ha of wheat (equal to the paddock average) in 1987. In 1987 and 1988, grass became established on some of the previously bare sandplain seep downslope from the drain.

Heavy rains in 1989 raised water-tables and caused slumping of the drains. As a result, salinity redeveloped.

To help reclaim the seep and eventually provide an alternative method to take over from the collapsing drain, clones of about 100 *Eucalyptus camaldulensis* (river red gum) were planted near the drain in 1987. Growth and
survival has been good, with the trees growing to four to six metres by 1991. [See further reading for a detailed account of the methods of reclaiming seeps by planting trees (George 1991a).]

Conclusions
Interceptor drains can reclaim sandplain seeps in one or more years, and the water can be used for stock. Water drained off the Doodlakine site provided a supplementary source of fresh water for livestock. Lined drains, using bluemetal and slotted pipe, are better than open drains. Open drains collapse and become ineffective in time.

At Bencubbin, the more saline groundwater, when evaporated over summer, became highly saline. Brackish waters with a conductivity exceeding 400 mS/m should not be left exposed in open storages unless used by livestock quickly, or covered to prevent evaporation.

Tube drains
Tube drains are an alternative to interceptor drains. They can provide a solution to water storage and salinity problems, but they are more expensive to construct than interceptor drains.

Tube drains could be used in regions where sandplain groundwaters are more saline than 400 mS/m and where additional stock water supplies are needed. They also may be adequate to lower the saline water-table. This would lead to lower soil salinities developing in the seep and may eventually enable normal cropping.

Stock water supply at Holleton
Tube drains were constructed at Holleton using a pipe-laying ripper, attached to a large bulldozer. Sixty-five millimetre diameter slotted and solid pipe was laid to a maximum depth of two metres below the soil surface and gradually brought to the soil surface at the lowest end of the seep (Figure 4). The drains had a maximum depth of two metres upslope.

The solid pipe was located in the more saline groundwater area (sandplain seep) to prevent the entry of this water, while the slotted pipe collected fresher groundwater (500 mS/m) immediately upslope, adjacent to the seep. Pipes were located at about right angles to the contour.

A laser level was used to ensure a constant gradient on the pipe to allow for gravity flow. The slope of the hardpan governed the gradient of the pipe within the salt-affected area (Figure 4).

Four drainage lines, each about 125 m long (50 m solid pipe and 75 m slotted pipe) were installed. Drain spacings ranged from zero at the outlets, to about 30 to 50 m above the seep (Figure 5).

Results
Drain flows were monitored regularly for two to three months during the summers of 1987 and 1988. Flows ranged from 5 to 30 kL per day, depending on rainfall. The conductivity of the drain water improved from 900 mS/m to 500 mS/m over the two to three months.

Further monitoring of the drains is needed to estimate the long-term discharge rates. However, the seep has the potential to supply about 1000 kL per year of stock quality water as a 'one-off' supply like the interceptor drains, or as a perennial supply at about 5 to 10 kL per day.

Flow rates will depend on seasonal rainfall, the size of the seep and volumes of groundwater involved. Measurements made in the summers
of 1987 and 1988 suggest that the drains can supply 1000 to 2000 sheep over summer without jeopardizing the water resource.

To effectively lower water-tables and reclaim the seep, tube drains must be allowed to flow throughout the year. However, water with a salinity above 400 mS/m cannot be stored in dams. Disposal to creeks is not a sound environmental practice.

Landholders must now submit drainage plans for inspection to the Department of Agriculture (see Farmnote No. 15/91 ‘Notification of draining or pumping saline land [Agdex 558]’). Therefore to reclaim a seep and maintain a summer water supply farmers may have to combine both trees and drains (Figure 6).

French drains
So called modified French drains are also suitable for sandplain seeps as they can be used to improve the yield of shallow aquifers with a low permeability.

These drains can be constructed by sinking one-metre diameter cement well-liners just upslope from the seep and using a backhoe or excavator to dig a trench, on a grade, for 20 to 50 m away, forming a V shape (Figure 6). The trench may be lined and equipped in a similar way to the interceptor drains installed at Doodlakine. Water flows into the well-liners, and pumps or gravity drains then carry it away from the site.

The principles of generating flow in French drains are the same as for the tube drains. However, French drains store water in the trench and well-liners, not in slotted pipe. French drains are cheaper and easier to install than tube drains because heavy machinery does not have to be used on boggy, saline soils.

To date we know of no cases where this type of drain has been used to reclaim seeps, although similar excavator-built pits or soaks have been used. Their purpose, however, is to store, not drain water, so they will not be successful in reclaiming seeps. For the same reason, French drains will only be successful when built near seeps which have consistently used water supplies.

Drainage systems are more expensive to install than tree belts to reclaim sandplain seeps. Even simple (as at Bencubbin) interceptor drains cost about $1500, whereas most tree belts planted to reclaim seeps cost less than this, including fencing.

Before starting a drainage project, a farmer must decide on the objectives. When the water can be used for stock, or safely disposed of elsewhere, drains can be used. If the water is not needed, planting trees may be the best choice.
WHAT THE RESEARCH SHOWED

- Sandplain seeps have been reclaimed with interceptor drains and the water made available for stock supplies (Doodlakine).
- Buried drains that use perforated agricultural pipe and a screening material (such as at Doodlakine) appear to be more effective than open drains (at Bencubbin). Open drains, if they are not maintained, will silt up.
- At sites where the undulating nature of the hardpan makes grade control difficult, or where the drains are not maintained, control of the water-table may be inefficient and the drainage effect minimised (Bencubbin). Careful site preparation and surveying is essential before choosing the type of drain to install.
- Waters with a conductivity greater than 400 mS/m should not be stored in open dams because evaporation can quickly concentrate salts to unusable levels.
- Tube drains installed to capture seep water and then gravity feed this water to stock watering points have been successful. At the Holleton site, this method has the potential to supply 1000 to 2000 sheep over summer. Tube drains can reduce waterlogging and salinity, but only when the water is used consistently.
- French drains appear to be cheaper alternatives to tube drains as a water supply, however, their effectiveness in reclaiming seeps is not known. Only consistently used water supplies will help to reclaim seeps. Planting trees on the site as well as installing drains is an alternative.

In 1990, the Commissioner of Soil Conservation amended the Soil and Land Conservation Act to include new regulations on drainage. Owners or occupiers of land must now submit a Notice of Intention to drain or pump saline water from land. Application forms for Notices of Intention are available from the Department of Agriculture.

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Further reading