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Managing Wet Soils: Subsurface Pipe Drainage

This Agnote describes the design and construction of subsurface pipe drainage to drain excess water from the profiles of wet soils. It discusses the major design factors that need considering when installing subsurface pipe systems. However, there are much more technical aspects to some of these factors and a contractor experienced and well trained in subsurface drainage should be consulted.

Introduction

Wet soils are a common problem in the high rainfall districts of Victoria. Surface drainage systems can improve the situation, but in many cases the soil profile itself needs better drainage so that pastures and crops can grow to their potential and stock damage by treading (pugging) and compaction can be reduced.

Subsurface drainage can be achieved by subsurface pipes, mole drains or a combination of subsurface pipes and mole drains. It is important to select the right drainage system for the particular soil type to be drained (see Agriculture note AG1355: *Managing wet soils: determining which subsurface drainage system to use*). Detailed site investigation is recommended before installing pipe or mole drainage systems.

Types of subsurface pipe drainage systems

There are two systems for removing subsurface water with subsurface pipe drainage. These are:-

- Subsurface pipes
- Interceptor drains

Subsurface pipes

Subsurface pipes, referred to as tile drainage in the past due to use of short clay pipes, are best suited in deep permeable soils where their depth allows wider spacing and minimises cost. Subsurface pipes can also successfully drain heavy (clay), poorly drained soils but have to be installed so close together that they are uneconomic in extensive farmland systems.

Subsurface pipes can also be used in soils which may have an impeding (e.g. clay) layer at some depth but, if the clay type

and content is suitable, mole drains can be installed above these in a 'mole drainage over collector pipe system' See Agriculture note AGO949: *Managing wet soils: mole drainage*.

Subsurface pipes were formerly known as tile drains. Clay pipes or tiles have been superseded by slotted plastic PVC and corrugated polythene pipe and are now referred to as pipe drains. Specifically designed drainage machines (Figure 1) dig the trench with a chain slightly wider than the pipe diameter, lay the pipe at the base of the trench, and funnel permeable backfill via a hopper and neck down onto the pipe. The amount of backfill used is governed by soil type, soil permeability, depth of backfill, trench width, etc. Backfill is a major cost of a drainage system but is crucial to the drain's effectiveness so the quality and price of backfill should not be compromised.

Although trenches can be dug with a typical builder's type trencher, producing a flat even trench base of constant slope is very difficult. Laying pipes manually, without knocking soil into the trench before the pipe is laid, is also very difficult. The specific drainage machine uses lasers to maintain constant depth and fall regardless of ground surface conditions.

Correctly installed and maintained, these systems can last many years. Regular inspection of outfalls is necessary, as this is the weak link in all drainage systems.



Figure 1. Machine designed for installing subsurface pipes

Interceptor drains

These drains are installed across the direction of water flow at or near the interface where sloping land meets the flats (Figure 2). Water flow on slopes not only runs off the surface but often penetrates into the permeable top layer until it reaches a much less permeable, high clay content soil or rocks.

The slotted PVC or corrugated plastic pipes are laid at the base of a trench (slightly wider than the pipe itself) and back filled with permeable material almost to the surface. This permeable layer intercepts the water flowing from upslope and delivers it into the large diameter drain pipe which carries the water to an outflow. This system prevents excessive upslope water from encroaching onto the flats.

This system is also very useful for intercepting water from hillside springs or lines of springs. Stock traffic at or near the springs causes severe pugging and pasture damage in the areas below the springs as the soil is very wet and has little structural strength. This affected area usually spreads unless fenced off. Interceptor drains installed as close as possible to the spring and across its downhill flow can be effective in controlling the spread.

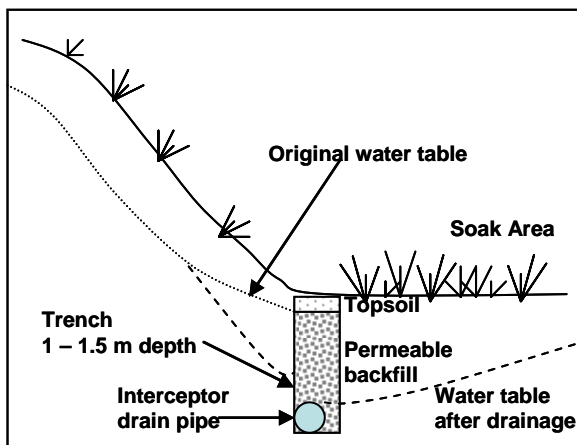


Figure 2. Interceptor drain design

Hiring a backhoe to try to find the source of the spring and back filling this hole/trench with permeable backfill which leads to the interceptor drain is worth considering.

Soil suitability for subsurface pipe drainage

Soil survey the proposed drainage area by auguring to at least a metre depth, noting soil type and its permeability. This is best done during winter so that soil permeability can be readily estimated by noting how long it takes for the surrounding water to fill an auger hole. The permeability or hydraulic conductivity is important in estimating the required drain spacing and depth and therefore the cost.

Generally, permeable soils that are sandy or loam based are suited to pipe drainage, but some well-structured clay loam soils can also be suitable.

Agriculture note AG1355: *Managing wet soils: determining the type of subsurface drainage to use* provides some very

useful and practical methods to help determine the most likely drainage system for a particular soil type.

Design considerations:

1. Drain Depth

Uniform permeable soils suit deeper the drain placement and wider drain spacing, which reduces cost. Pipe depths are typically a minimum of 700 to 1200 mm for drainage in soils growing pasture. Machines specifically constructed for trenching and pipe laying (Figure 1), are used solely by experienced contractors in Australia and can trench to a depth of about 2 meters.

In layered (Duplex) soils, an impeding layer at some depth, such as a clay subsoil or coffee rock layer, causes the watertable to build up. This is referred to as a “perched” watertable. These are common soil types in the south western district of Victoria and some areas in Gippsland. The impeding layer is situated at 300 to 900 mm depth. In these soil types, drains are usually installed just into the clay layer or some distance below the coffee rock layer and back filled with a permeable material to well above the impeding layer.

The depth of the open main drain or creek (outfall) used to dispose of the water from the pipe system usually determines the depth of the tile drains. In some cases it will be better to use widely spaced deep pipes that drain to a sump. Although water must then be pumped to the outfall, this can be more economic than using closer spaced, shallower pipe drains.

2. Drain Spacing

Drain spacing depends on the hydraulic conductivity of the soil, crop or pasture requirements and the drainage coefficient.

Hydraulic conductivity of the soil

Hydraulic conductivity is the speed at which the water moves through the soil. The more permeable the soil, the more rapid the water moves through that soil, and this allows much wider drain pipe spacing. The minimum hydraulic conductivity suitable for tile drains needs to be about 40 to 60 mm per hour (See Agnote AG0947 *Managing wet soils: determining which subsurface drainage system to use*). Conductivity rates lower than this requires pipe spacing to be too close, and is therefore uneconomic.

Crop or pasture requirements

Orchards for example need to keep the watertable lower than do crops or pastures. For pasture the watertable should be maintained at least 300 mm below the surface, mid way between drains, to enable grazing and tractor work on dairy farms without causing soil or pasture damage.

Design drainage rate

The design drainage rate is expressed as the amount of water the drain system has to remove over 24 hours to keep the watertable below 300 mm (for pasture) midway between drains (Figure 3). Different plants can tolerate waterlogging to

different extents and farmers also require paddocks to be re-usable soon after rainfall events. This dictates the removal rate of water from the soil profile after a rain even and is governed rainfall intensity, (duration and amount), soil type and pipe spacing and depth will influence this figure. Limited trial work in the dairy areas of south west Victoria shows that 7 to 10 mm per day should be used as the drainage coefficient.

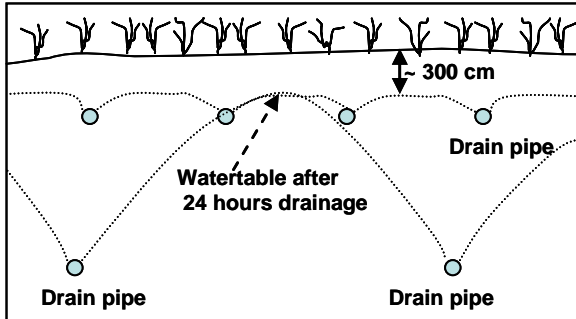


Figure 3. Effect of drain depth on pipe spacing

3. Pipe diameter

The pipe diameter is dependent on the volume of water to be removed per unit area per day and the gradient. Type of drain such as pipe only, compared to collector pipe system will also influence pipe diameter size. Tables are available from experts to help choose this information.

In pasture situations, most pipe laterals are slotted corrugated polythene pipes of 65 to 80 mm diameter. The main drains to outfalls are usually 150 to 225 mm diameter PVC pipes. However, other pipe sizes and types are available so seek further advice from subsurface drainage contractors. Laterals are the smaller diameter pipes used to collect the water from the area to be drained. These then deliver the drainage water to larger pipes or main drains.

It is important to design the drainage system to allow for future extensions when circumstances (e.g. financial, land purchase next door) allow so that the pipe diameter is large enough to cope with the increased flow from new extensions.

4. Pipe length

The maximum length of main pipe lines is determined by the design drainage rate, the area to be drained and its capacity according to the gradient used. The steeper the gradient, the faster the drainage rate. Pipes should not be installed at excessive gradients as fast flowing water may create a suction effect on the surrounding soil and create erosion.

The length of the laterals depends on slope and length of the area to be drained, but a rough rule of thumb is that one length of small diameter pipe drains into the next diameter size up. Realistically, in most dairying areas, the smaller pipe diameter would drain into larger diameter main drains (100 to 160 mm) directly into outfalls

5. Backfill

Permeable backfill should be placed around the pipe. This increases the permeability in the vicinity of the pipe,

facilitating much faster removal of the water. It also acts as a filter to prevent fine sand and silt from entering the drains.

Most commonly used backfill are coarse washed sand, graded or pea gravels and blue rock screenings of small diameter. Due to its plentiful supply, scoria (30 to 40 mm diameter) is commonly used in the Western districts of Victoria.

When drainage pipes are installed in the impermeable layer such as clay, the permeable backfill should extend well above the impermeable layer.

Collector pipe drains for mole drains should have screened gravel or scoria (12 to 20 mm diameter) to allow rapid water infiltration into the pipe. Sourcing good quality clean backfill close to the job will keep costs to a minimum.

Filter socks around slotted corrugated pipe are available for some situations to prevent very fine particles from entering the pipes. However, there may be the potential for the fine particles to block the filter itself so consult an expert to determine their suitability.

6. Gradient

Pipe gradient is determined by the layout, outlet depth and drain depth.

Minimum gradients can be as low as 0.1 % but the ground surface needs to be perfect with no irregularities. More often, 0.25 % should be the minimum gradient. Laser graded trenches give more consistent grades and are absolutely necessary for situations with low gradients. Lateral pipes should cut across the slope to maximise water interception.

Costs

Each drainage system will vary in cost depending on size of area to be drained, soil type (which determines pipe depth and therefore spacing), whether it is suited to mole drainage (with subsurface pipes or a combination), location of outfalls and proximity and availability of suitable backfill.

Current costs of a soil drained by mole drains over a pipe collector system are about \$2000 to \$2500 per hectare in soils where moles would be re-moled every 5 to 7 years. In a well maintained drainage system with appropriate pasture management, and depending on milk price, payback or breakeven price ranges from 3 to 5 years.

Other points to consider:

Inspection pits (sediment traps)

Install these at specific pipe junctions. They assist in locating blockages in pipe lines and provide access for removing blockages.

Drain markers

Draw up a farm plan and accurately mark drain locations on paper and distances from known permanent points on the ground, as after a year or two there will be no sign where the drains are installed. An aerial photograph of the drained area

immediately after installation is valuable. Recording the location of existing pipes and their sizes are essential for future extensions.

There are many examples where existing drains have been dug up by not having them properly marked. Drainage installations should add value to the land and is a good selling point as long as their location is known.

Outlets

Drain outlets are the most important part of the system. If an outlet becomes blocked, the drainage system fails, becoming a huge needless expense. Outlets must be well marked (particularly when cleaning open drains) and protected from stock trampling. Self-closing flaps will prevent vermin from making a home in the pipes and blocking the outlet.

Drainage water

The water may contain nutrients such as nitrogen and phosphorus and may have high salt levels if saline areas are drained.

Good management practices such as not applying fertiliser within four days of predicted rain should reduce nutrient runoff to a minimum. Well-drained soils are less likely to waste nitrogen fertiliser through denitrification and plants are able to access the nitrogen readily. Phosphorus can leach via drainage water but the total amounts lost are less than through surface runoff of saturated soils.

Some pockets of saline soils have the potential to be restored over time as rain water flushes out much of the salt via the drainage system. This will cause saline water to enter streams initially but eventually will actually improve the quality of the stream water as salt is leached from the soil profile.

Tree roots

Fine tree roots will very quickly gain entry through the slots so avoid laying slotted pipe where these may be a problem. Use un-slotted pipe for several metres to bypass tree roots.

Grazing management of drained paddocks

It is absolutely essential that, after heavy rain, drained paddocks are not grazed for at least 24 hours after the last rain. This allows the soil to drain and regain strength to withstand cattle and wheel traffic without damage.

A common fault by many farmers is to put cattle into drained paddocks during or soon after rain. This results in a compacted soil surface and reduces the drainage capacity of the soil. Animals should be kept off drained soils for at least 24 to 48 hours to allow the drainage system to drain the excess moisture to about 30 cm below the ground surface. This will also retain the structural strength of the soil. A waterlogged soil has greatly reduced strength so is easily pugged by hooves and damaged by machinery. See Agriculture Note AG0943: *Managing wet soils: grazing techniques*.

The Water Act

The Water Act (1989) provides guidance for the management of waterways and swamps. Before considering draining a wet area you should contact your local Catchment Management Authority and Regional Water authority for advice, as a permit may be required.

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