# Design and performance of land drainage systems

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**Summary**

- Two main types of drainage system exist: a groundwater drainage system and a shallow drainage system. The optimum system and its design depend entirely on soil drainage characteristics.
- With appropriate drainage, grass production has been shown to increase by between 4 and 7 t DM/ha per year.

## Introduction

The objective of any form of land drainage is to remove excess water from the soil, to lower the watertable, and to reduce the period of waterlogging. This can have potential benefits such as lengthening the growing and grazing season, improving utilisation of grazed grass by livestock and improving accessibility of land to machinery. Drainage of poorly drained mineral soils has positive effects on greenhouse gas emissions by reducing losses of nitrous oxide, while drainage is linked to carbon loss on carbon-rich soils, such as peats. Drainage works should therefore be focused on mineral soils. A number of drainage techniques have been developed to suit mineral soil types. There are two main categories of land drainage:

*Groundwater drainage system:* A network of deeply installed field drains exploiting permeable layers.

*Shallow drainage system:* Where the permeability is low at all depths a shallow system, such as mole or gravel mole drainage, improves soil permeability by cracking the soil and encourages water movement to a network of field drains.

A number of test pits (at least 2.5 m deep) should be excavated within the area to be drained. These test pits should be dug in areas that are representative of the area as a whole. As the test pits are dug, observe the faces of the pits, establish the soil type and record the rate and depth of water seepage into the soil test pit (if any). Visible cracking, areas of looser soil and rooting depth should be noted as these can convey important information regarding the drainage status of the different layers. The depth and type of drain to be installed will depend entirely on the interpretation of soil characteristics.

## Groundwater drainage system

In soil test pits where there is strong inflow of water or seepage from the faces of the pit walls, layers of high permeability are present. If this scenario is evident on parts of your farm, it would be best to focus on these areas first as the potential for improvement is usually very high. The installation of field drains at the depth of inflow will facilitate the removal of groundwater assuming a suitable outfall is available. Conventional field drains at depths of 0.8-1.5 m below ground level have been successful where they encounter layers of high permeability. However, where layers with high permeability are deeper than this, deeper drains are required. Deep field drains are usually installed at a depth of 1.5-2.5 m and at spacings of 15-50 m, depending on the permeability and thickness of the drainage layer. Field drains should always be installed across the slope to intercept as much groundwater as possible, with main drains (receiving water from field drains) running in the direction of maximum slope.

## Shallow drainage system

Where a test pit shows no inflow of water at any depth, a shallow drainage system is required. These soils with no obvious permeable layer and very low hydraulic conductivity are more difficult to drain. Shallow drainage systems are those that aim to improve the capacity of the soil to transmit water by fracturing and cracking it. These include mole drainage and gravel mole drainage. Mole drainage is suited to soils with high clay content that form stable channels. Mole drains are formed with a mole plough comprised of a torpedo-like cylindrical foot attached to a narrow leg, followed by a slightly larger diameter cylindrical expander. The foot and trailing expander form the mole channel while the leg creates a narrow slot that extends from the soil surface down to the mole channel depth.

The success of mole drainage depends on the formation of cracks in the soil that radiate from the tip of the mole plough at shallow depth. Gravel filled mole drains employ the same principles as ordinary mole drains but are required where an ordinary mole will not remain open for a sufficiently long period. This is the case in unstable soils having lower clay content. The mole channel is formed in a similar manner but the channel is then filled with gravel, which supports the channel walls. The gravel mole plough carries a hopper that controls the flow of gravel. During the operation the hopper is filled using a loading shovel or a belt conveyor from an adjacent gravel cart. Gravel moles require a gravel aggregate within the 10-20 mm size range to function properly.

## Performance analysis

Performance analysis of drainage systems installed on Heavy Soils Program (HSP) farms allows examination of the impact of the type of drainage system, soil type and seasonal variations in soil moisture on drainage system performance. All of the systems installed reduce the overall period of waterlogging and control the water table, thereby improving the conditions for both the production and utilization of the grasslands they drain. Drained sites increased grass production by between 4 and 7 t DM/ha per year. Deeper drain systems with direct connectivity to groundwater discharge greater volumes of water and maintain a deeper water table compared with shallow drainage designs. The differences in drainage capacity observed between the different drainage design types is dictated largely by the hydraulic capacity of the soil within a catchment and connectivity to different water bodies. This work is allowing a more complete understanding of the capacity of individual drainage systems, and providing useful information on appropriate drainage design practices for poorly drained soils.

## Land drainage publications

The Teagasc Manual on Drainage - and Soil Management is available via the Teagasc website.