

# Tile Drainage Systems

Avat Shekoofa, Assistant Professor,  
Crop Physiologist-Water Stress and Irrigation,  
Department of Plant Sciences

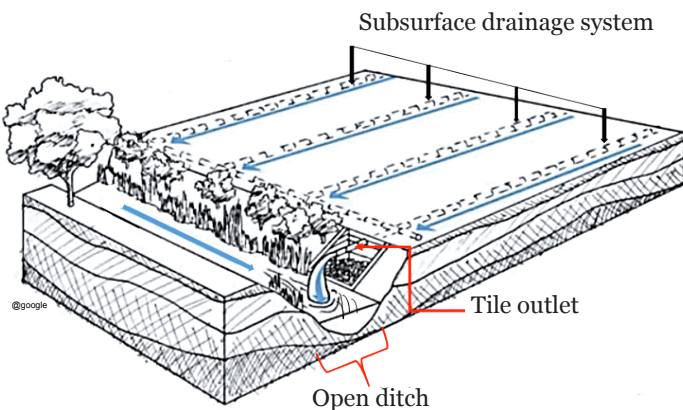
Brian Leib, Associate Professor,  
Irrigation and Water Management,  
Department of Biosystems Engineering and Soil Science

Irrigation is the practice of adding water when the soil is naturally dry, whereas drainage removes the excess water of soil to a proper level where it will not interfere with plant growth. Excess water may be caused by rainfall, high water table, floods or by applying too much irrigation water.

There are two major systems for farmland drainage:

- **Surface drainage**, which removes excess standing water by using drainage ditches.
- **Subsurface drainage**, which removes excess water through a system of underground drainage tiles.

Tile drainage is a form of water management that removes water from the subsurface of the soil (Figure 1).

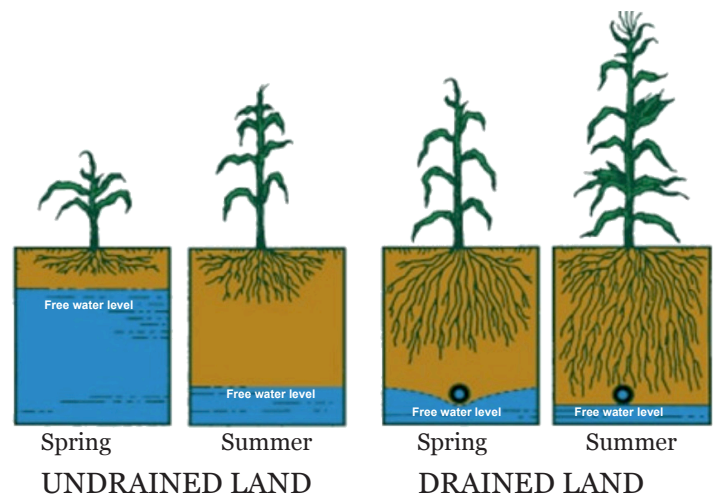


**Figure 1. Two common farmland drainage systems for poorly drained agricultural land.**

Tile drainage systems were first used in America in 1838 when John Johnston, a farmer, installed clay tiles on his farm in Seneca County, New York, and he was dubbed “the father of tile drainage” in the United States.

## Why use a tile drainage system?

Where water stands on the soil surface or drains very slowly from the root zone, soil will remain too wet for a long time. Optimal root growth requires both water and air to be present in the spaces between the soil particles, often in equal proportions. If water fills all the soil spaces (saturated), there is no room for air. The major reason for installing tile drainage is to provide better conditions for crop root growth and improve the yield potential of the farm (Figure 2).



<http://slideplayer.com/slide/9809625/>

**Figure 2. A drainage system promotes better root growth and plant quality when soils have poor natural drainage.**

The advantages of tile drainage systems can be:

- Improved root development and increased crop yield.
- Earlier and more timely planting.
- Better germination and crop stand.
- Less runoff.
- Less crop stress from waterlogged conditions.
- Higher spring soil temperature.
- More efficient use of nitrogen fertilizers.
- More days of machinery operation.
- Reduced soil compaction.
- Making a better environment for plant health and growth.
- Increased land value.

## Tile drainage system design

Planning and designing an effective drainage system needs time and, of course, requires consideration of a number of factors, including:

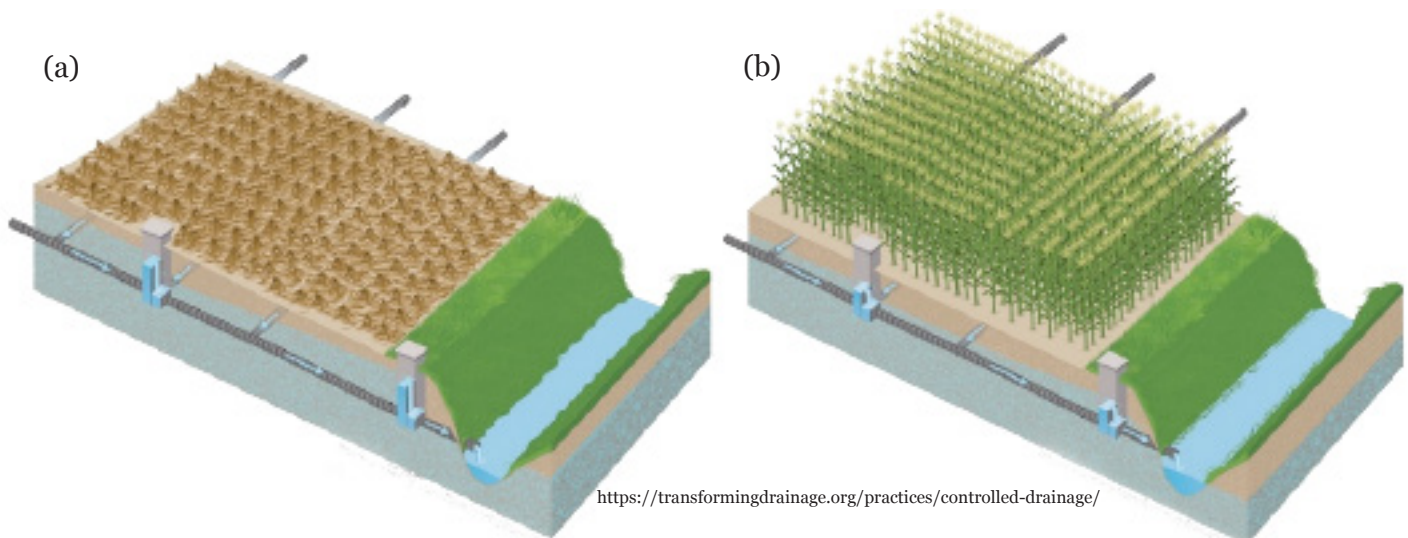
- Water table level.
- Soil texture and class.
- Field elevation and slope.
- Current and future cropping system.
- Quality of the installation.
- Environmental effects (dry or/and wet year).
- The frequency of rainfall.

Depending on the design of the drainage system, a typical tile drainage has a number of small laterals – 3, 4 or 5 inches in diameter – that drain water to larger diameter collectors and the main ditches. Water collected from the tile laterals and main lines flow into an outlet point on the edge of the field and are discharged into an open drainage ditch outside of the farm or other body of surface water. (Figures 3 and 4).



@google

**Figure 3.** *The soil water management for poorly drained agricultural land with artificial drainage.*



<https://transformingdrainage.org/practices/controlled-drainage/>

**Figure 4.** *Drainage during non-growing season (a) drainage during the growing season (b).*

### Sizing pumps to remove/drain water from the field:

In cases that land topography does not allow for free surface drainage outside the farm, using a pump station will be necessary to lift the water over a hill or rise that is between the field and the discharge channel or/and canal.

In such a case there is a need to refer to the “Drainage Coefficient (DC)” value which was selected to design the tile drainage system for the field. The drainage coefficient is the water draining capacity of the drainage system and is typically expressed as a depth of water removed from soil in 24 hours (inches/day). The whole drainage water in 24 hours is the multiplication of the drainage coefficient by the field area. The maximum pump flow rate for a given field area can be estimated with the following formula:

$$\text{Maximum pump flow rate (gpm)} = 18.9 * DC * \text{Area}$$

Table 1 shows a few examples of varying drainage coefficients. Installing a pump station will increase the investment in a tile drainage system, but often it is the only option for moving the tile drainage water to the outlet/ditch. The annual per-acre cost to pump water will depend on the size of the motor, the number of pump starts, the number of pumping hours and local electric rates.

**Table 1. The maximum flow rate per acre that will flow into the outlet for a selected drainage coefficient value.**

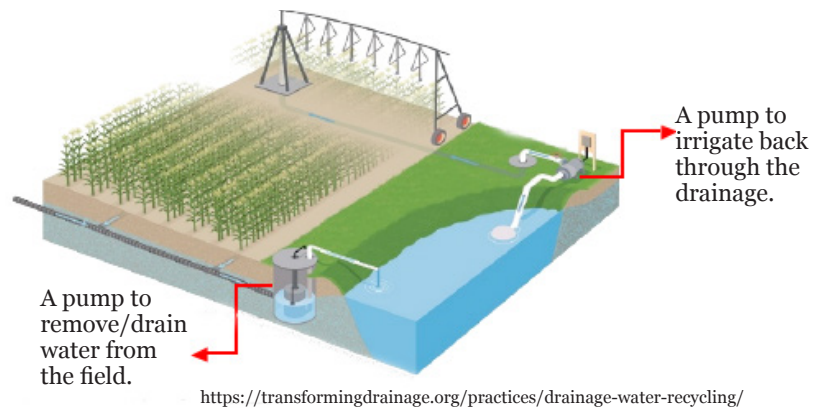
Drainage coefficient (acre-inches per day)	Gallons of water from one acre of land	Average gallons per minute of flow per acre in 24 hours (1,440 minutes)
1/4	6,800	4.7
3/8	10,210	7.1
1/2	13,610	9.5
3/4	20,420	14.2

<https://www.ag.ndsu.edu/publications/crops/tile-drainage-pump-stations-for-farm-fields>

### Sizing pumps to irrigate back through the drainage system:

The main purpose of this system is to conserve farm irrigation water and water quality by collecting the drain water from the field surface for reuse as subsurface irrigation or/and overhead pivot system.

**The water return flow pump** removes water from the source and moves it to the discharge point where it will be reused for irrigation (Figure 5).



**Figure 5. A schematic picture of using pumps to drain water from the field and irrigate back with the drained water.**

### What do the economics look like for tile drainage?

Tile drainage is a long-term investment. The investment is made up-front but the benefits are spread over many future years. Whether a tile drainage system will provide returns depends on crop yield response, initial capital outlay for the materials and installation of the system, and any annual operation and maintenance costs (pumped outlets) involved as well as yearly rainfall amounts received. The drainage system installation costs can vary significantly based on terrain, soils and outlet availability, however, a rough estimate could be almost \$1,000 to \$1,500 per acre.

The typical yield increases from tile drainage might be 10-30 bu/ac for corn and 5-10 bu/ac for soybeans in fields that drain poorly. Producers in West Tennessee have recorded 20-25 percent yield improvement for corn and up to 25 percent higher yields in soybean, during the first five years of using tile drainage.

Wheat has been shown to yield only 58 percent of potential yield when the water table is 15-20 inches below the surface for long periods of time, on a clay loam soil. Since higher yields translate into greater economic returns, the decision to invest in tile drainage is based on whether the higher crop returns will justify the investment in subsurface drainage.

In a suitable field, tile drainage systems can return the cost of investment in 3 to 10 years. In general, adding tile drainage can be a good investment if the economics work on a specific farmer’s land, but for others, the situation or timing may not be right.

## **Acknowledgements**

---

The senior author gratefully acknowledges the time and opportunities provided by Jeff Lannom, Extension agent in Weakley County, and David Oliver, Weakley County producer, to visit a few active tile drainage systems in West Tennessee.

## **Sources**

---

Understanding the Economics of Tile Drainage: [extension.iastate.edu/agdm/wholefarm/html/c2-90.html](http://extension.iastate.edu/agdm/wholefarm/html/c2-90.html)

What Is Drain Tile 101: [uswaterproofing.com/learning-center/what-is-drain-tile-101-how-drain-tile-works](http://uswaterproofing.com/learning-center/what-is-drain-tile-101-how-drain-tile-works)

Operating and Maintaining a Tile Drainage System: [omafra.gov.on.ca/english/engineer/facts/10-091.htm#8](http://omafra.gov.on.ca/english/engineer/facts/10-091.htm#8)

An Introduction to Agricultural Tile Drainage: [wiswcsdotorg.files.wordpress.com/2012/11/panuska.pdf](http://wiswcsdotorg.files.wordpress.com/2012/11/panuska.pdf)

Tile Drainage Pump Stations for Farm Fields: [www.ag.ndsu.edu/tiledrainage/documents/tile-drainage-pump-stations](http://www.ag.ndsu.edu/tiledrainage/documents/tile-drainage-pump-stations)

Minnesota farm drain tiling: Better crops, but at what cost? [twincities.com/2012/08/31/minnesota-farm-drain-tiling-better-crops-but-at-what-cost](http://twincities.com/2012/08/31/minnesota-farm-drain-tiling-better-crops-but-at-what-cost)

Why is tiling necessary, and what are the benefits of tile drainage? [precisionlandsolutions.com/services/tile-drainage/faq](http://precisionlandsolutions.com/services/tile-drainage/faq)

Planning to Drain Your Land: [drainage.org/planning.htm](http://drainage.org/planning.htm)

iGrow Drainage Calculators: [igrowdrainage.org/#/calculators/pump-size](http://igrowdrainage.org/#/calculators/pump-size)

Drain Spacing Calculator Guide: [climate.sdstate.edu/water/DrainSpacingCalculatorDocumentation.html](http://climate.sdstate.edu/water/DrainSpacingCalculatorDocumentation.html)

Irrigation Water Management: Training Manual No. 1 - Introduction to Irrigation: [fao.org/docrep/r4082e/r4082e07.htm](http://fao.org/docrep/r4082e/r4082e07.htm)

Drainage Water Recycling: [transformingdrainage.org/practices/drainage-water-recycling](http://transformingdrainage.org/practices/drainage-water-recycling)

AG.TENNESSEE.EDU

Real. Life. Solutions.™

W 778 09/18 19-0050

Programs in agriculture and natural resources, 4-H youth development, family and consumer sciences, and resource development. University of Tennessee Institute of Agriculture, U.S. Department of Agriculture and county governments cooperating. UT Extension provides equal opportunities in programs and employment.