WATER MANAGEMENT 101

ELLINGSON
WATER MANAGEMENT

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BETTER SUBSURFACE WATER MANAGEMENT DRIVES YIELD AND LOWERS RISK

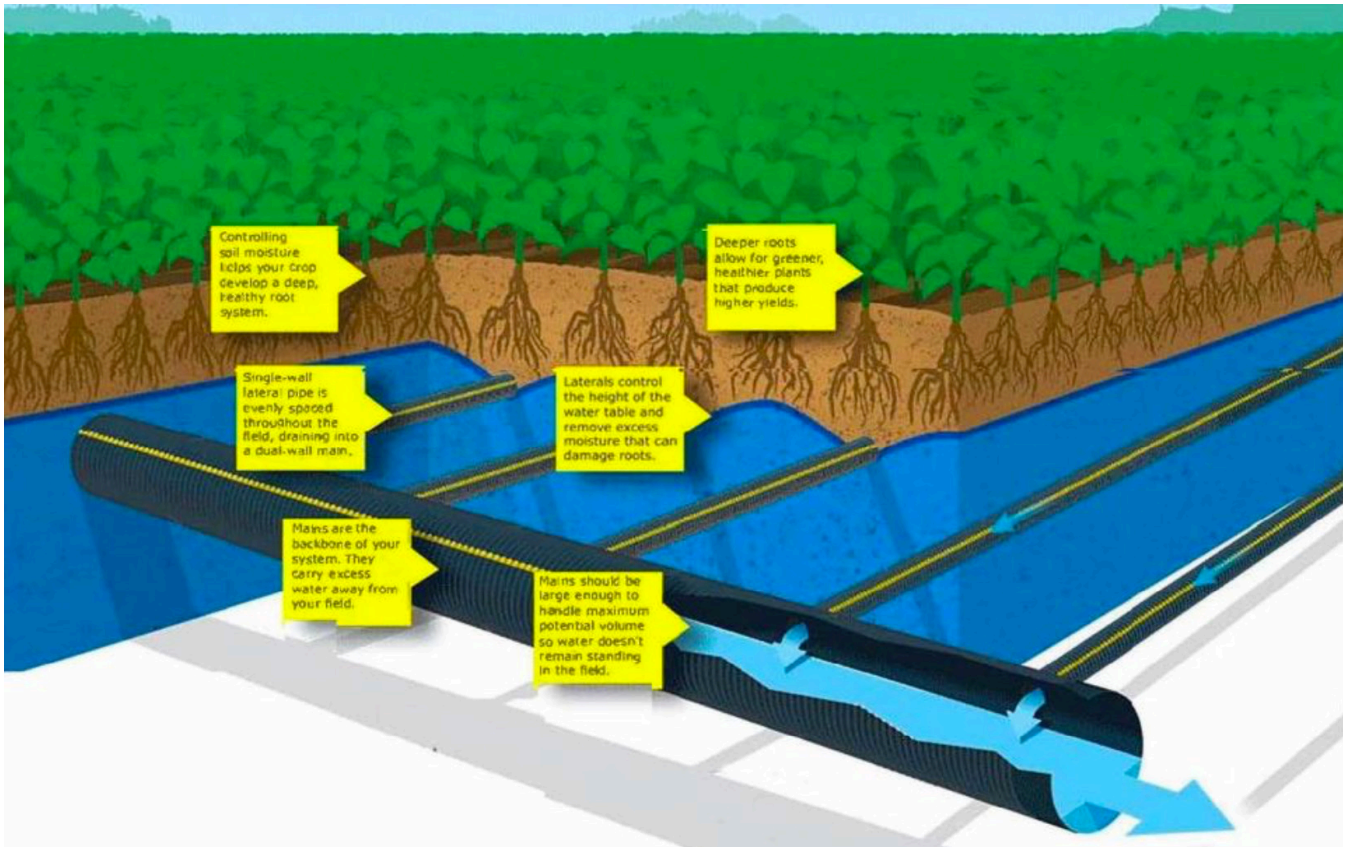
Many agronomists will tell you that next to proper pH, proper subsurface water management of the soil profile is the most important factor in maximizing yield potential.

As part of a leading subsurface water management and trenchless construction company providing nationwide services, Ellingson Technology and Engineering is actively engaged in the critical dialogue about advancing subsurface water management practices and technology and the impact of evolving environmental regulations.

The resources here share our insights gleaned from working with thousands of growers and notable clients across a variety of other industries, as well as relevant research findings from leaders in the marketplace.

WATER MANAGEMENT 101

The agricultural practice of tile drainage is a method to effectively remove excess water from below the soil surface. For optimal crop growth, soil moisture levels must be kept in check. Too much water beneath the soil can be detrimental to the success of a healthy plant. Studies have shown that by correctly managing water on a field through drainage, one can see tremendous affect on a crop's quality, consistency, and yield.



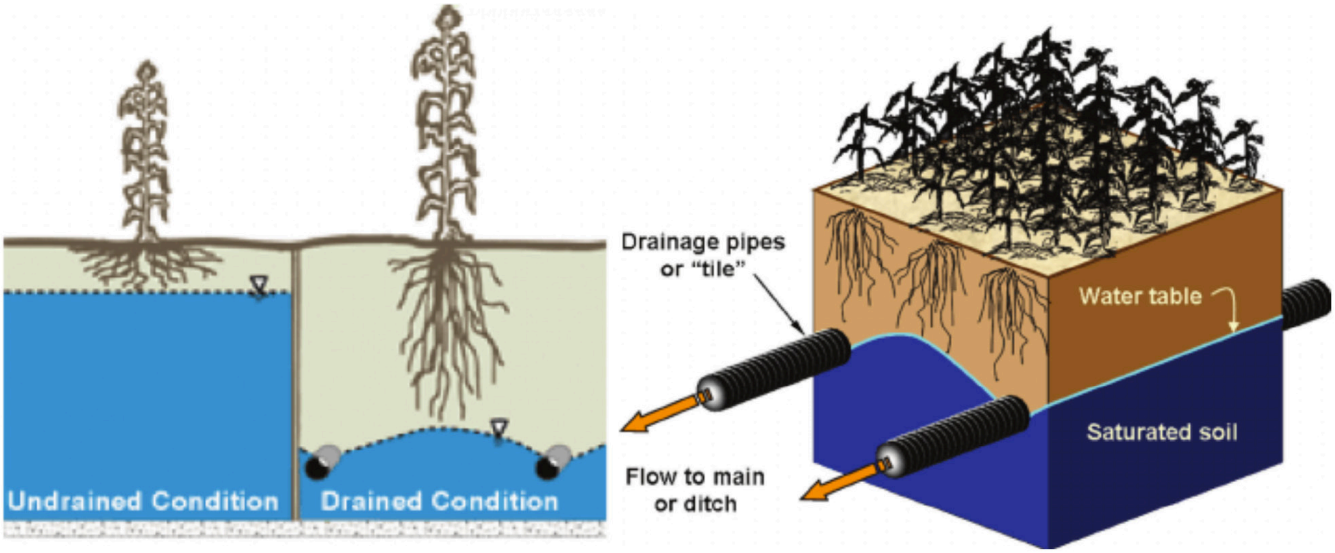
A tile drainage system consists of a network of below ground pipes called laterals and mains that work together to manage the water table. The laterals are spaced throughout the field and collect water that travels to a main. The main allows the system to carry the water out of the field in a controlled and responsible fashion. An entire drainage system is designed on a grade (or slope) so the water flows in a specific direction.

3 Goals of a Drainage System

1. Lower the water table. A good tile drainage system lowers the water table to a level that allows for (and encourages) strong root growth. The removal of excess water above the tile system, allows roots more room to grow and develop, which leads to healthier plants.

2. Remove water at the appropriate rate. A good tile drainage system can remove excess water from the root zone within the critical timeframe before harm is caused to the plant. If a crop is left saturated for too long, the plant will be damaged – adversely affecting yield.

3. Engineered for the field. A good tile drainage system is properly engineered for the specific field it serves – taking into account factors like soil properties, crop rotation and weather patterns. A modern tile system is designed with longevity in mind so that the investment is truly long-term.



In an undrained field, poor drainage can cause shallow root growth and sometimes crop failure due to the plant not getting the oxygen it requires in the root zone. With tile drainage systems the roots have the room and oxygen to grow deeper into the soil, promoting stronger and healthier plants which can turn into higher yielding crops.

The use of controlled drainage can help reduce nutrient loss (nitrogen and phosphorus) by holding the water in the soil profile for an extended amount of time – reducing the nutrient concentration of the water being discharged.

Tile Spacing and Depth

The spacing between tile and how deep it is laid in the ground will directly impact the subsurface water table. Between two tiles you will notice that the water table takes on a curved bell shape; this is because directly above the tile, the tile is able to pull the saturated level down to the level at which it is. As you move further away from the tile, the tile's affect lessens on the water table line above it.

With this principle at work, the water table's highest point lies directly between two installed tile lines. Properly installed tile keeps the water table at an appropriate distance below the surface at all locations – which becomes a balancing act between spacing and depth. Soil type is a particularly important variable. As you'd probably imagine, porous sandy soils give ground water the ability to move more freely allowing for deeper and more widely placed tiles, whereas thicker clay soils demand closer shallower tile lines. Working with an engineer who understands all factors is critical to optimizing a drainage system's design and performance.

Drainage Coefficient

Each drainage system is designed to a certain capacity. The design capacity of a drainage system is expressed as a depth of water removed in 24 hours (inches/day). For example, a ½ inch drainage coefficient means the system can remove ½ of an inch of water in a day. A drainage coefficient should be chosen that maximizes return on investment. This is accomplished by determining the most economical means to minimize risks for your crop rotation.

THREE DRAINAGE MYTHS WE BET YOU'VE HEARD BEFORE

It's understandable that a practice that's been around so long has picked up some confusion and inaccuracies along the way. The very name "tiling" finds no modern connection, originating from the old material (ceramic tiles from fired clay) used in the practice historically. It's no wonder certain myths are connected to this process. Here are 3 myths, we bet you've heard about drainage:

Tiling the wettest field = best ROI

For years the approach to drainage has been the: "Fix the Wettest farm First" approach. There is a better way. By analyzing each field and determining which field has the best opportunity to reach its maximum yield potential you are able to invest in the fields that will return your investment the quickest. Think of it as the precision farming approach to drainage. You don't increase inputs and seed population in poor ground in hopes of a better crop, nor should you do that with your drainage system. Invest in the fields that will pay you back the fastest and then improve your poorer ground with the profits.

We can help put together a plan to improve your drainage on your entire farm with our H2Onomy approach. When your fields are your portfolio – taking a strategic approach in order to maximize return on investment is the smart way to go.

My crop will be hurt by drain tile in a dry summer.

Contrary to popular belief, drain tile does not dry out the soil. Drain tile only removes excess moisture from the soil profile. It is this additional moisture that can lead to delayed planting in the spring, and shallow root growth during development. Soil that is properly drained can allow for earlier planting dates and promotes deeper root growth down into the soil profile – giving the plants a leg-up in the event of a dry period. Think of it this way; if your soil were a sponge, drain tile would not actively wring it out. Soil will hold on to only as much water as its capacity allows for, tile simply provides the excess moisture an exit path.

You may be surprised how fast crop damage can occur without proper drainage or how many extraordinary rainfall events actually happen in your area.

Tile is really expensive.

A drainage system investment may feel like you are buying the farm all over again, but how much profit are you losing to the field each year without having the proper drainage? With the right tools and guidance, you can answer this 'lost profit question', and forecast a typical drainage investment over ten years. What you'll find is that your drainage investment not only returns your initial investment but provides a nice profit on top; and such calculations are before you take into account the increase in value your land will see when tile is beneath its soil. A drainage system can assume an insurance-like role in your operational plan, and make your input investments (like seed and fertilizer) work even better. They're not making any more land, improve what you already have.

THE PROOF IS IN THE YIELD

Drainage plays a crucial role in long-term yield performance and the positive effects of proper water management have been studied and observed academically. Drainage has shown to significantly improve the consistency of yields from year-to-year, proving that investing in drainage systems pays dividends in the long-term.

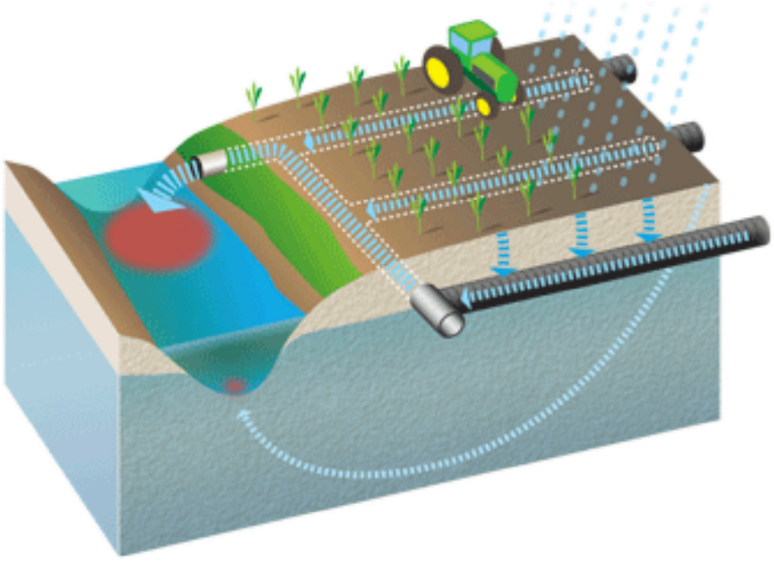
The research consistently presents 20%-30% long-term yield increases across nearly all crop types. Such dramatic yield gains are attributed to several variables, including direct ones like increased root health and strength, and indirect ones

like less soil compaction caused by heavy machinery on wet ground. Further, early seeding (1-2 weeks) and faster soil warming result in efficiency gains for the operation.

Just like other investments in an operation, water management is a key factor that will address the drainage issues that are damaging to yield. The yield impacts of subsurface drainage have been studied for decades. Review some key findings from the literature below:

Yield Improvements from Drainage

- Improve yield by 20% (Kumar, 2014)
- Increased corn yield from 0.92 to 1.88 Mg/ha (10-22%) (Nelson, 2013)
- Increased yield from 1.1 to 6.6 Mg/ha (Nelson, 2012)
- Improve trafficability by 60 days (Chieng, 1987)
- Increased corn yield by 1.8 t/ha, increased soybean yield by 0.4 t/ha (Sipp, 1986)
- Corn yields increased an average of 0.85 metric tons/ha (Fausey, 1983)
- Corn yield increase 0.8 t/ha (Walker, 1982)



Controlled Drainage/ Water Management Systems

- Reduce drainage volumes and N losses by 17-80% (Skaggs, 2010)
- Help control the water table and improved corn yield by 64% over free drain (Tan, 1998)
- Help reduce nitrate loss by 37% (Tan, 1998)

Subirrigation

- Increases corn yield up to 4.41 Mg/ha (24-38%) (Nelson, 2013)
- Increased yield from 4.7 to 7.2 Mgha-1 (Nelson, 2012)
- Help reduce nitrate loss by 41% (Tan, 2007)
- Reduced phosphorus loss by 36% (Tan, 2007)
- During low rainfall growing seasons increased corn yield by 91% (2001) and 41% (2002) and soybean yield by 49% (2002) compared to free drain (Tan, 2007)
- During wet years increased corn yield by 7% (2000) and 22% (2003) and soybean yield by 19% (2004) compared to free drain (Tan, 2007)
- Increased the available water capacity, there were more small pores and fewer large ones which retained more water at the mid-range tensions (Fausey, 2003)
- Increased corn and soybean yields by 34.5% and 38.1% respectively during dryer growing seasons. increased yield by 14.4 and 9.7% during average growing seasons and increased overall yield by 19.6% and 17.4% (Allred, 2003)
- Increased corn yield by 5 t/ha, increased soybean yield by 0.7 t/ha (Sipp, 1986)

INCLEMENT WEATHER EVENTS

While weather events will still fluctuate from season to season, drainage can provide you and your crops a level of consistency when it comes to your risk and their water. Excess water in a crop's surroundings (saturated soil) can deprive them of certain basic needs – top of the list? – oxygen. And with oxygen deprivation comes numerous negative effects for a plant at any growth stage; it can cause root organ damage and hypoxic damages, reductions in root respiration and total root volume, resistance to transporting nutrients through the roots, and formation of toxic compounds in soils and plants. If water tables remain close to the soil surface, root maturity suffers, and in turn can lead to nutrient deficiency. In the heat of summer, the harm caused by saturated soils can be exaggerated – as findings show plants (corn in particular) are more susceptible to flooding at higher temperatures than at lower temperatures (Fausey, 1985).

The questions then become:

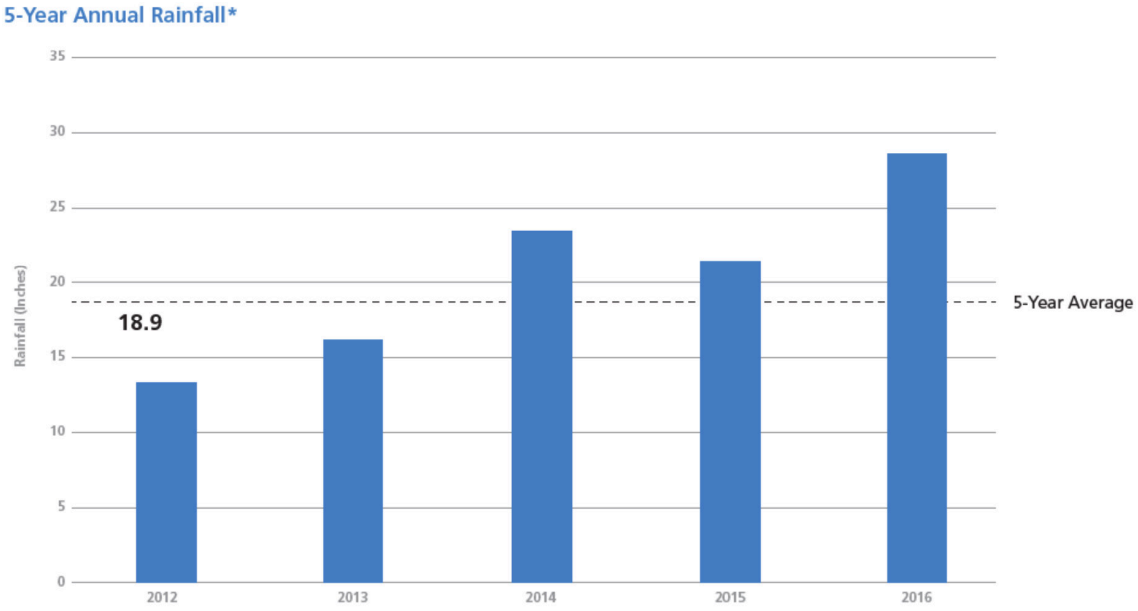
How quickly do the crops grown on my operation become 'at risk' from excessive rainfall?

How often do yield impacting rainfalls actually occur in my area?

The answers may surprise you.

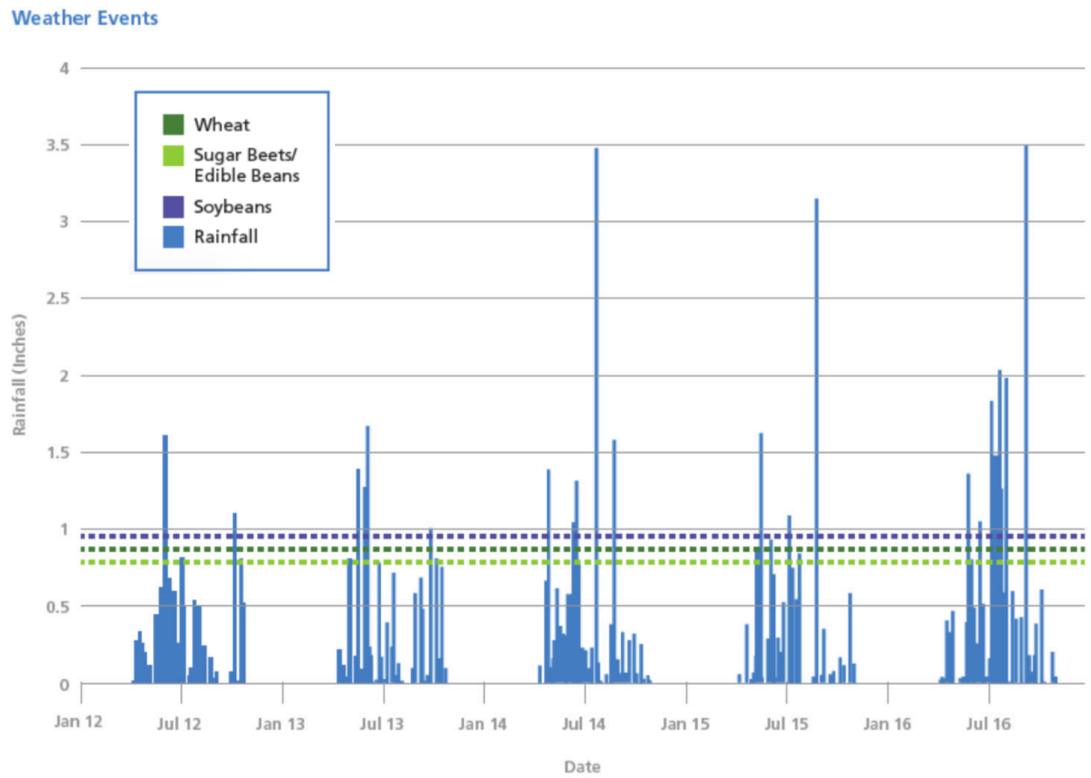
Consider the following data sets in this Example case below. Each piece of information was used by the farmer to assess their field's susceptibility to yield-impacting rainfall events, and then determine the drainage needs required to counter those risks.

5-year weather and precipitation data on this field.



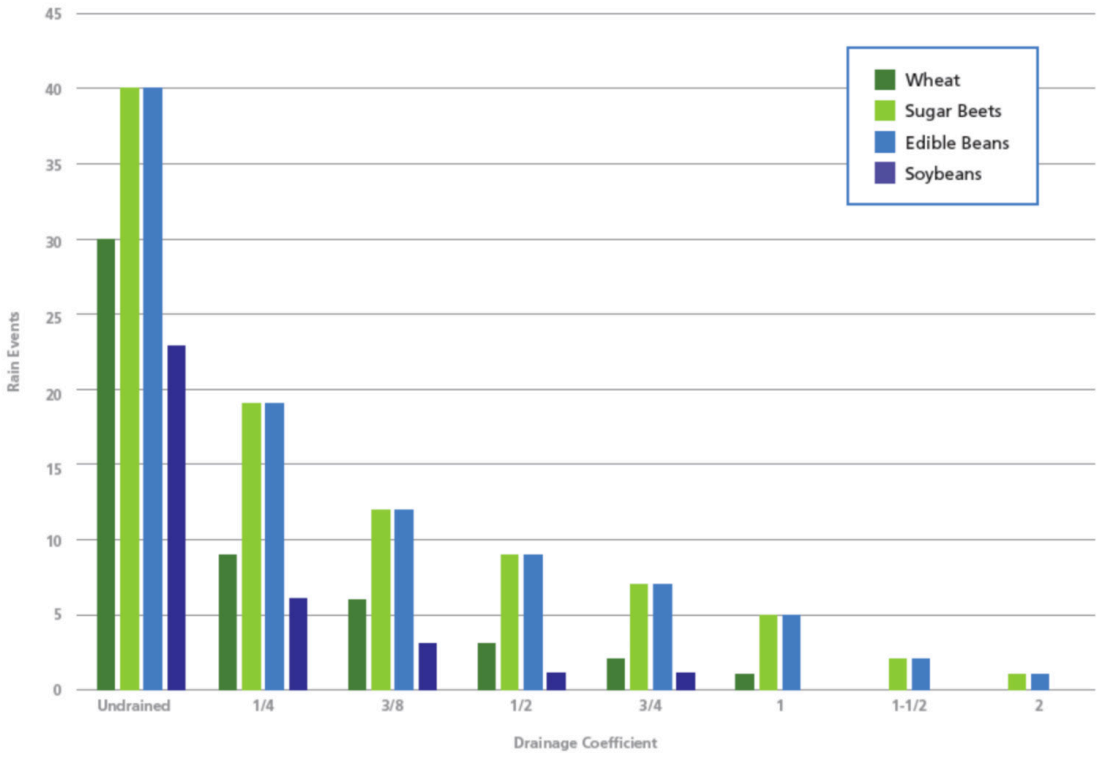
Historical rainfall data provided by DTN

Daily rainfall events over the last 5 years in your area. The horizontal dashed lines represent the rainfall amount that a crop can handle without drainage before the crop is damaged or drown out – resulting in impacted yields or complete losses.



Daily rainfall events data provided by DTN

The number of significant, negative yield-impacting rainfall events over the five-years on this field and the difference in impact if the field were to remain undrained as well as if tiled with different drainage coefficients.



An Element advisor can help you use Element's tools to look at your fields individually and understand what weather, crop and soil data can tell you about your specific drainage needs. To find out more contact us.

1. Fausey, N. R., Baker, B. J. (2003). Effects of subirrigation on soil properties. (2003). ASABE Meeting Presentation, Paper Number: 032086.

DIGGING DEEPER INTO DRAINAGE

Salinity

Crop yields and production are affected by salinity. Soil salinity is the dissolved mineral salt content (Na2SO4) in the soil on a weight basis (Kahlown, 1998). Salinity can be caused by irrigation, left behind by precipitation or the soil itself can contribute to salinity.

Over time, as the soil minerals weather they release natural salts. These salts are removed from the soil profile by the soil's drainage. If the water table in the soil is too high, the salts will not be able to leach downward and can be brought closer to the surface by capillary action. Tile drainage can lower the water table and help leach the salts out of the soil profile, improving plant health.

Impacts and Ideas On Salinity

- Subsurface drainage and irrigation used together can reduce salinity by 18-86% (Azhar, 2010)
- Whole plant response is stunting of growth, predisposition to infection by soil pathogens and reduced nutrient uptake and nutrient accumulation (Maas, 1999)
- Reduces growth rate, primarily because it increases the energy that the plant must use up, to acquire water from the soil (Kahlown, 1998)
- Total concentration of salts and various discharged ions has been decreasing somewhat logarithmically from the time the tile systems were installed (Pillsbury, 1965)
- With the use of irrigation, total salt load can decrease by 24%-43% (Xinlin, 2016)

Water Quality and Environmental Benefits

An understated benefit of a drainage system, is human's ability to control where water goes. When control is instilled, our ability to maintain water quality and sustainable practices is amplified.

- Controlled drainage reduces nitrogen losses in drainage by 17-80% during both the growing season and fallow months (Skaggs, 2010)
- The soil heterogeneity had the most effect on the water quality variables (Jia, 2012)
- Controlled drainage reduced nitrate concentrations in the water by 38% and reduced total nitrate loss by 37% (Tan, 1999)

Sodicity

Sodicity is the amount of sodium (Na+) held in a soil and causes tillage problems, poor seed germination and restricted root growth. Sodicity issues stem from the the same causes as salinity (soil mineral breakdown, and management practices). Further, a high water table also contributes to sodicity problems. Managing sodicity is also similar to managing salinity, but first a calcium supplement is added to the soil to change the sodium (Na+) to a salt (Na2SO4). Then tile drainage can be utilized to help leach the salt out of the soil profile and help control the water table. Reclamation of sodic soils takes longer due to the degradation of the soil structure and the dispersion of the clay particles – resulting in decreased micro and macro pores (Kahlown, 1998).

Tile Spacing & Patterns

Tile spacing and patterns can be different from field to field and should be assessed on an individual basis. Various academic studies throughout the years have looked to quantify yield gains from tile spacing and pattern differences.

AN INVESTMENT MENTALITY

In any business, return on investment (ROI) is a guiding principle. And when your fields make up your business's portfolio each decision needs to be calculated. Improvements in productivity of your farmland mean higher yields, and that translates into greater returns. A drainage ROI decision is based on whether the higher crop returns will justify the investment it takes to install drain tile. All factors should be considered while calculating ROI. For example, a field that is able to dry out quicker may afford the ability to plant and harvest earlier in the spring and fall and a longer plant and harvest window allows efficiencies to a farmer that can translate to real time and money – particularly for farmers who have large acreages to cover.

Just like a mutual fund's performance in the stock market depends on the collective success of the individual funds within it, the individual investments made on the farm collectively make up the operation's overall success.

The inputs you purchase, and the treatment you provide to your fields is variable. Your investment level depends on (and is determined directly from) your return on investment. Drainage tile decisions are no different. And any factor that could manipulate drainage ROI needs to be considered during the planning process. These factors include:

Soil Productivity

Not all soils are created equal; each soil is unique in its ability to produce high yielding crops. Your best soil may not be producing to its full capacity. A properly engineered drainage system can help you maximize the potential of each type of soil.

Weather History

Our weather patterns are changing and our approach to drainage needs to change with it. Your drainage system needs to be engineered with weather patterns in mind.

Drainage Coefficient

One size doesn't fit all when it comes to a drainage system. Your farm is unique and your drainage system should be engineered accordingly. Selecting the proper drainage coefficient for your farm is critical when maximizing yield potential.

Crop Value and Potential

Each crop has its own set of risks and cost associated with production. Your drainage system should take these factors into consideration to ensure this valuable asset is protected from wet feet and potential yield loss.

ELLINGSON IS YOUR WATER MANAGEMENT PARTNER FROM CONCEPT TO CONSTRUCTION.

At Ellingson Water Management we combine science and technology with a half-century of practical experience in field drainage to consistently deliver results. From land assessment, to planning and design, to drain tile installation, mapping and record-keeping: our bundled full-service solutions help gain more production from your land. Our goal is to truly partner with our clients as their trusted water management advisor. By leveraging in-field experience, data and technology we provide valuable insights that allow our clients to make informed decisions that maximize productivity and ensure sustainability for future generations.

To get started on your customized water management plan, contact us at 888.527.2294.

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