

The Basics of Agricultural Tile Drainage

Basic Drainage Science and Principals

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**Sunrise Acres Farm
Sheboygan Co.
August 22, 2018**



Overview

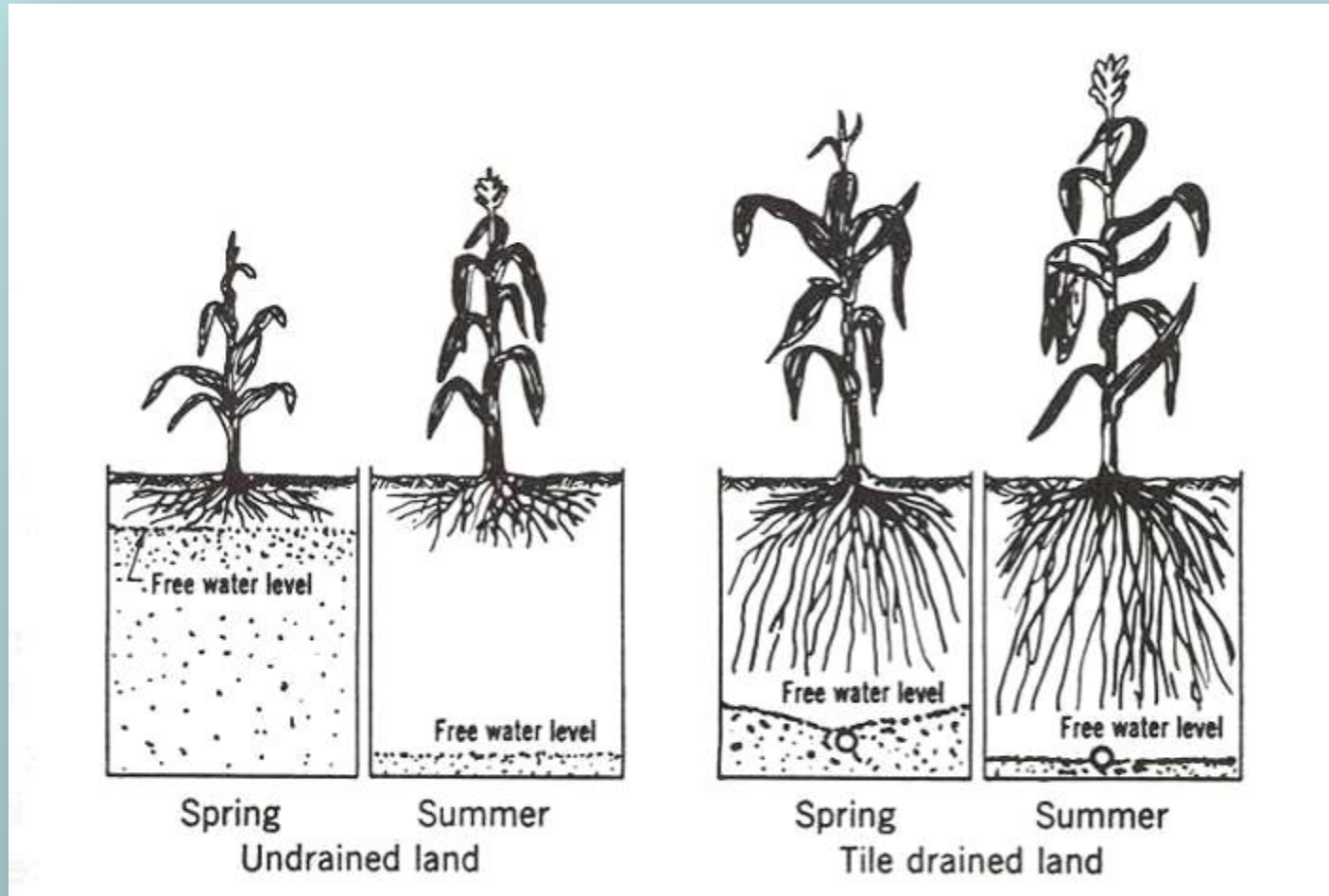
- Basic Drainage Science -

- ✓ Design objectives, benefits and risks.
- ✓ Drainable water and tile system layouts.
- ✓ Locating tile lines in the field and introduce the drainage coefficient.

System Design Objectives

1. Maintain water table at proper level for healthiest plant growth.
2. Keep soil voids free of excess water, which permits air flow and allows important biological processes to take place in soil.
3. Minimize inefficient equipment operation caused by wet areas.

System Design Objectives



Improved Root Development

Benefits of Subsurface Drainage

- ✓ Increase crop yields and field trafficability.
- ✓ Greater soil water storage capacity.
- ✓ Conserve topsoil by reducing runoff.
- ✓ Raises soil temperature

Dry soil is warmer than wet soil. It takes 5 times as much heat to raise an equal volume of water 1° as it does to raise an equal volume of soil 1°.

Environmental Risks of Tiles

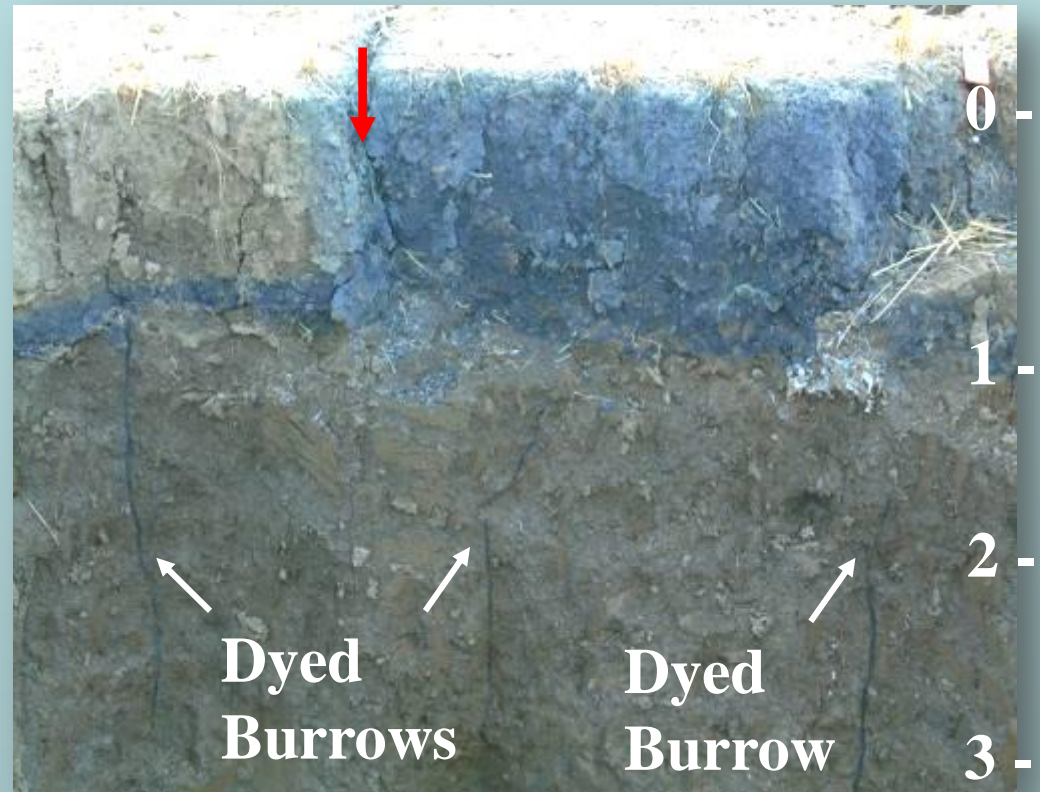
- ✓ Increased export of nutrients (NO_3 and P), pesticides and pathogens.
- ✓ Surface inlets act direct conduits to receiving waters.
- ✓ Macro-pores (roots and earth worm holes) are natural direct conduits.
- ✓ Drainage of wetlands is illegal !

Environmental Risks of Tiles

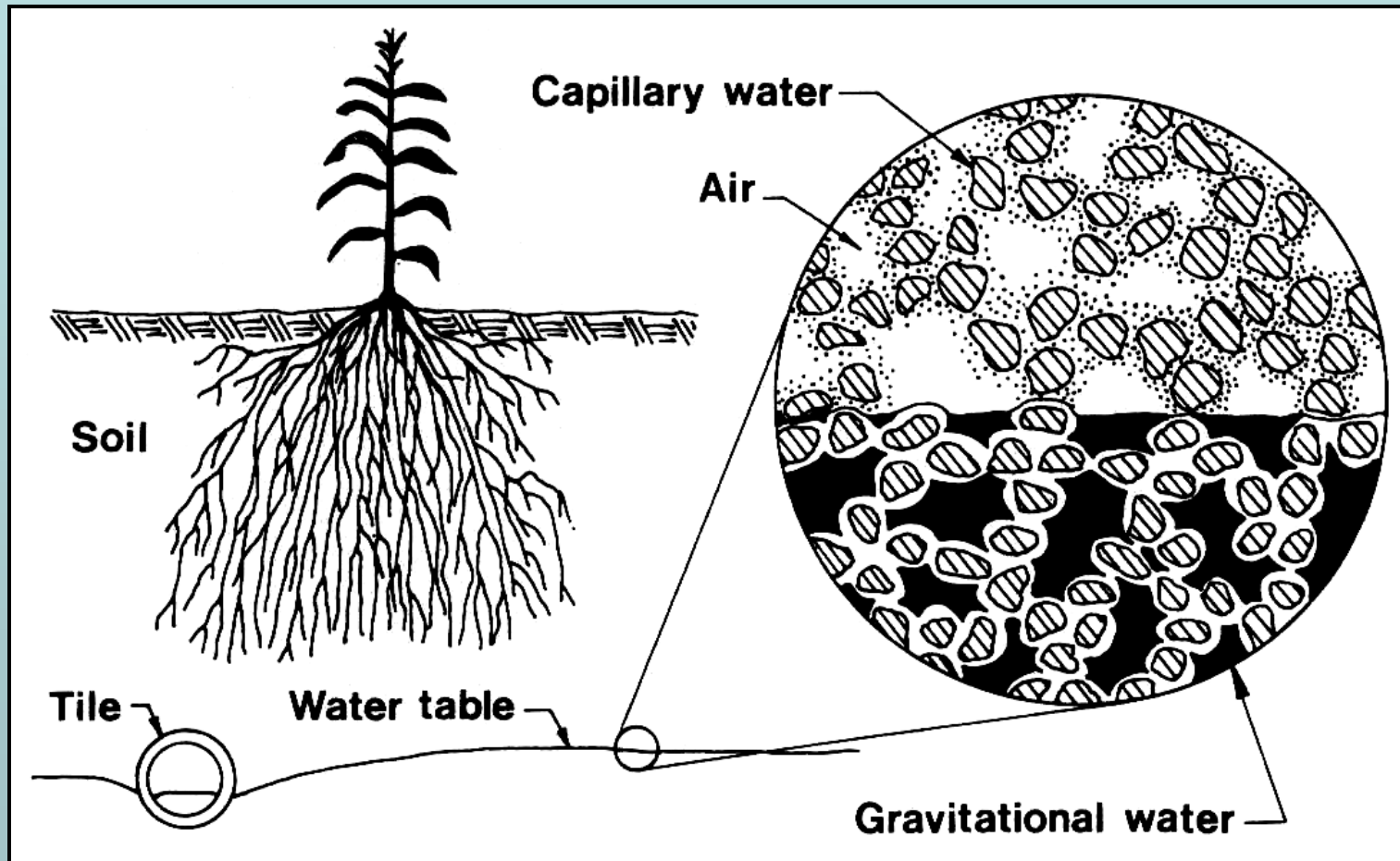
- Macropores -

Preferential flow

- Earthworm burrows
- Root holes
- Shrinkage cracks
- Structural porosity

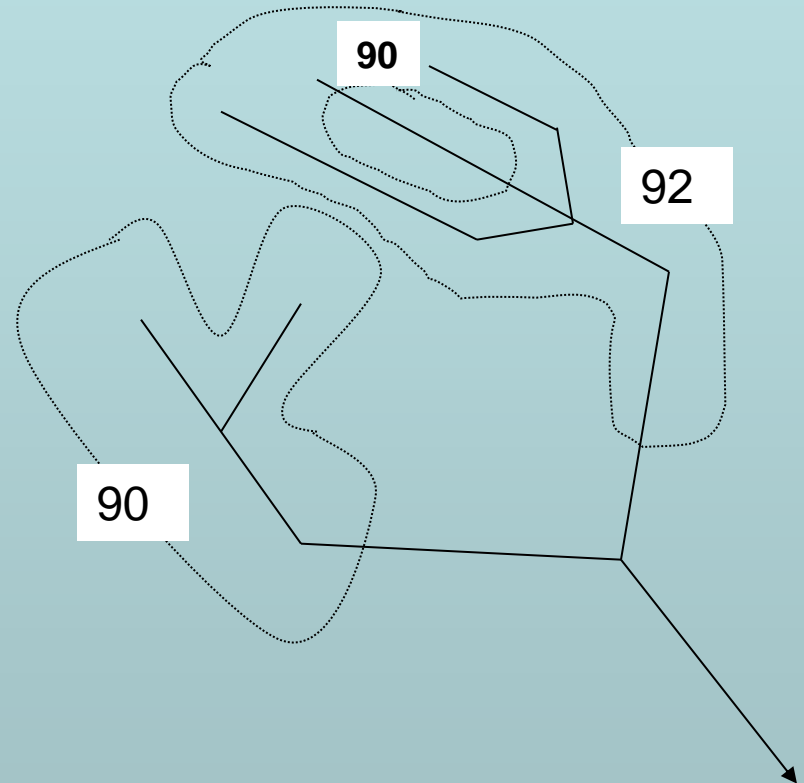


Drainable Water



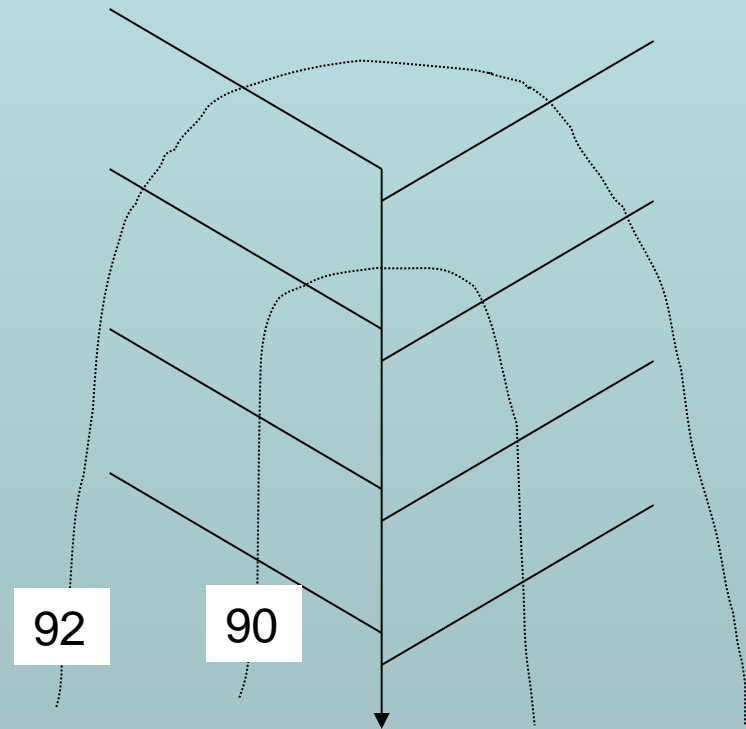
Natural or Random

- ✓ Follow natural depressions.
- ✓ Used frequently in “pot hole” landscapes to drain isolated depressions.



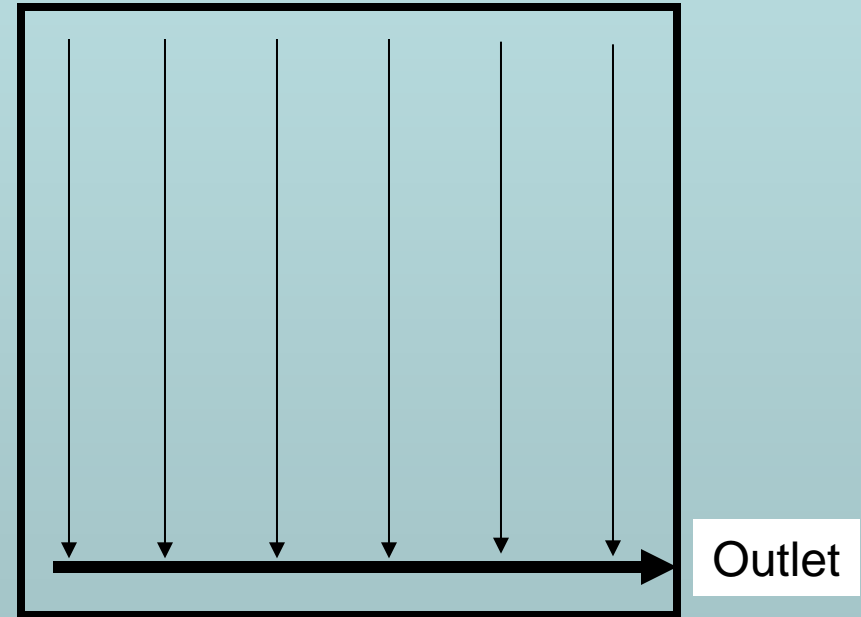
Herringbone

- ✓ Advantageous for heavier soil often found in narrow depressions.
- ✓ Double drainage around main.
- ✓ More junctions – Added cost



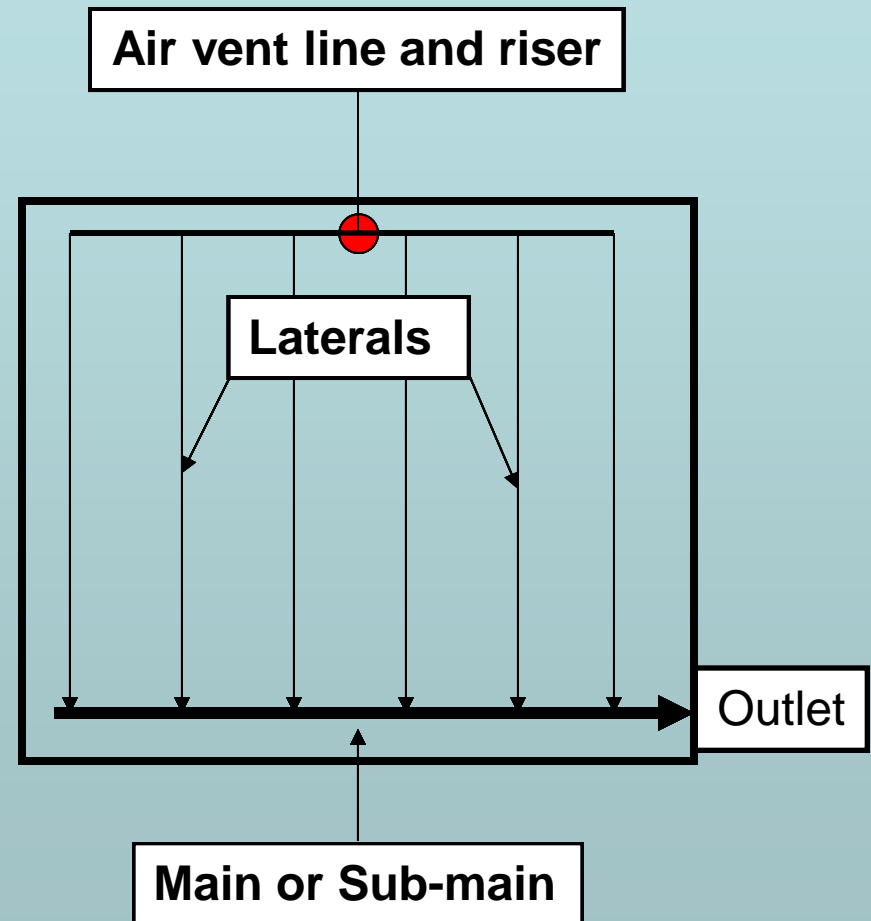
Gridiron

- ✓ Drainage of level areas, uniform slopes and soils w/ widespread wet areas.
- ✓ One main or sub-main serves as many laterals as possible



Tile System Components

1. Laterals are the initial collectors.
2. Sub-main or collector-main collect from laterals.
3. Mains collect from sub-mains and collector-mains.

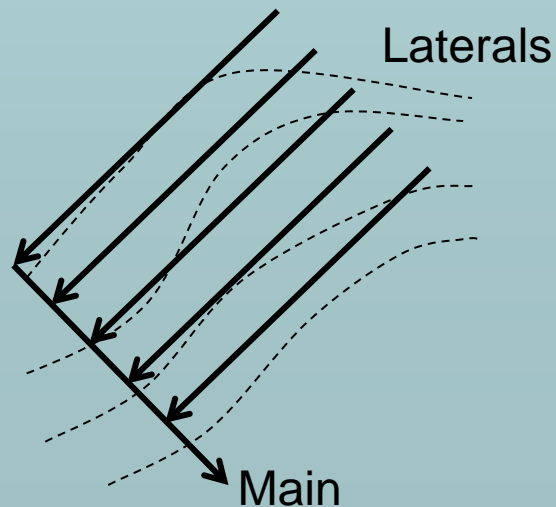


Tile System Layout

Always start with contour map of the field !

When feasible and site conditions allow

- ✓ Place field laterals on the contour to maintain a uniform depth and improved drainage uniformity.
- ✓ Place mains and sub-mains on steepest grades to decrease pipe size.

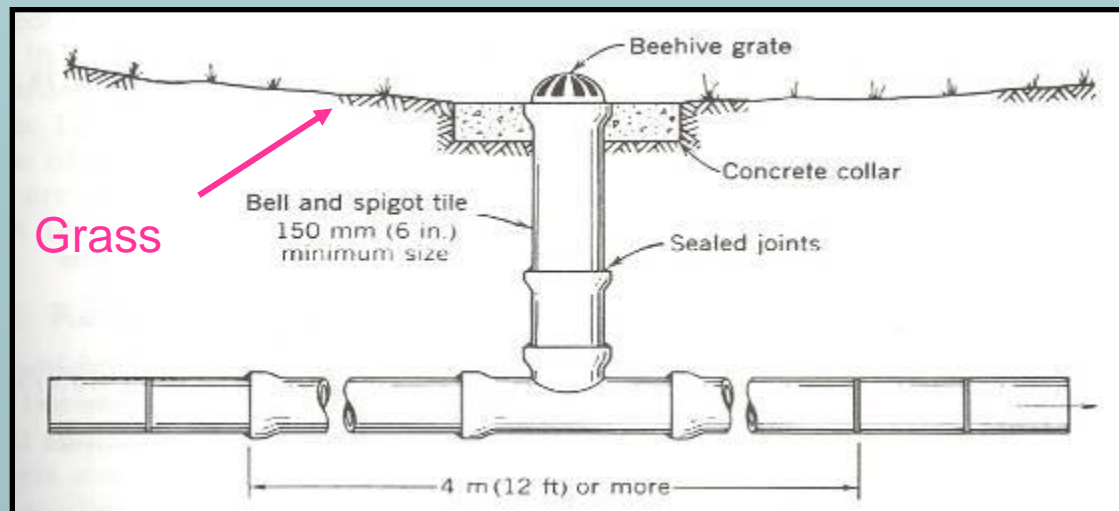


Surface Inlets

- ✓ Increased potential for water quality impacts.
- ✓ Finer inlet screens and rock filters reduce sediment inflow

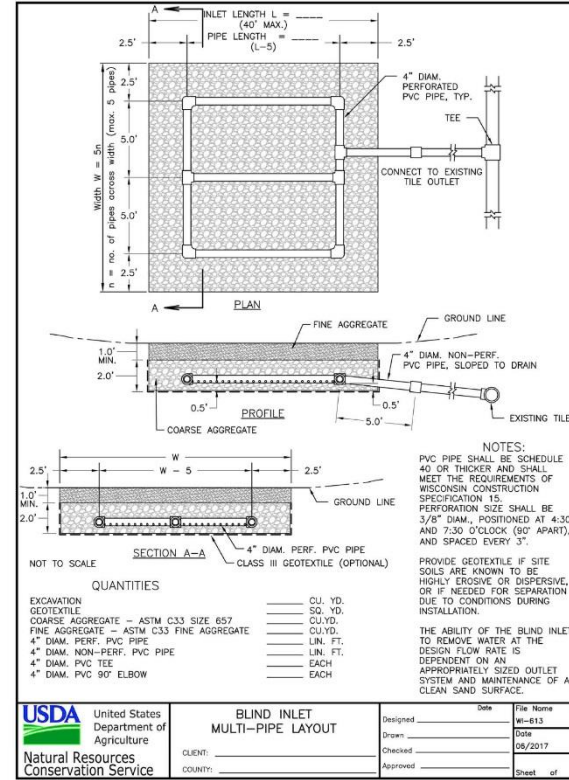
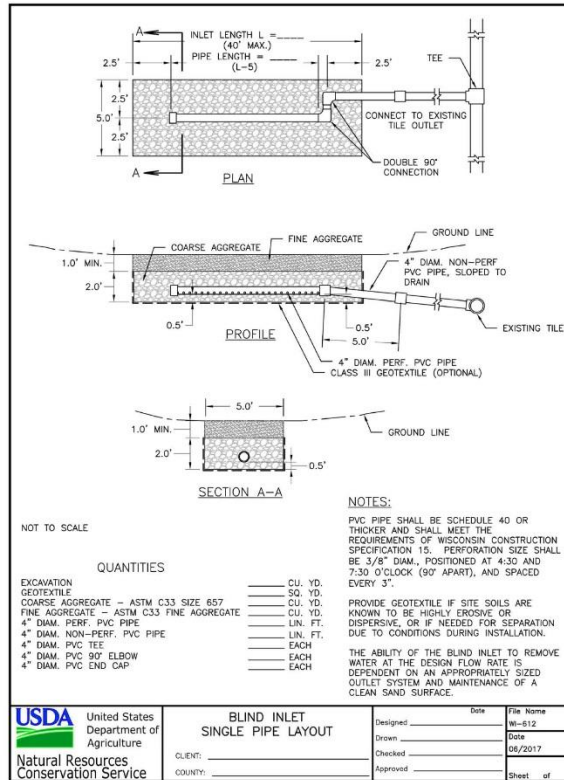


Hickenbottom Inlet



Blind Inlet Design

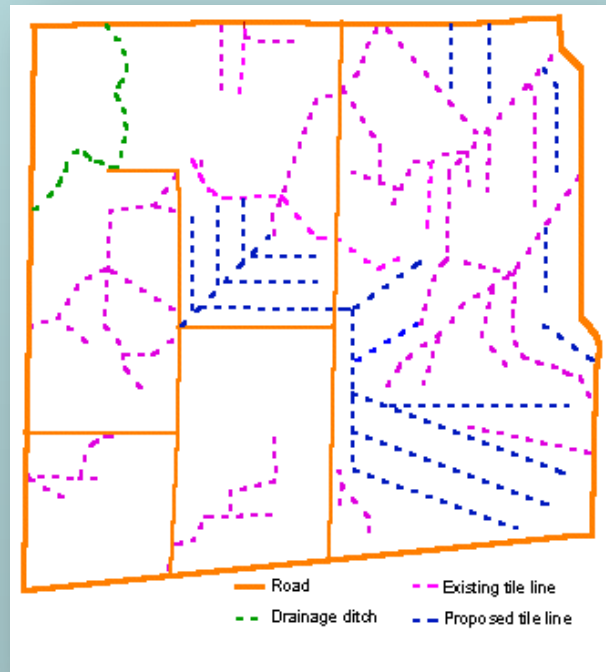
- Wisconsin NRCS Standard -



Drawings 612 and 613 on blind inlets for tiles can be found in the Engineering Section of the WI-NRCS Home Page

Field Locating Tile

There is no hard and fast method !!



As-Built Plans

Recorded during or shortly after installation.

Not often available

Field Locating Tile

Crop Health



Regular patterns in crop stand health and yields can indicate tile line location.

Yield monitors make this very evident !



Field Locating Tile

Air Photos

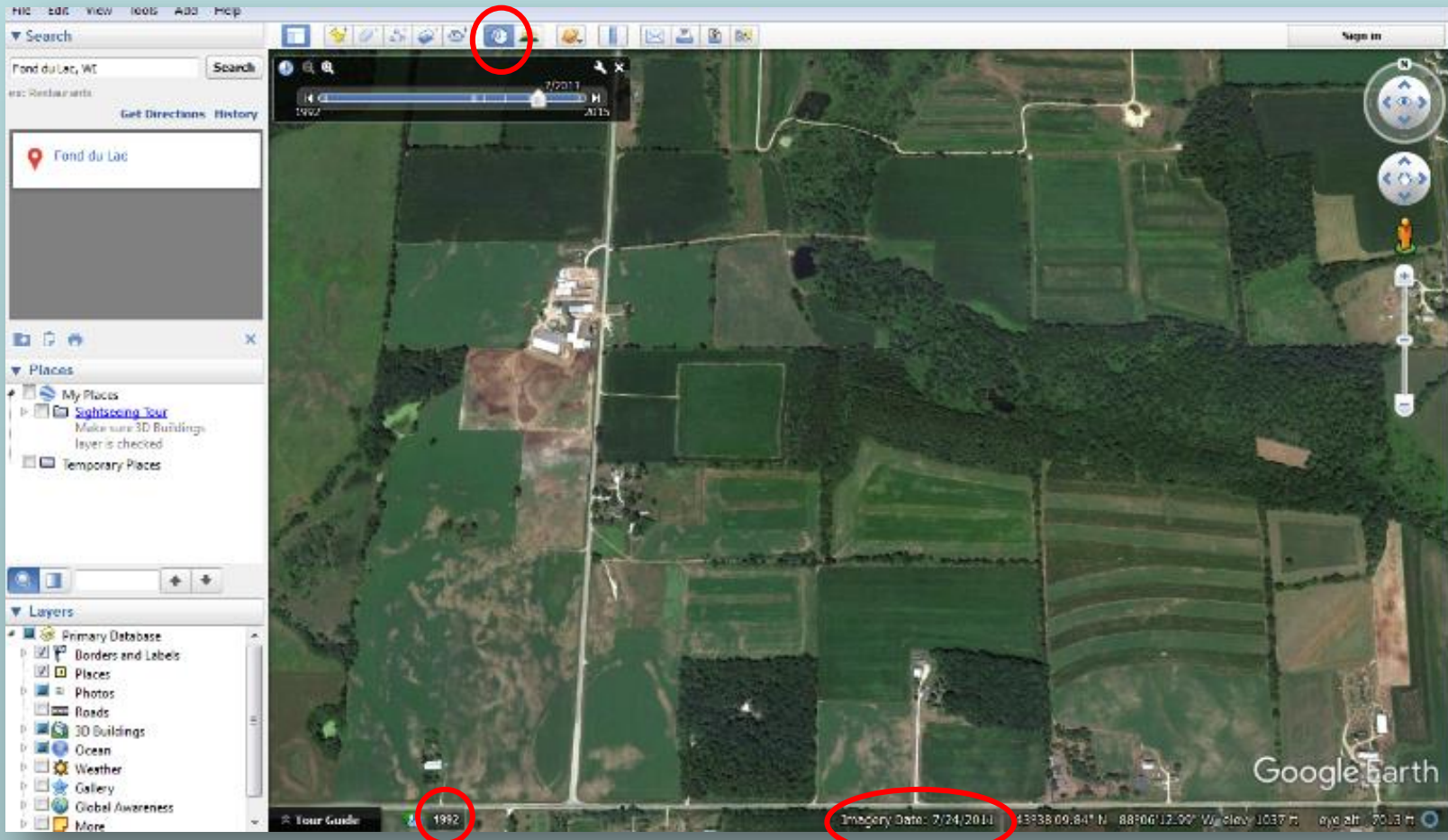


Electronic soil survey map from Outagamie Co., WI

Some counties also have imagery available

Field Locating Tile

Air Photos



Google Earth is another good tool !

Drainage Coefficient

- ✓ *Drainage coefficient* (D_c) or (q) is a desired water removal rate.
- ✓ The D_c equals the volume (depth (in) x area (ac)) of water to be removed from a field in 24 hours.
- ✓ Drainage area can be computed from the length and spacing of the drains.

Drainage Coefficient

- ✓ Where surface inlets are installed, the contributing watershed is the surface drainage area not the pipe drained area and the Dc value is increased.
- ✓ A higher Dc equals greater system design flow rate, larger pipes, quicker water removal and a higher cost.

Recommended Drainage Coefficients (in/day) for Pipe Drains in Humid Areas

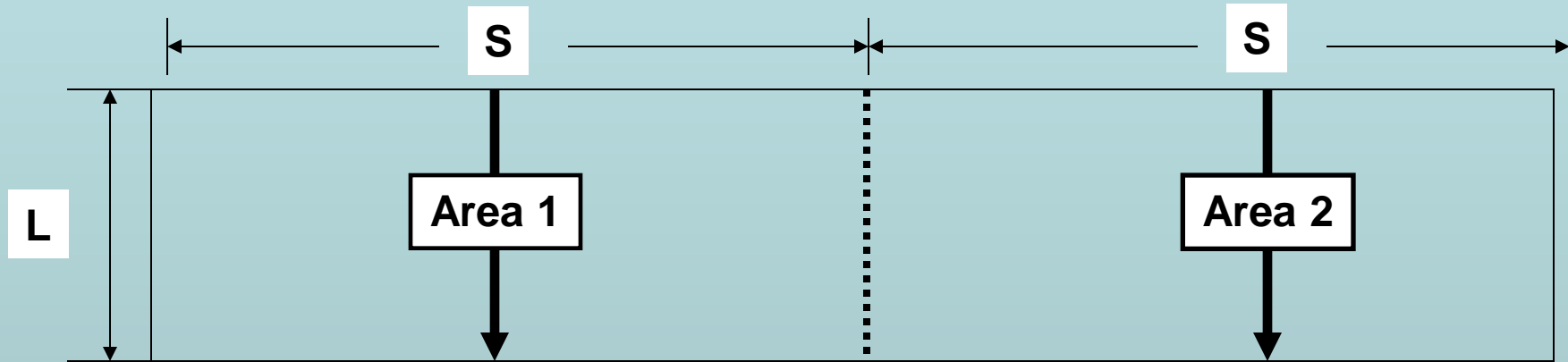
Crops and Degree of Surface Drainage	Mineral Soil (clay and silt)	Organic Soil
Field Crops		
Normal	3/8 – 1/2	1/2 – 3/4
With Blind Inlets	1/2 – 3/4	3/4 – 1.0
With Surface Inlets	1/2 – 1.0	1.0 – 1.5
High Value Crops		
Normal	1/2 – 3/4	3/4 – 1.5
With Blind Inlets	3/4 – 1.0	1.5 – 2.0
With Surface Inlets	1.0 – 1.5	2.0 – 4.0

This is essentially a simple risk management framework

Drainage Coefficient

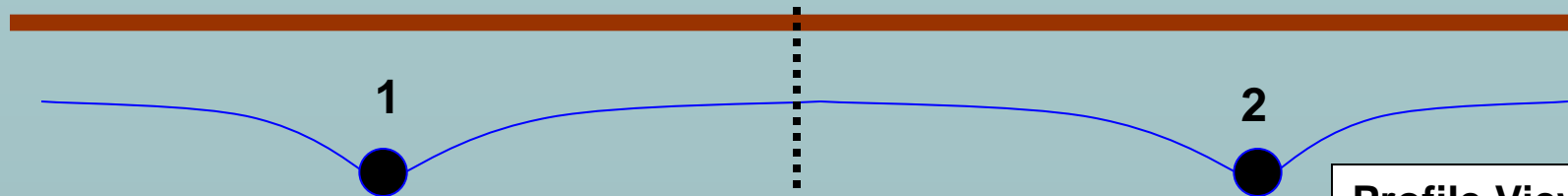
Drainage Coefficient (Dc) = Depth rate (in/day)

Area x (Dc) = [ac] · [in / day] / 23.8 = Flow rate (ft³/sec)



Plan View

Also applies at the whole field scale



Profile View

Drain System Construction

- ✓ Equipment and materials.
- ✓ Drain outlet, depth and spacing.
- ✓ Installation sequence.
- ✓ Where to get more information.

Drain System Construction

-Things to Think About -

- ✓ You need a good topographic map.
- ✓ You need an accurate way to control grade (Engineer's Level, Laser, RTK GPS).
- ✓ What about pipe layout, locating (mains and laterals).
- ✓ Are there any buried utilities in the field.
(Power Lines, Gas Pipelines !!)

Drain Tile Installation Equipment



Tractor Backhoe



Tile Plow



Chain Trencher



Wheel Trencher

Drain Tile Materials



Clay Tile (organic soils)



Concrete Tile (mineral soils)



Drain Pipe Materials

- Polyethylene Plastic -

Single wall corrugated



Dual wall (smooth wall)



Water enters the pipe through slots in wall

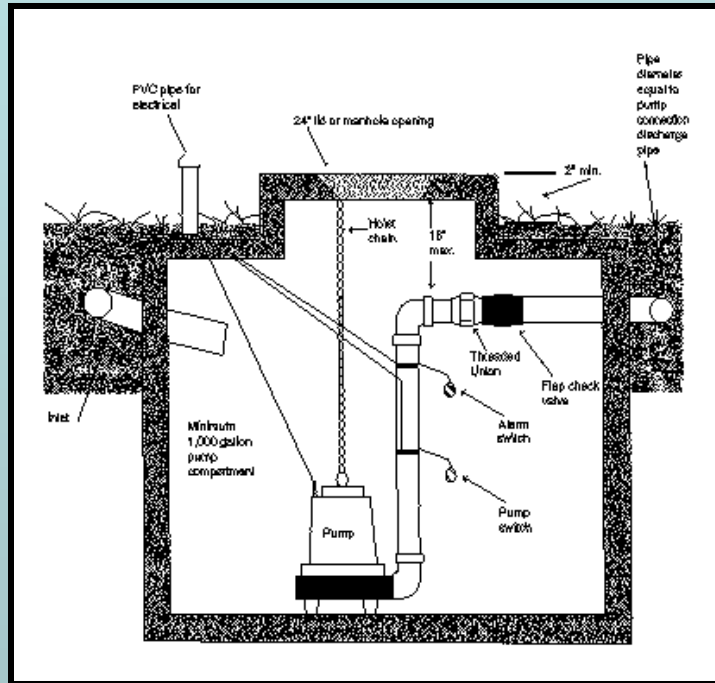
The Drain Outlet

- ✓ MUST have sufficient grade for gravity flow !
< set preliminary grade>
 - If not, a pump station will be necessary.
- ✓ Receiving water must have adequate capacity.
- ✓ Provide guards to keep animals out.



- ✓ Daylight outlet pipe
1 ft above base flow
in receiving channel

Drainage Pump Stations



When you don't have the fall to use gravity

The Drain Outlet



State of Wisconsin

Department of Agriculture, Trade and Consumer Protection



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DATCP Home > Drainage Districts

Drainage Districts

About a third of Wisconsin farms depend on constructed drains to remove excess water from their land. Most of these are operated by a single landowner or by voluntary cooperation among neighbors. However, about 10 percent of these drains are organized as drainage districts, governed by county drainage boards. The Wisconsin Department of Agriculture, Trade and Consumer Protection regulates drainage districts under Wisconsin law.

[Approved consulting engineers](#)

[Annual reporting requirements](#)

[Training materials](#)



Additional Resources

[Drainage program factsheet](#)

[Interactive map of Wisconsin drainage districts](#)

[Drainage board handbook](#)

[List of approved consulting engineers](#)

[WI Statutes Chapter 88](#)

[Administrative rule ATCP 48](#)

[Drainage Board Directory](#)

Contacts

christopher.clayton@wi.gov
(608)224-4630

https://datcp.wi.gov/Pages/Programs_Services/DrainageDistricts.aspx

Lateral Depth and Spacing

Varies with soil permeability, crop and soil, kind of management practices crop, extent of surface drainage.

Typical drain depth range = 3 to 5 ft.

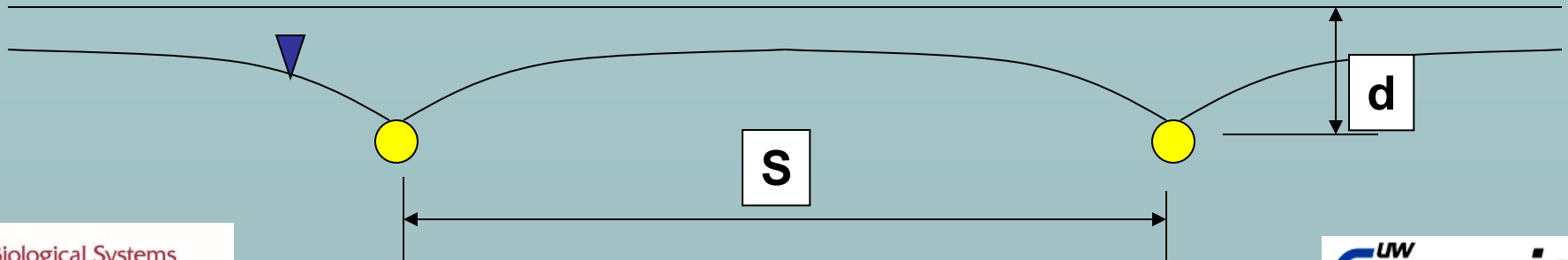
Typical spacing = 30 to 100 ft.

Depth / spacing balance to minimize cost.

Minimum cover greater than 2.5 ft.

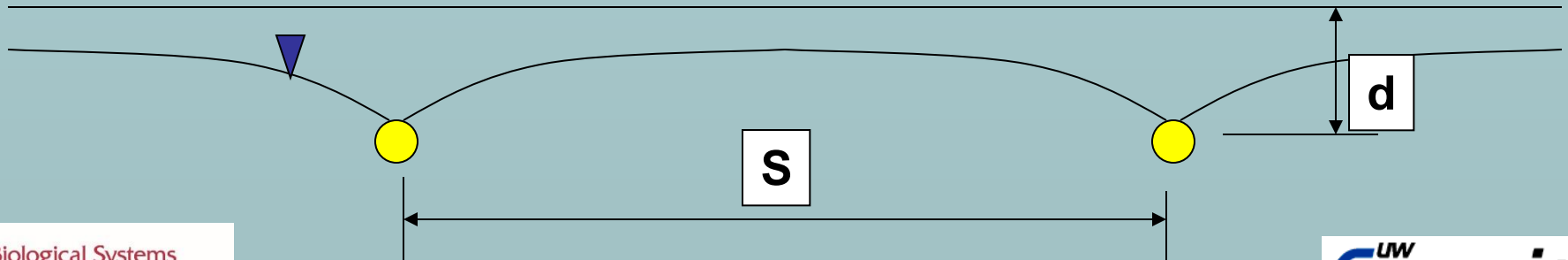
Lateral Depth and Spacing

- ✓ A relationship exists between depth and spacing of drains.
- ✓ For soils of uniform permeability, the deeper the drains, the wider the spacing (within limits).
- ✓ Higher permeability soils can have greater spacing.
- ✓ Need to provide adequate root depth above the saturated zone.



Lateral Depth and Spacing

The goal is to maintain as consistent a D_c value across the field as possible.



Drain System Construction

- More Things to Think About -

- ✓ What Dc should I use for the system.
- ✓ A pipe at a steeper grade will carry more flow one at a flatter grade.
- ✓ A pipe with a smooth interior will carry more flow than one with a rough lining.

Drain System Construction

- More Things to Think About -

- ✓ A larger diameter pipe will carry more flow at the same grade than smaller diameter pipe.
- ✓ The capacity of the tile main line will need to increase going downstream as drained area increases, “telescoping the main”.
- ✓ Maintain minimum velocity to clean pipe.
(0.5 ft / s - No silt; 1.4 ft / sec - w/silt)

Drainage Calculator



Drainage Calculators

Utilize these calculators to address common drainage questions. Additional information is available on [iGrow](#)


Pipe Size -> Area Drained	Area Drained by Pipe Sizes	Avg. Hydraulic Conductivity	Drain Spacing
Drainage Coefficient	Grade -> Fall	Fall -> Grade	Min. Grade Needed
Hydraulic Conductivity Converter	Max. Lateral Length	Length -> Lateral Sizing	Max. Laterals on Main
Area Drained -> Pipe Size	Pump Size	Subirrigation Spacing	Sump Storage

Visit [iGrow.org](#) for the latest information from SDSU Extension. This tool was developed in collaboration with [University of Minnesota Extension](#)

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<http://www.igrowdrainage.org/>

Tile spacing - Example



Drainage Calculators

Pipe Size -> Area Drained

Area Drained by Pipe Sizes

Avg. Hydraulic Conductivity

Drain Spacing

Drainage Coefficient

Grade -> Fall

Fall -> Grade

Min. Grade Needed

Hydraulic Conductivity Converter

Max. Lateral Length

Length -> Lateral Sizing

Max. Laterals on Main

Area Drained -> Pipe Size

Pump Size

Subirrigation Spacing

Sump Storage

DRAIN SPACING

Drainage Coefficient in./day [Calculate](#)

Tile Diameter in

Tile Depth ft

Depth to Restrictive Layer ft

Minimum Water Table Depth ft

Hydraulic Conductivity Units

Hydraulic Conductivity Value

CALCULATE

RESULTS

Drain Spacing 32 ft

CLEAR ALL FIELDS

Area Drained – Pipe Size - Example



Drainage Calculators

Pipe Size -> Area Drained

Area Drained by Pipe Sizes

Avg. Hydraulic Conductivity

Drain Spacing

Drainage Coefficient

Grade -> Fall

Fall -> Grade

Min. Grade Needed

Hydraulic Conductivity Converter

Max. Lateral Length

Length -> Lateral Sizing

Max. Laterals on Main

Area Drained -> Pipe Size

Pump Size

Subirrigation Spacing

Sump Storage

AREA DRAINED -> PIPE SIZE

Drainage Coefficient

0.5 in./day

Calculate

Drained Area

20 Acres

Pipe Grade

0.3 %

Calculate

Pipe Material

Single Wall Plastic

CALCULATE

RESULTS

Flow Rate (full pipe)	0.4201	cfs
Flow Velocity (full pipe)	1.45	fps
Required pipe size is	7.3	inches

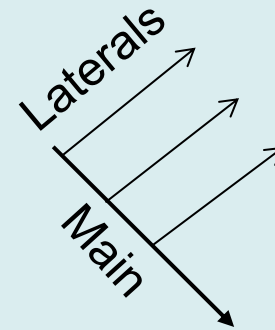
CLEAR ALL FIELDS

Note non-standard pipe size. Round up to 8 inch.

Lateral Depth and Spacing

The tile installation process

1. Mains are typically installed first and buried.
2. Laterals are then installed at the predetermined spacing.
3. Lateral installation involves:
 - Excavating down to the main.
 - Connecting into the main using a tee.
 - Install lateral (typically via tile plow) moving at a right angle away from the main.



Drainage Resources

fyi.uwex.edu/drainage/



The screenshot shows the website interface for 'Tile Drainage Resources' on the University of Wisconsin-Extension (UW Extension) website. The header includes the 'University of Wisconsin-Extension' logo on the left and 'Cooperative Extension' with a menu icon on the right. A search bar is located in the top right corner. The main content area features a blue background with a photograph of a white pipe in a field on the left. To the right of the photo, the text reads 'Tile Drainage Resources' and 'Cooperative Extension'. Below this, a navigation menu lists 'Home', 'Trainings & Workshops', 'University & Agency Links', 'Video Resources', and 'Web Resources'. The 'UW Extension' logo is also present in the top right of the main content area. The page content is divided into two columns. The left column contains a paragraph: 'This site is designed to provide farmers, conservationists, and agronomists with a variety of information and resources related to agricultural tile drainage.' Below this is a section titled 'Workshops' with a list of topics: 'Understanding Agricultural Drainage Mapping Tile Drainage Systems Controlled or Managed Drainage Systems Research Update - What we've learned from WI Farms Drainage District Overview Enabling no-till yields to increase with earthworms, drainage Corps Regulatory Process'. The right column is titled 'PAGES' and lists: 'Trainings & Workshops', 'University & Agency Links', 'Video Resources', and 'Web Resources'. Below this is a section titled 'UW DISCOVERY FARMS' with a link to 'UW Discovery Farms'.

Drainage System Cost

- Approximate ! -

Drainage system installation costs can vary ***significantly*** based on terrain, soils, outlet availability, etc.

Rough Range

~ \$1,000 - 1,500 / ac

QUESTIONS ? ? ?