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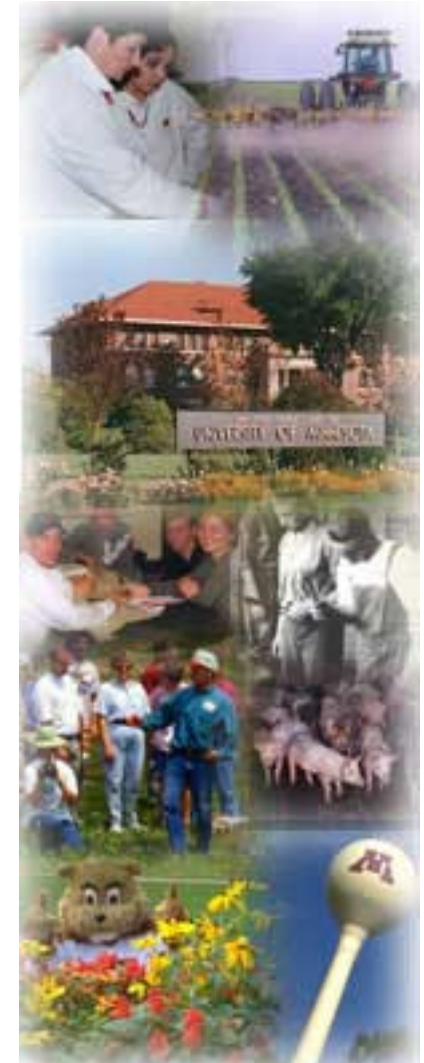
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**BIOSYSTEMS & AGRICULTURAL
ENGINEERING**



Subsurface (Tile) Drainage Design



Outline

- ◆ How drainage works
- ◆ Drainage design objectives
- ◆ The Design Process:
 - ◆ *Outlet*
 - ◆ *Layout & location of lines*
 - ◆ *Spacing & depth*
 - ◆ *Grade*
 - ◆ *Drain Sizing*
- ◆ Design Tools (throughout)

How Drainage Works

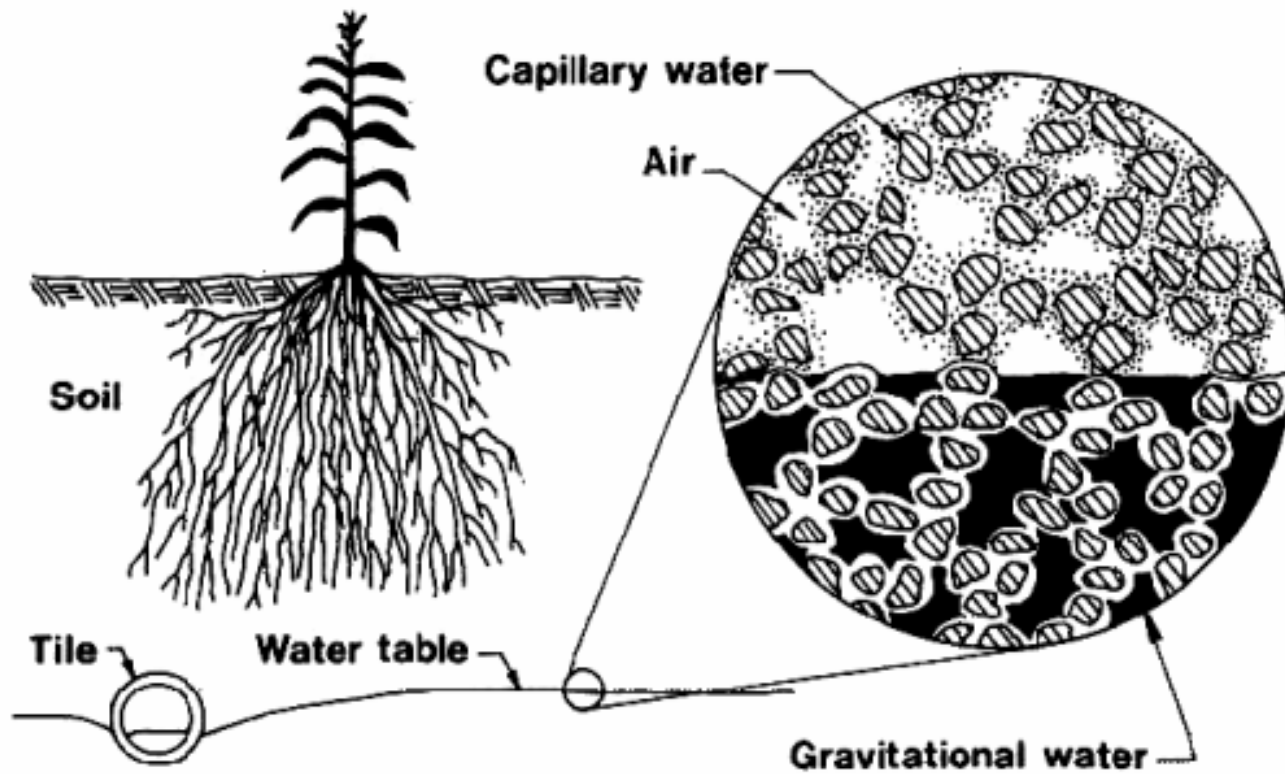


Drainage Fundamentals

- ◆ Drainable water
- ◆ “Physics” of drain flow
- ◆ Influence of design choices



Drainable Water



Drainable Water

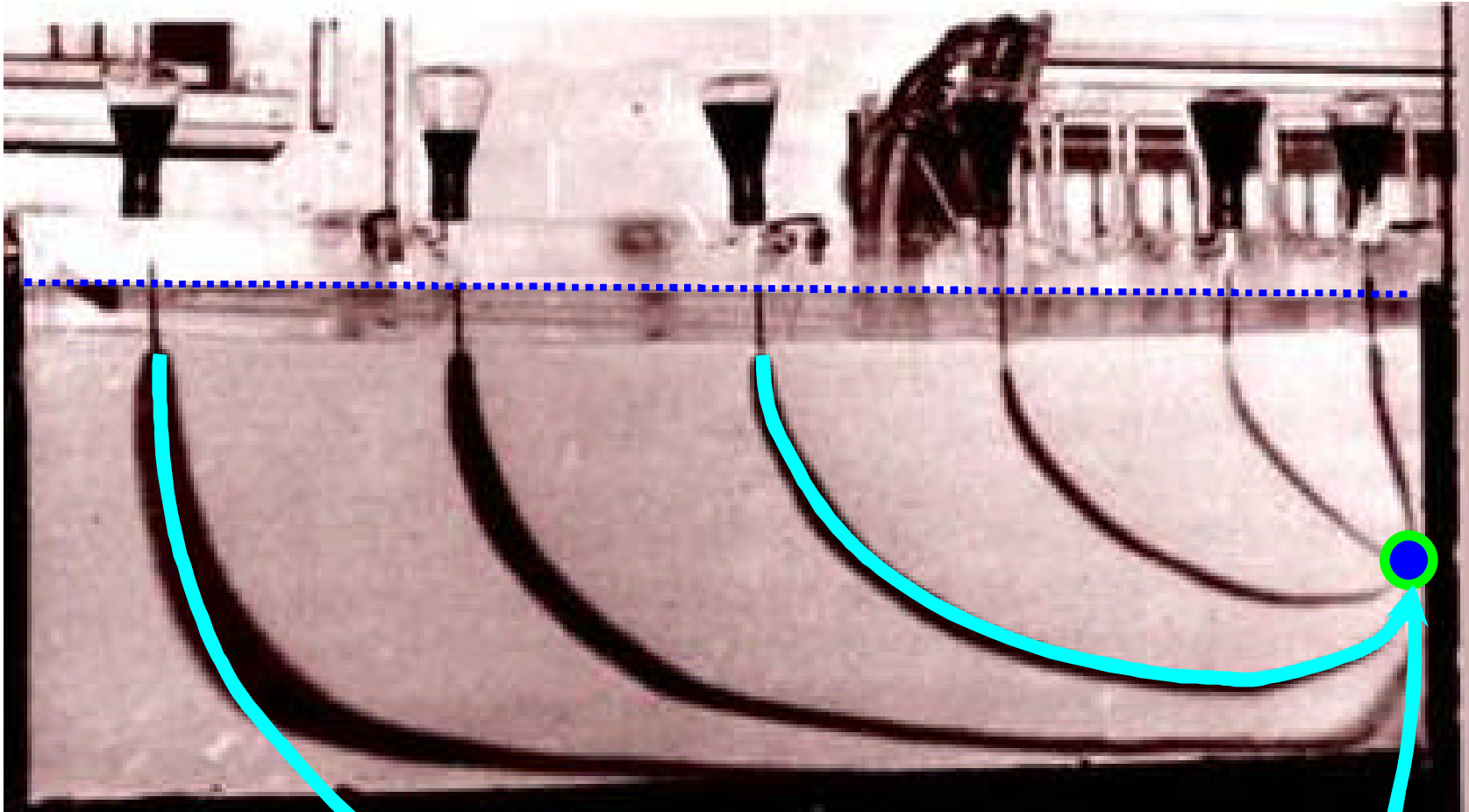
Soil Texture	Field Capacity (% by vol)	Wilting Point (% by vol)	Drainable Porosity (% by vol)
clays, clay loams, silty clays	30-50%	15-24%	3-11%
well structured loams	20-30%	8-17%	10-15 %
sandy	10-30%	3-10%	18-35 %

Example: a 5% drainable porosity means that the watertable drops/rises 100 inches for every 5 inches of water drained.

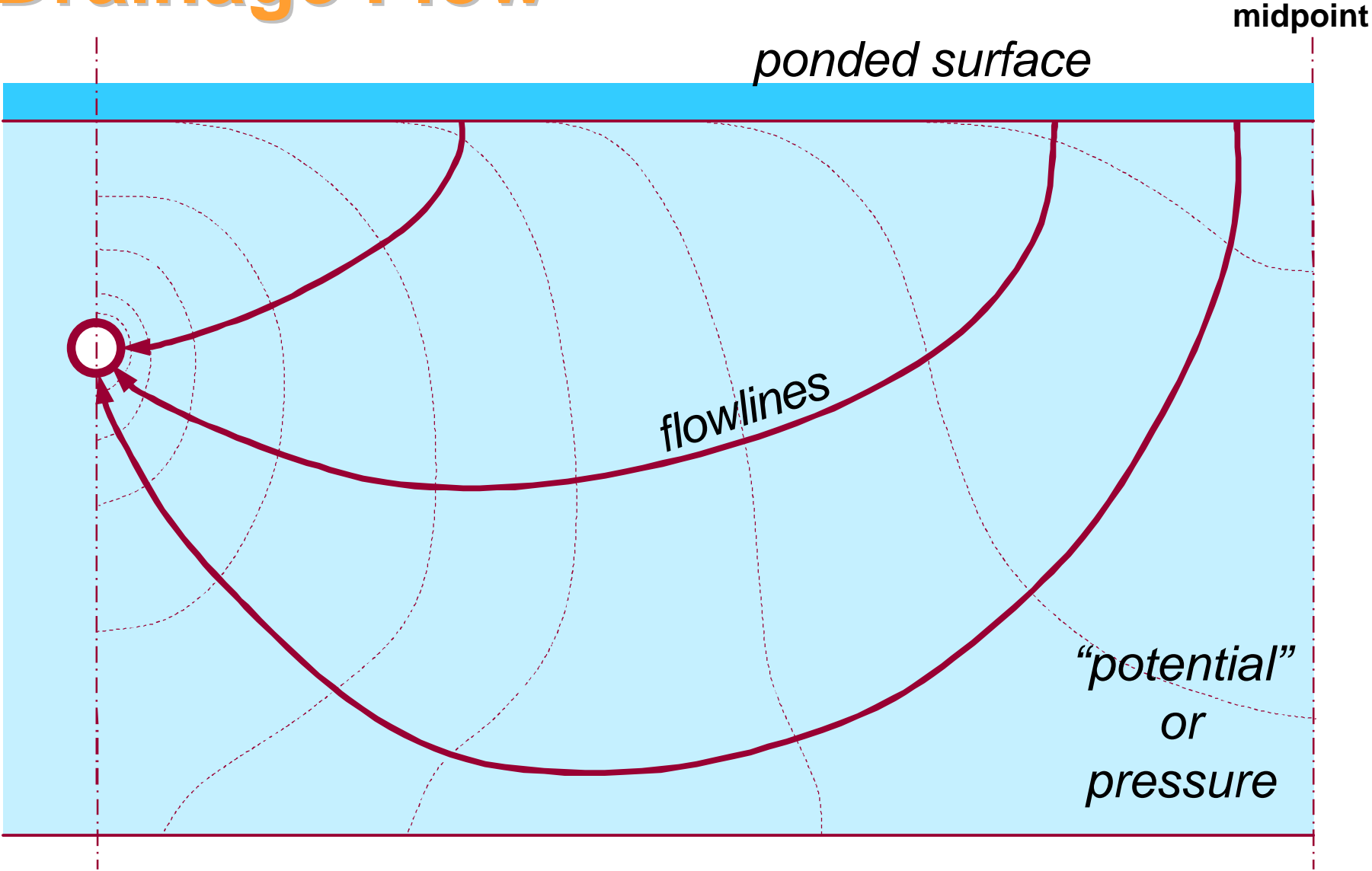
Drainable Water

- ◆ Example: A clay loam soil with a watertable at 6" below the soil surface is drained to a watertable depth of 3.5'. How much water was drained from the soil profile?
- ◆ Solution: Assuming a Pd of 8%, the volume drained is:
 - ◆ $\text{vol} = 8 \times (3.5' - .5') \div 100 = 0.24' = 2.88''$

“Physics” of Drainage Flow



Drainage Flow



Influence of “Design” Choices

- ◆ Design choices:
 - ◆ *Drain depth*
 - ◆ *Drain spacing*
 - ◆ *Drain size*
 - ◆ *System layout*
 - ◆ *Outlet configuration (elev, pumped, natural)*
- ◆ Do all of these affect water flow to the drains?

Drainage Design Objectives



You tell me!

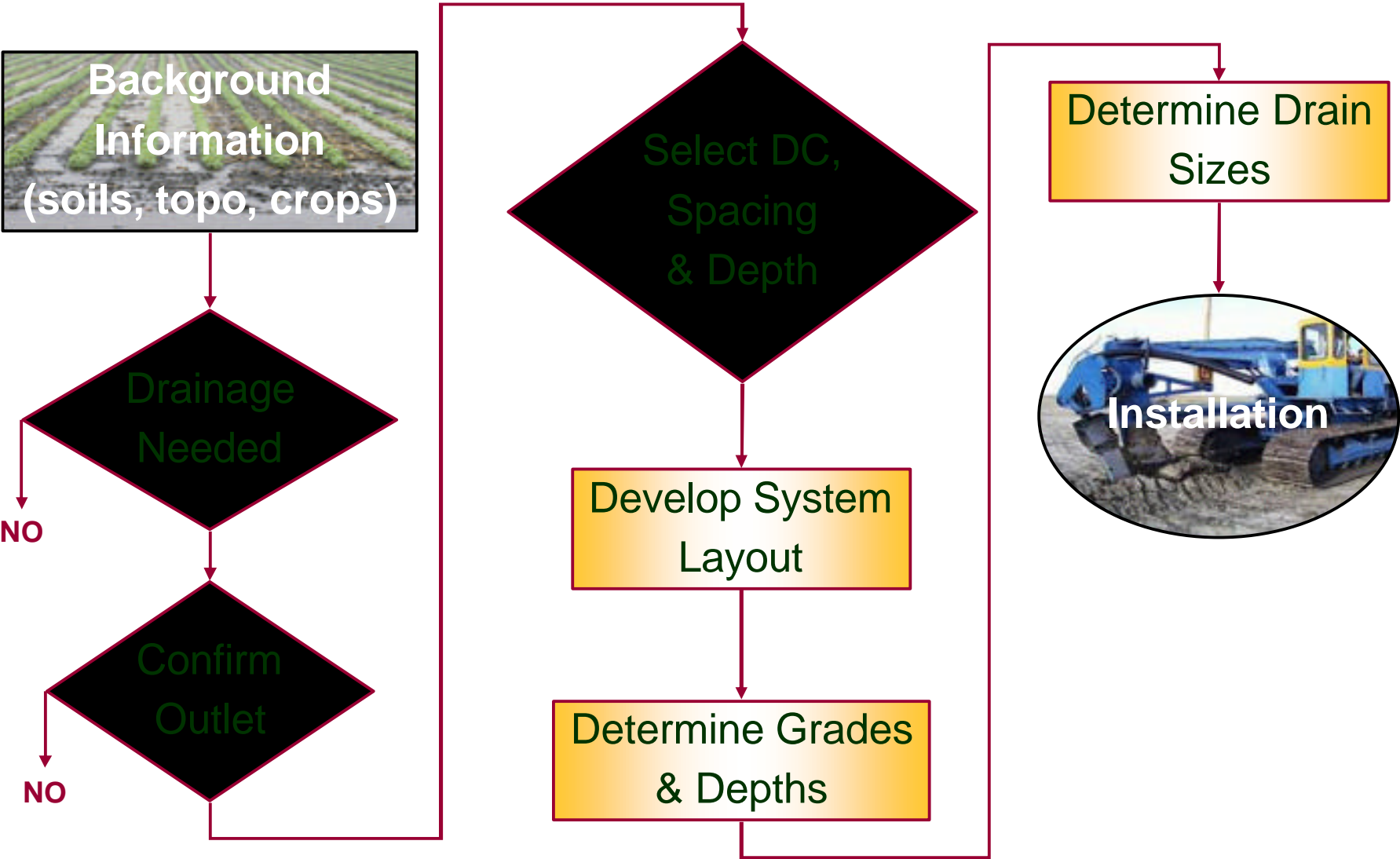
Possible Design Objectives

- ◆ Remove as much water as quickly and as cheaply as possible
- ◆ Design a system that functions with hydraulic efficiency and uniformity
- ◆ Design & install a maintenance-free system
- ◆ Provide for the agronomic needs of the crop
- ◆ Minimize unwanted environmental effects to the extent possible
- ◆ Design with future outlet management in mind

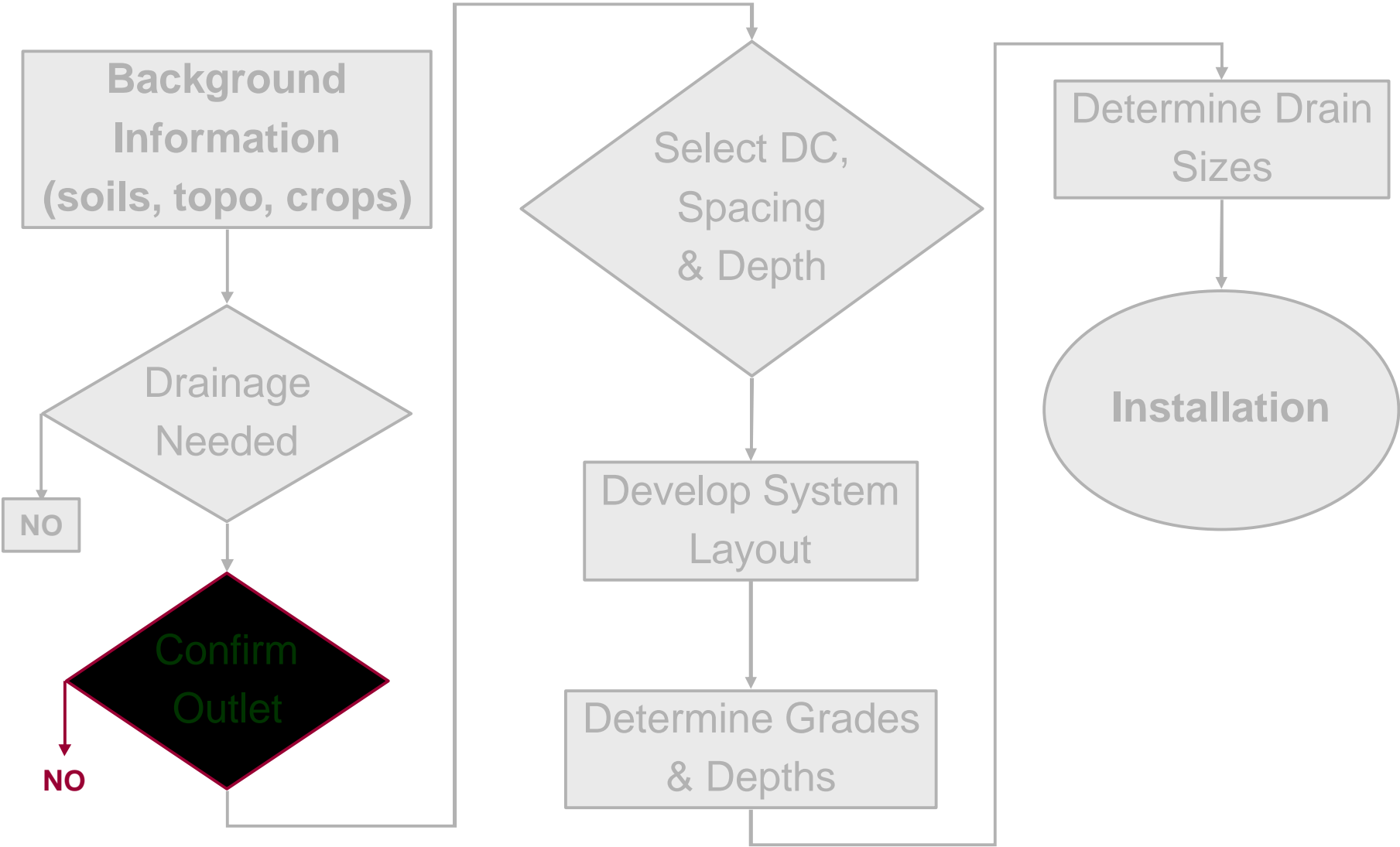
The Design Process



Design Process Flowchart



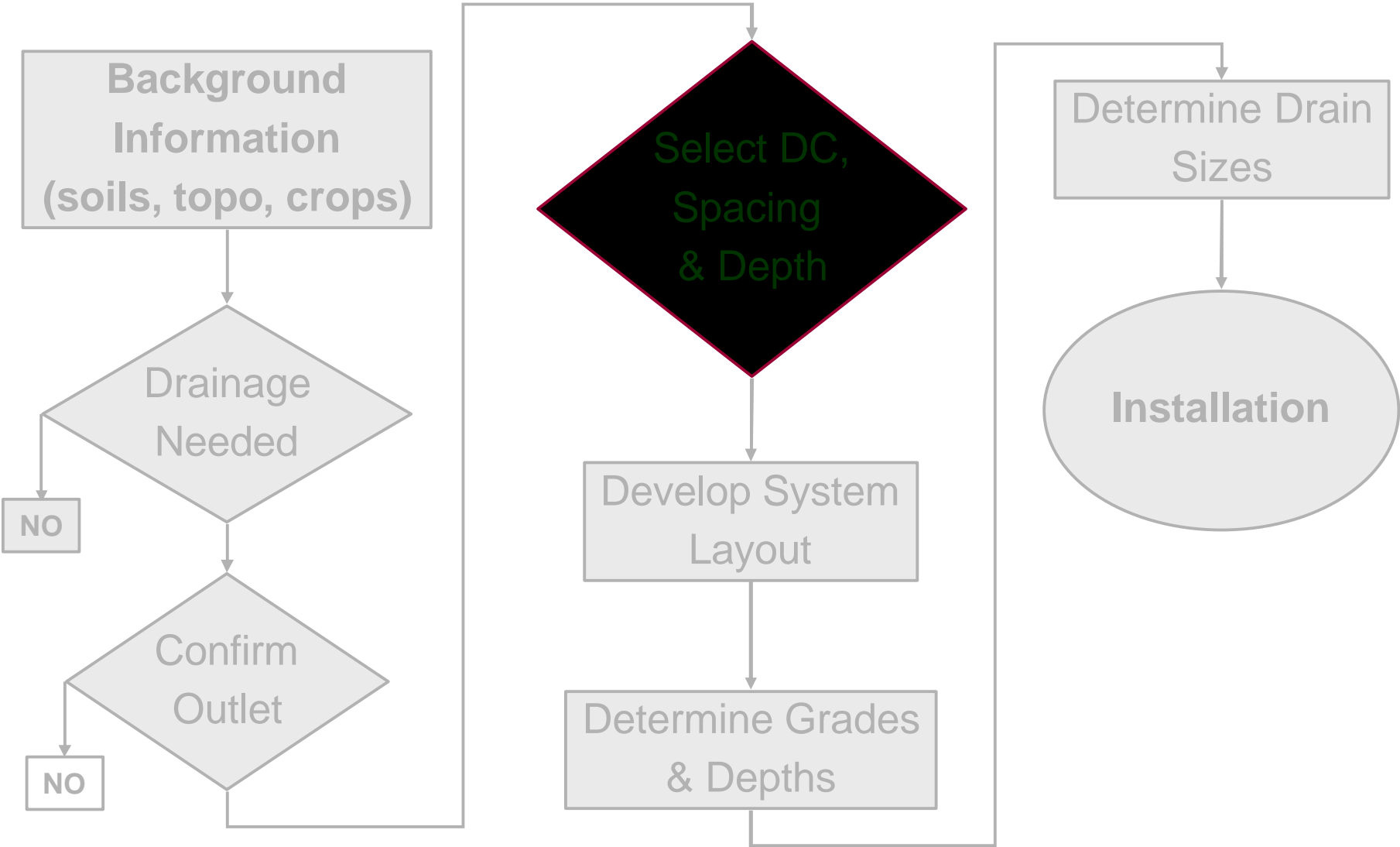
Design Process Flowchart



Outlets

- ◆ Ditch, tile main, other?
- ◆ Location (right of way issues)
- ◆ Capacity (flow and timing issue)
- ◆ Rules & regs
- ◆ Elevation (physical structure & water surface)

Design Process Flowchart



Drain Spacing & Depth

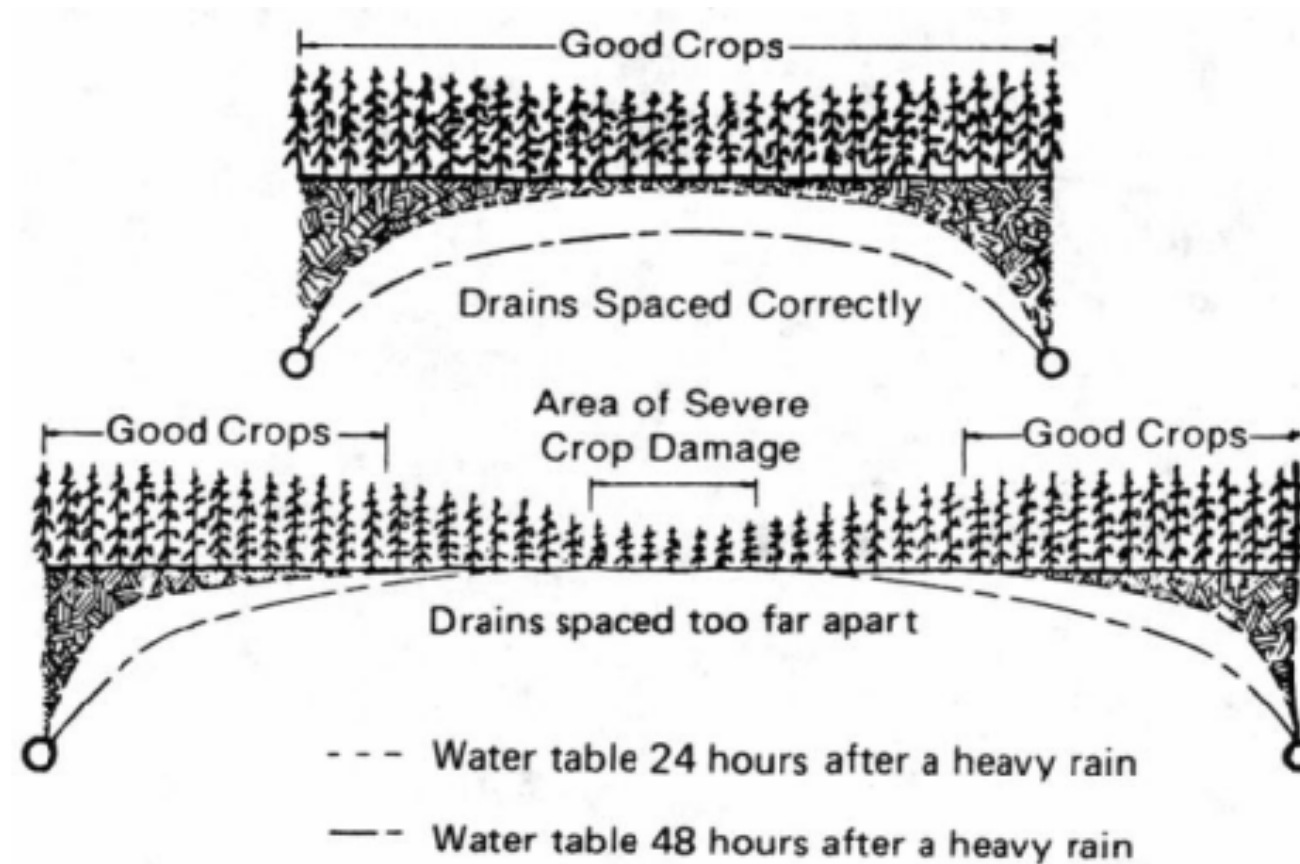
- ◆ What are we doing by selecting spacing & depth?
 - ◆ *DRAINAGE COEFFICIENT*
- ◆ What factors push us wider/narrower, deeper/shallower?
- ◆ Importance of uniform drainage

Generalized Drainage Coefficients

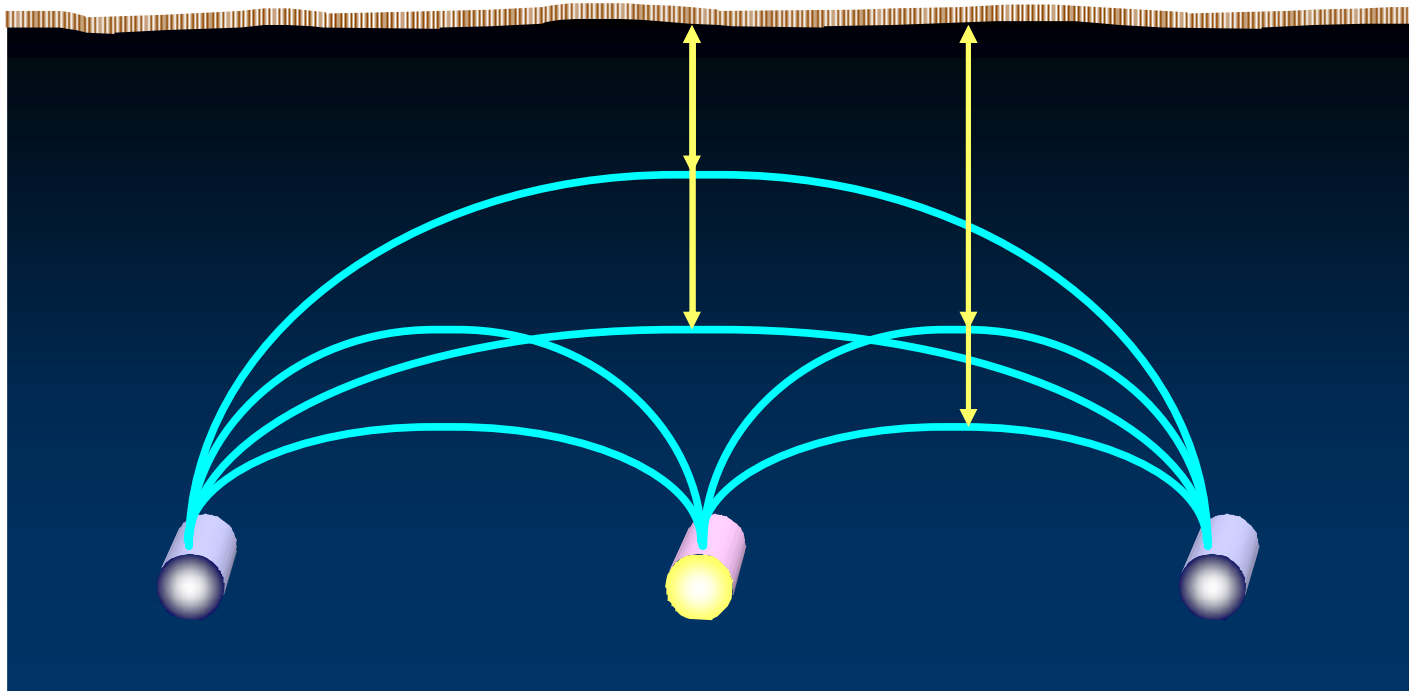
Soil Type	Inches to be removed in 24 hours	
	<i>Field Crops</i>	<i>Truck Crops</i>
Mineral	$\frac{3}{8} - \frac{1}{2}$	$\frac{1}{2} - \frac{3}{4}$
<i>w/ surface inlets</i>	$\frac{1}{2} - 1$	$1 - 1\text{-}\frac{1}{2}$
Organic	$\frac{1}{2} - \frac{3}{4}$	$\frac{3}{4} - 1\text{-}\frac{1}{2}$
<i>w/ surface inlets</i>	$1 - 1\text{-}\frac{1}{2}$	$2 - 4$

- ◆ We don't really know what the "right" number is for our soil, crop, and region
- ◆ Risk management for farmer
 - ◆ *Protect crop for any condition?*
 - ◆ *Protect crop for average condition?*

Drain Spacing: How Close is Close Enough?



Drain Spacing: But how close is too close?



- ◆ Issue is both economic and environmental

Minnesota Drainage Guide

DRAINAGE GUIDE DATA FOR MINNESOTA

SOIL NAME UNIT KIND MODIFIER	ID NO.	DRAIN DESIGN RECOMMENDATIONS						SOIL CHARACTERISTICS					
		COMMENTS	DSN	DRAIN	SPACINGS, Ft.		HORIZ	UNIFIED SOIL CLASSIFICATION	PERMEA- BILITY In./Hr.	pH RANGE	DEPTH TO WATER TABLE ft.	DEPTH TO BED- ROCK In.	
			GRP	DEPTH In.	DRAINAGE COEFF. In./24 Hrs.	DEPTH In.	DEPTH In.						
BLOMFORD SERIES	MNO239		1					0-9	SM	6.0-20	5.1-7.3	10.5-1.5	>60
			5	36	143	115	98	79	0-9	SM, SP-SM	6.0-20	5.1-7.3	
			5	48	179	144	124	100	9-25	SM, SP-SM	6.0-20	5.1-7.3	
									25-39	ML, CL, SC, SM	0.6-2.0	5.1-7.3	
									39-60	ML, CL, SC, SM	0.6-2.0	6.1-8.4	
BLOOMING SERIES	MNO150		7						0-8	ML, CL, CL-ML	0.6-2.0	5.6-6.5	>6.0
									8-15	CL	0.6-2.0	5.6-6.5	>60

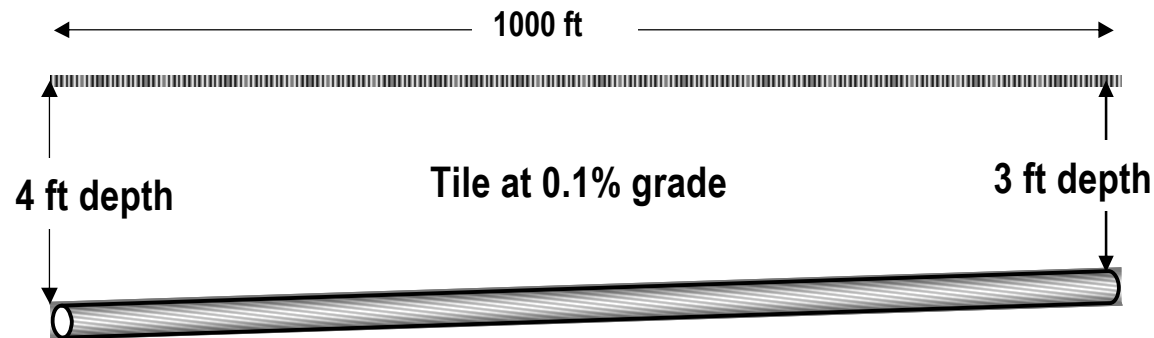
SOIL NAME UNIT KIND MODIFIER	ID NO.	DRAIN DESIGN RECOMMENDATIONS						SOIL CHARACTERISTICS					
		COMMENTS	DSN	DRAIN	SPACINGS, Ft.		HORIZ	UNIFIED SOIL CLASSIFICATION	PERMEA- BILITY In./Hr.	pH RANGE	DEPTH TO WATER TABLE ft.	DEPTH TO BED- ROCK In.	
			GRP	DEPTH In.	DRAINAGE COEFF. In./24 Hrs.	DEPTH In.	DEPTH In.						
BLUE EARTH SERIES	MNO064		1						0-10	PT			
			5	36	95	74	62	49	0-10	OL, ML			
			5	48	121	96	81	64	10-60	OL, ML			
									60-70	CL, ML			

SLOPING			4	40	81	50	72	50	0-10	OL			
BLUE EARTH VARIANT	MNO177		1						0-16	OL	0.6-2.0	7.4-8.4	+1-1.0
			1						16-25	ML	0.6-2.0	7.4-8.4	
			5	36	127	101	86	68	25-47	SM, SP-SM	2.0-6.0	7.4-7.8	
									47-60	CL	0.6-2.0	7.4-7.8	
BLUE EARTH VARIANT	MNO442		5	36	134	127	135	186	0-28	OL	2.0-6.0	7.4-8.4	+2-1.0
			5	48	142	134	292	234	28-33	CL-ML, CL	0.6-2.0	7.4-8.4	>60
									33-60	SP-SM	6.0-20	6.1-8.4	
BLUFFTON SERIES	MNO184		1						0-19	CL	0.6-2.0	5.6-6.5	+2-2.0
		1L, SIL	5	36	58	46	39	30	0-19	SC, SM, SM-SC	0.6-6.0	5.6-6.5	>60
			5	48	76	60	51	40	19-22	SM, ML, CL, SC	0.6-6.0	5.6-7.3	
		SL, SCL	5	36	66	53	45	35	22-60	CL, ML, SC, SM	0.2-0.6	7.4-8.4	
			5	48	85	68	58	46					

◆ Assumes WT at 1 ft within 1 day after rainfall

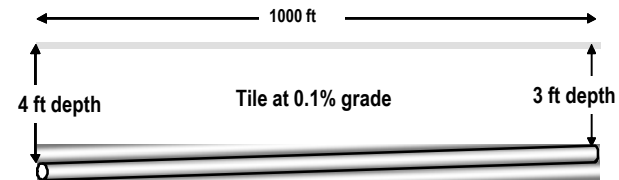
Drain Spacing & Depth

- ◆ Design for uniform depth throughout system (depends on layout)
- ◆ Depth will of course vary on flat and rolling topography



Drain Spacing & Depth

- ◆ For the previous soil:



SOIL NAME UNIT KIND MODIFIER	ID NO.	DRAIN DESIGN RECOMMENDATIONS								
		COMMENTS	DSN GRP	DRAIN DEPTH In.	SPACINGS, Ft.		HORIZ DEPTH In.			
					DRAINAGE COEFF.					
				1/4	3/8	1/2	3/4			
BLUE EARTH SERIES	MN0064		1					0-10	PT	
			5	36	95	74	62	49	0-10	OL, ML
			5	48	121	96	81	64	10-60	OL, ML
									60-70	CL, ML

- ◆ A foot of depth means a significant change in DC!

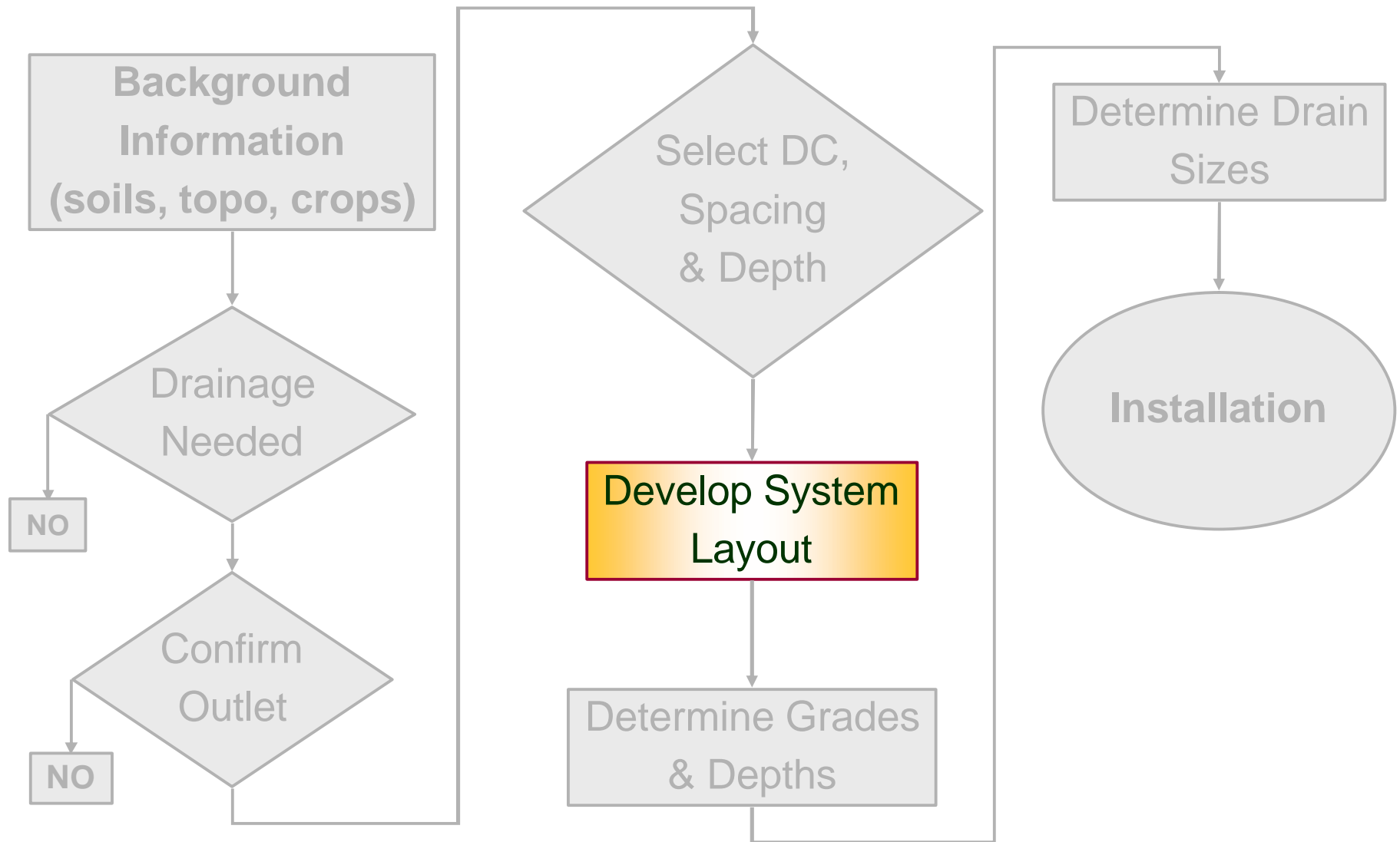
Spacing & Depth

- ◆ Many combinations of depth/spacing are possible
- ◆ Resources:
 - ◆ *Mn Drainage Guide*
 - ◆ *Local experience, (farmers, contractors)*
 - ◆ *Extension*
- ◆ Two important issues:
 - ◆ *How narrow is economically justified?*
 - ◆ *Moving from deeper/wider to shallower/narrower may have important environmental benefits*

Depth of Cover Requirements

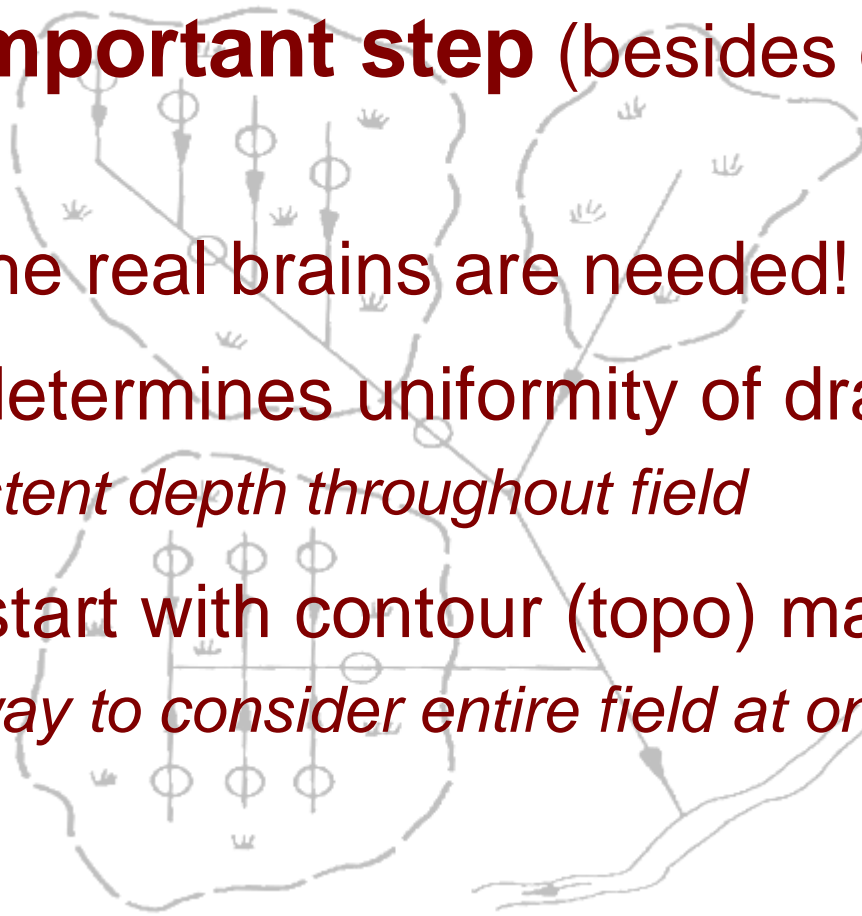
- ◆ For a well-bedded drain:
- ◆ 2 feet minimum cover for 3, 4, 5 & 6 in pipe
- ◆ 2.5 feet minimum cover for 8, 10, 12, 15, & 18 in pipe

Design Process Flowchart



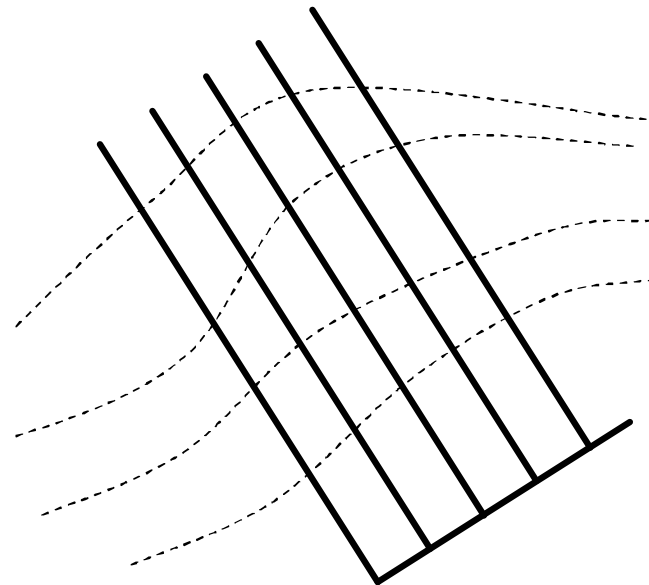
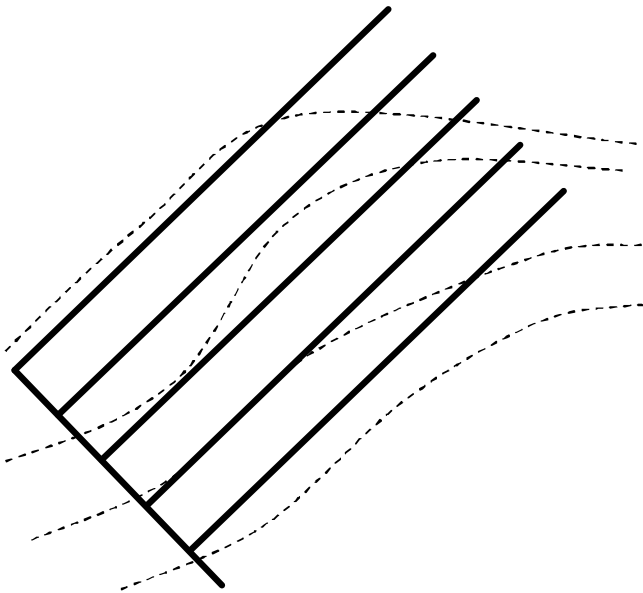
Layout

- ◆ **Most important step** (besides determining an outlet!)
- ◆ Where the real brains are needed!
- ◆ Layout determines uniformity of drainage
 - ◆ *Consistent depth throughout field*
- ◆ Should start with contour (topo) map of field
 - ◆ *Only way to consider entire field at once*



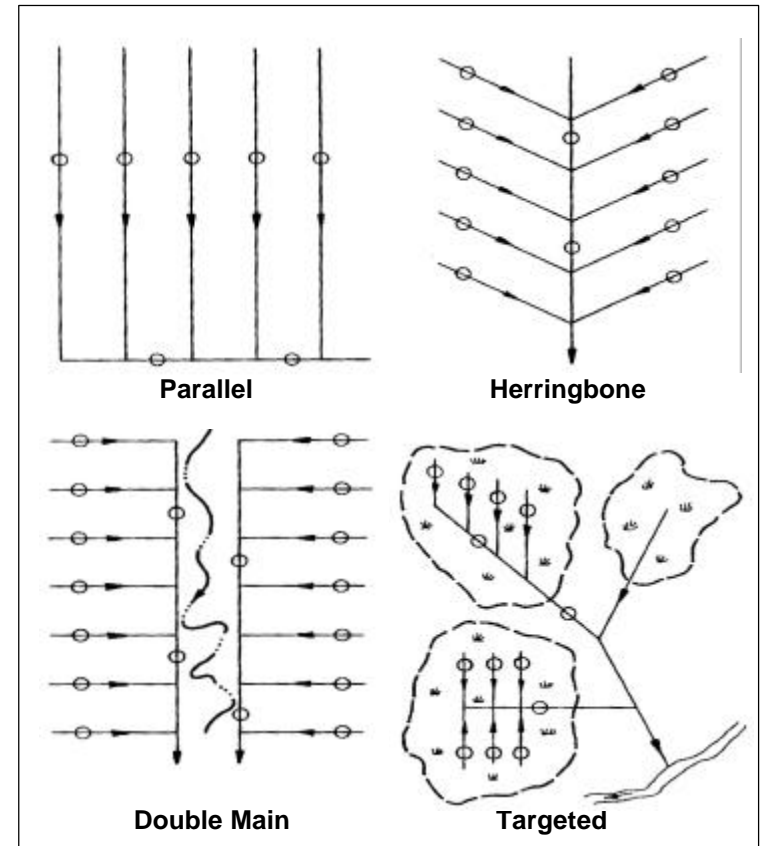
Layout

- ◆ Put (sub)mains on steepest grades
- ◆ Field laterals more on contours (intercept water)

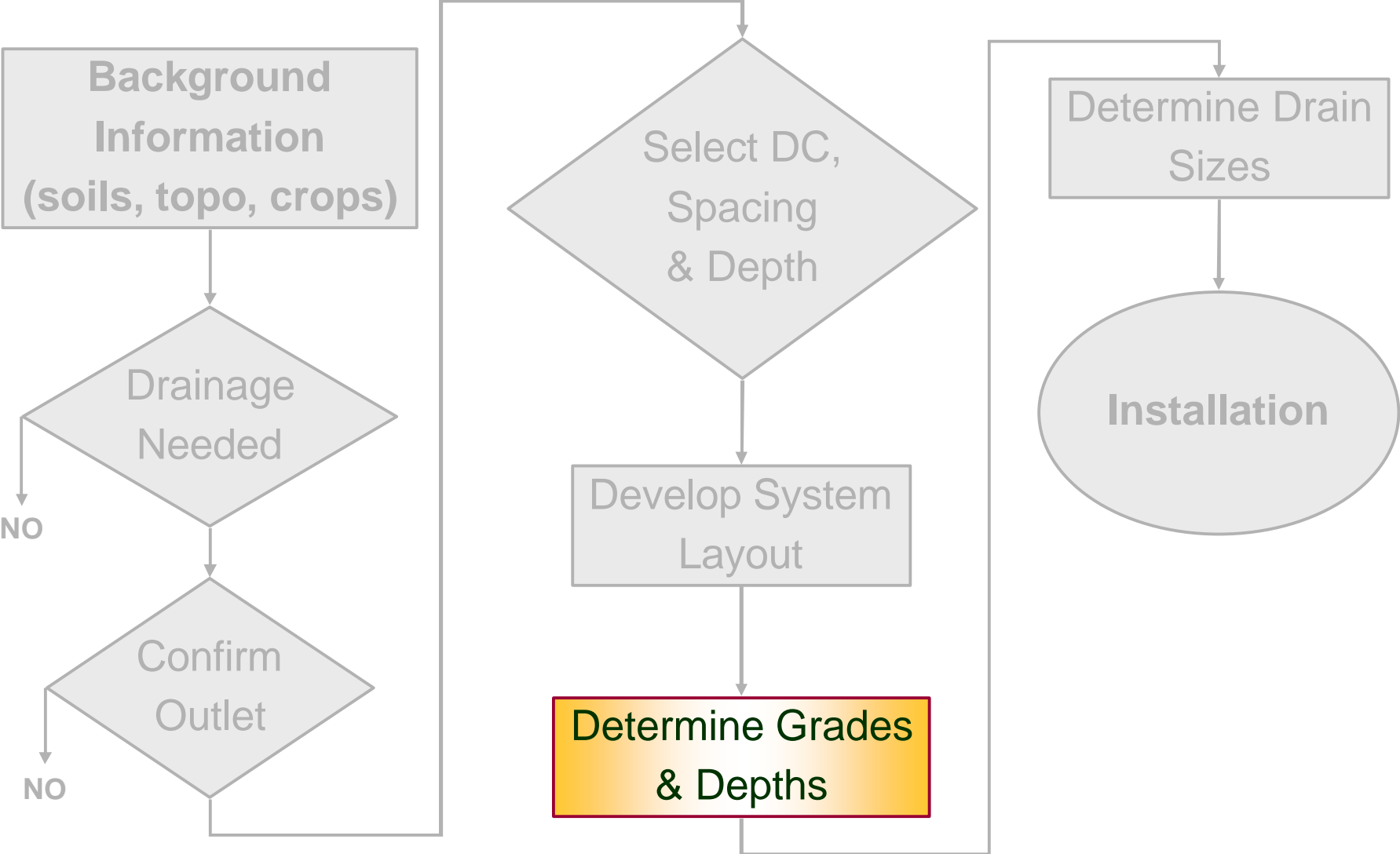


Layout

- ◆ Consider & plan for future needs
- ◆ Make maps of everything:
 - ◆ *As designed*
 - ◆ *As built*



Design Process Flowchart



Tile Grades

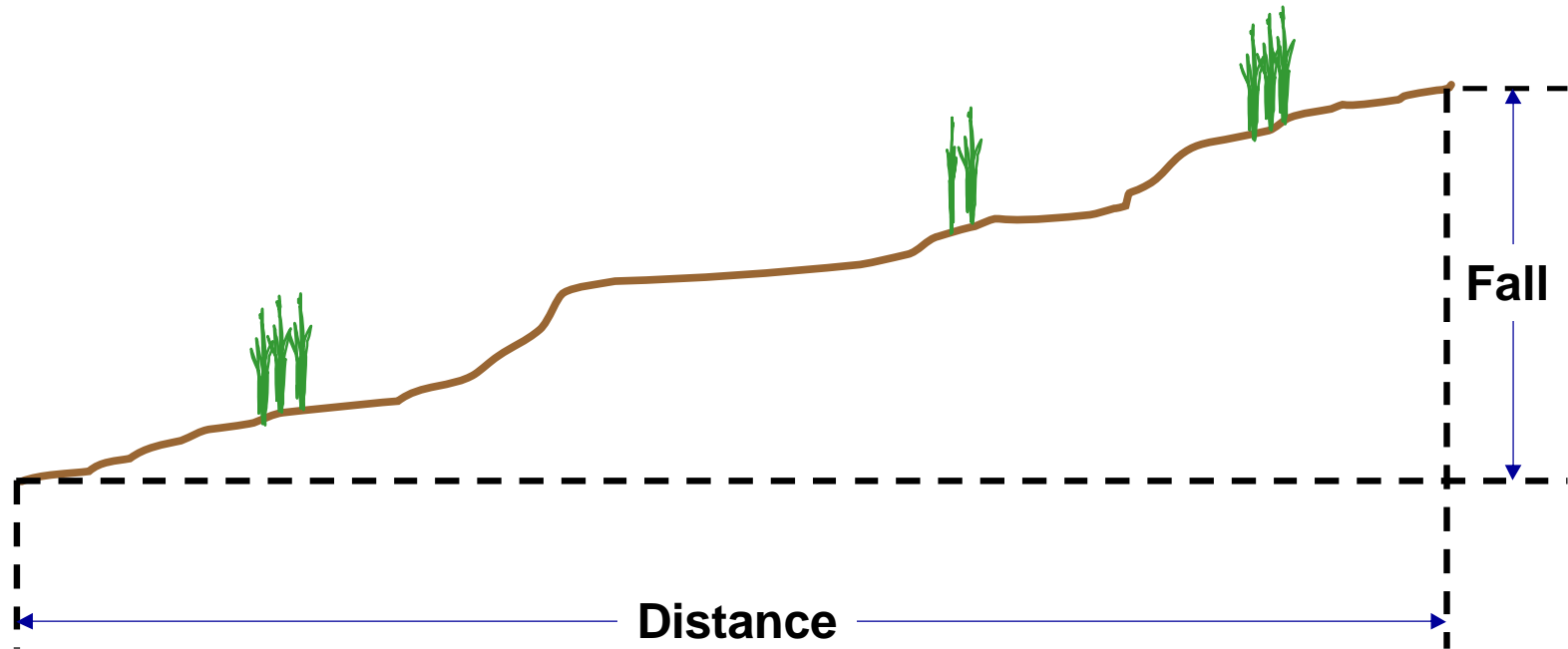
- ◆ Enough grade to:
 - ◆ *Keep the water moving*
 - ◆ *Keep sediment suspended in the water*
- ◆ Flat grades
 - ◆ *Shallower average depth, less digging*
 - ◆ *More prone to sediment build up*
 - ◆ *Installation errors more costly*
- ◆ Steep grades -- Higher Velocities
 - ◆ *Increase tile capacity*
 - ◆ *Too steep -- very high velocities can cause tile failure by “suckholes” or “blowouts” when soil is actually pulled into the tile line*
- ◆ Watch out for steep-to-flat grade changes....blowouts!

Minimum Grades

Drain Inside Diameter (inches)	Drains not subjected to fine sand or silt <i>(min velocity 0.5 ft/s)</i>		Drains where fine sand or silt may enter <i>(min velocity 1.4 ft/s)</i>	
	<i>Tile</i>	<i>Tubing</i>	<i>Tile</i>	<i>Tubing</i>
3	0.08	0.10	0.60	0.81
4	0.05	0.07	0.41	0.55
5	0.04	0.05	0.30	0.41
6	0.03	0.04	0.24	0.32
8 – 12 ^ψ		0.07		
12 and larger ^ψ		0.05		

^ψ recommendation for these drain sizes are from the Minnesota Drainage Guide.

Difference Between “Fall” & “Grade”



$$\% \text{ grade} = \frac{\text{fall}}{\text{distance}} \times 100\%$$

Grade

1% Grade = 1 ft/100ft = .01 ft/ft

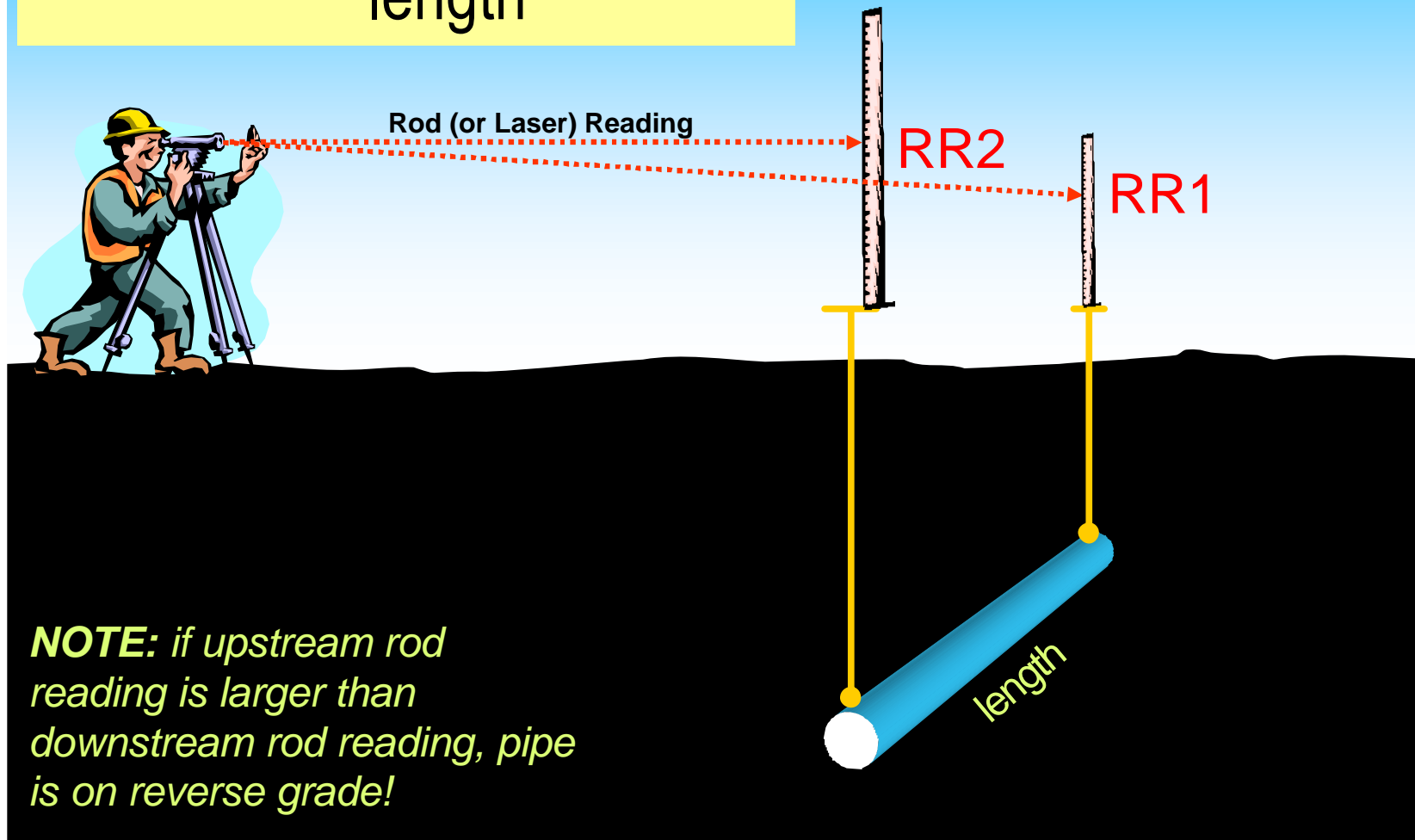
6 ft fall/mile = what % grade?

$$\% \text{ grade} = \frac{6}{5,280} \times 100\% = 0.11\%$$

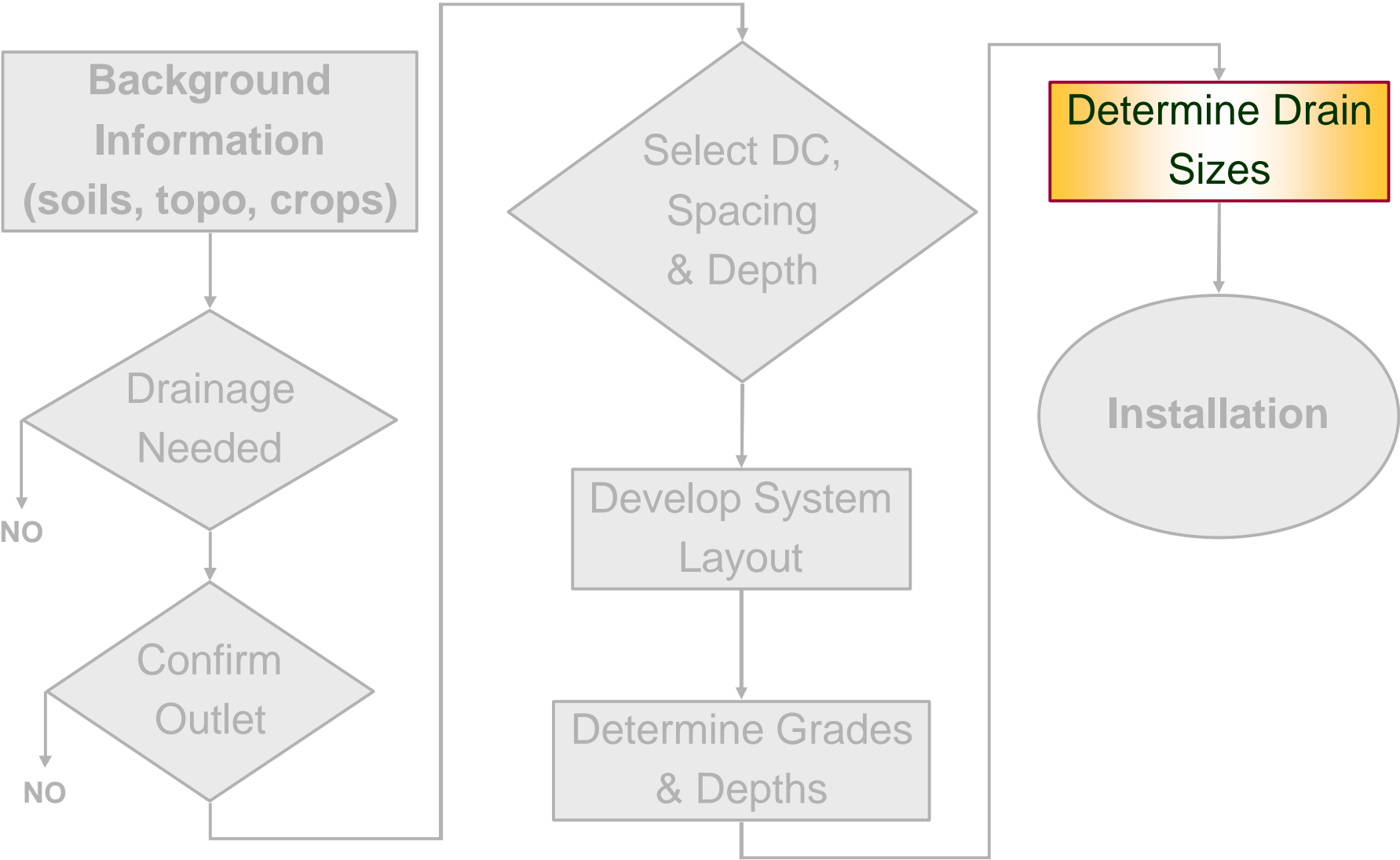
$$\% \text{ grade} = \frac{\text{fall}}{\text{distance}} \times 100\%$$

Checking Grade

$$\% \text{ grade} = \frac{RR2 - RR1}{\text{length}} \times 100\%$$



Design Process Flowchart



Drain Sizing

- ◆ What 3 things determine flow capacity of a drain pipe?
 - ◆ *Grade (determined from topography)*
 - ◆ *Material (plastic-single & dual wall, cement)*
 - ◆ *Size - we determine*
- ◆ Typical Procedure
 - ◆ *Grade, material, and DC set*
 - ◆ *Determine drain size with tools or tables*
 - ◆ *Just bookkeeping with acres-drained*

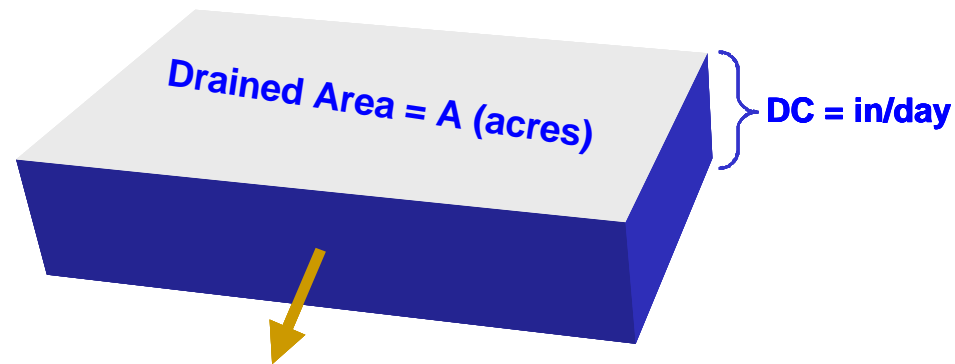
Tile Sizing - Velocity Important Too!

Drain Inside Diameter (inches)	Drains not subjected to fine sand or silt (min velocity 0.5 ft/s)		Drains where fine sand or silt may enter (min velocity 1.4 ft/s)	
	Tile	Tubing	Tile	Tubing
3	0.08	0.10	0.60	0.81
4	0.05	0.07	0.41	0.55
5	0.04	0.05	0.30	0.41
6	0.03	0.04	0.24	0.32
8 – 12 ^ψ		0.07		
12 and larger ^ψ		0.05		

^ψ recommendation for these drain sizes are from the Minnesota Drainage Guide.

Tile Sizing - Calculating Flow

Drainage Coefficient



Flowrate (Q) = DC x A
(ac-in/day or gpm)

Drain Size-Acres Drained Equation

$$\text{FLOW} = \text{DC} \times \text{Area} = \frac{11.05}{n} \times \left(\frac{D}{12} \right)^{2.67} \times \sqrt{\text{grade}}$$

- ◆ Mannings Equation
- ◆ Also used for flow in ditches

<p>n = .009 smooth interior pipe .015 3" to 8" sizes .017 9" to 12" .020 > 12"</p>

Solve for Acres Drained or Pipe Size

◆ Acres Drained

$$\text{Area} = \frac{11.05}{n \times DC} \times \left(\frac{D}{12} \right)^{2.67} \times \sqrt{\% \text{grade} / 100}$$

◆ Pipe Size (inches)

$$\text{Diameter}(D) = 12 \times \left[\frac{n \times DC \times \text{Area}}{11.05 \times \sqrt{\% \text{grade} / 100}} \right]^{0.375}$$

Can I use 2 Smaller Pipes?

Flow Capacity of Size at Left

	4	6	8	10	12	15
4	-	3	6.3	10	16	25
6	-	-	2.2	3.4	5.5	8.5
8	-	-	-	1.5	2.5	4
10	-	-	-	-	1.6	2.5
12	-	-	-	-	-	1.5
15	-	-	-	-	-	-

Design Tools



Nomograph

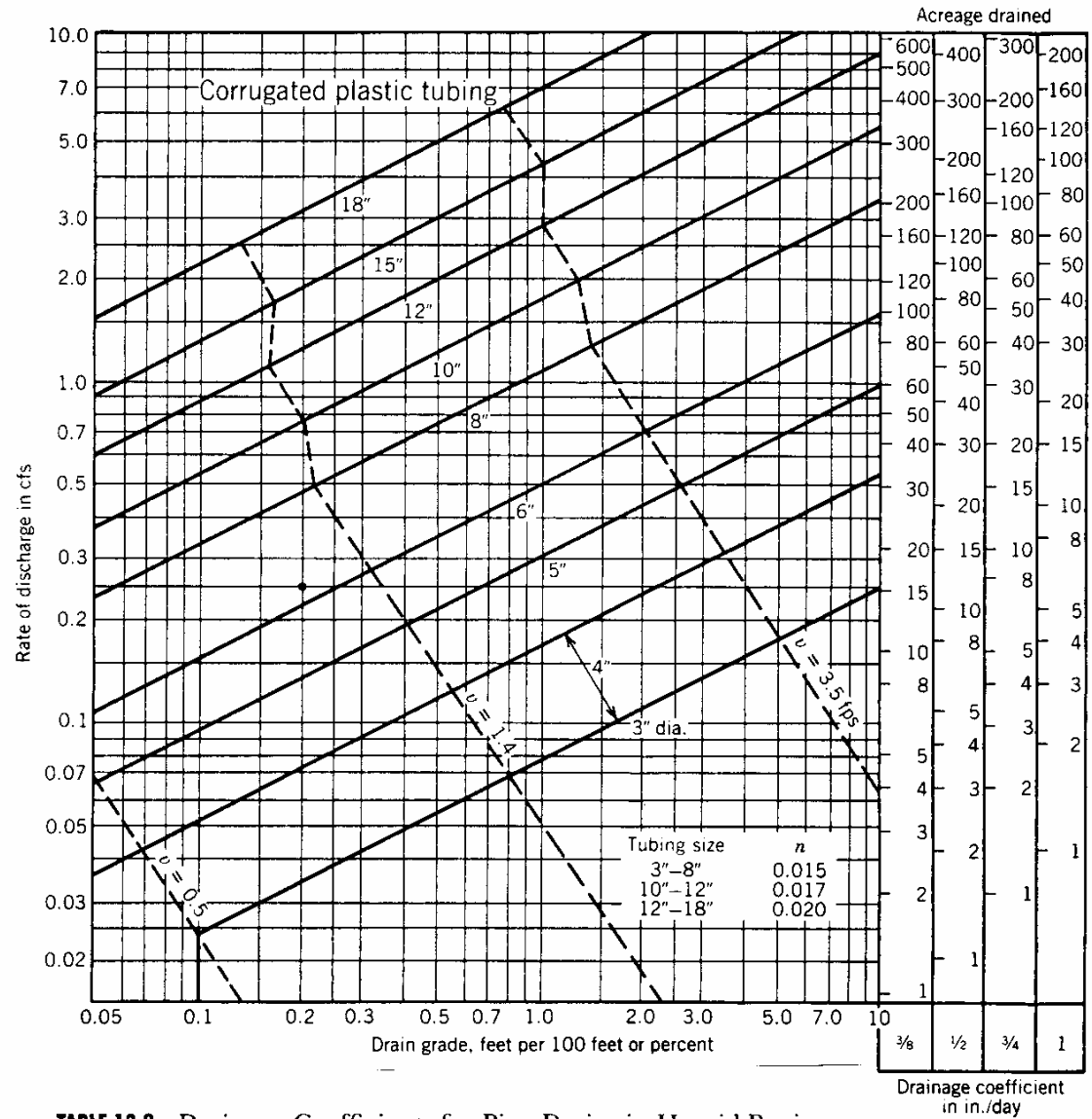


FIGURE 10. Discharge Rate of Corrugated Plastic Tubing

Calculators-Slide Charts

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Extension
University of Minnesota
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PIPE SIZE & ACRES DRAINED CALCULATOR

For Subsurface Drainage Pipe

GENERAL DRAINAGE COEFFICIENTS (Inches/24 Hours)

Soil Type	Field Crops	Truck Crops
artificial	2.0 to 1.0	1.5 to .8
clay	1.0 to .5	.8 to .4
clay loam	.8 to .4	.6 to .3
loam	.6 to .3	.4 to .2
loam sand	.4 to .2	.3 to .15
sandy loam	.3 to .15	.2 to .1
sand	.2 to .1	.1 to .05
sandy clay	.1 to .05	.05 to .025
clay loam	.05 to .025	.025 to .01

FLOW RATE AND VELOCITY CALCULATOR

Flow Rate (GPM) = 2.448 x (Pipe Diameter in inches)² x Velocity (ft/min)

Velocity (ft/min) = Flow Rate (GPM) / (2.448 x (Pipe Diameter in inches)²)

Head Loss (ft) = 0.025 x (Flow Rate in GPM)^{1.85} / (Pipe Diameter in inches)^{4.75}

SUBSURFACE DRAINAGE WITH PIPE

Q = Discharge in cubic feet per second for pipe flowing full on a given grade

V = Velocity in feet per second for pipe flowing full on a given grade

DRAINAGE COEFFICIENT

Q c.f.s.	V ft/sec.	Drainage Coefficient
0.08	0.95	3/8"
		1/2"
		3/4"
		1"
		1.5"
		2"
		2.5"

ACRES DRAINED

GRADE FALL IN FEET PER 100 FEET

-2.00
-1.50
-1.00
-0.75
-0.50
-0.40
-0.30
-0.25
-0.20
-0.15
-0.10
-0.05
-0.03

PIPE DIAMETER

PROPER DRAINAGE MAKES A DIFFERENCE
A properly installed drainage system makes investments pay off fast by getting you in the field earlier in the Spring. And, crops can be harvested at their peak in the fall, while keeping moisture content at a minimum. Hancor pipe is manufactured according to ASTM F426 and F607.

BENEFITS:

- Herbicides and fertilizers will be more effective for increasing yields.
- If soil in the control is required to remain level and productive, effective drainage is ideal.
- Better livestock farming, as improved drainage of pastures and leas leads to improved grazing management.

OTHER APPLICATIONS:

- Grass seedling
- Land reclamation
- Pond dewater
- Culverts

INSTALLATION:
Bedding material must be properly placed and compacted to provide lateral restraint against deflection in the pipe and to protect the pipe against damage during backfilling. The trench bottom must be smooth and free of exposed rocks. A specially shaped groove is needed on the trench bottom when a gravel envelope is not used. The groove provides extra support for the pipe and controls alignment during installation. The groove may be a 90° V, semi-circular or trapezoidal. The strength of back-compacted pipe is reduced by as much as 40% on a hot sunny day. Therefore, gravel and rocks must be taken to prevent the impact of sharp, heavy objects and reduce excessive soil during installation. The maximum allowable stretch is 5 percent. At low temperatures pipe flexibility decreases and there is a danger of cracking if the pipe is uncoiled too rapidly. The soil for any drainage system is important for successful operation. It must be deep enough so that the flow line of the drain at the outlet will be at least one foot above normal low water flow in the ditch. If an existing main is used for the outlet it should be in good condition, free of failures, and large enough to handle the additional flow of the new system. A rigid pipe should be used at the outlet pipe into an open ditch if exposed to tree, livestock or equipment. An animal guard is needed at the end of the outlet pipe.

REQUIRED DRAINAGE COEFFICIENT (Kd/24)

SOILS WITHOUT SURFACE INLETS	FIELD CROPS	TRUCK CROPS	SOILS WITH BLIND SURFACE INLETS	FIELD CROPS	TRUCK CROPS
MINERAL	3/4" to 1"	1/2" to 3/4"	MINERAL	1/2" to 3/4"	1/4" to 1"
ORGANIC	1/2" to 3/4"	3/4" to 1"	ORGANIC	3/4" to 1"	1/2" to 2"

SOILS WITH OPEN SURFACE INLETS

FIELD CROPS	TRUCK CROPS
MINERAL	1/2" to 1"
ORGANIC	1" to 1 1/2"

WITHOUT SURFACE INLETS (DRAINAGE AREA) = AREA TO BE DRAINAGE DIVIDED AS THE DRAINAGE AREA.
WITH SURFACE INLETS USE ENTIRE CONTRIBUTING WATERSHED AS THE DRAINAGE AREA.

HOW TO USE SLIDE RULE: Problem: A main is needed for 25 acres of mineral soil to produce field crops without surface inlets. Solution: From coefficient table read 3/8". Gravel is 0.20%. On front of rule move arrow to 0.20 opposite 6" pipe. Read 14 acres at 3/8" so 5' is too small. Now try 1" at 0.20 grade. Read 25 acres at 0.20. 1" is proper size.

The slide rule has been prepared in accordance with Soil Conservation Service standards, ASAE Recommended Practice EP 260-3 Design and Construction of Subsurface Drains in Hard Soils, and ASTM F-449 Recommendations for Development/Installation of Compacted Thermoplastic pipe for Agricultural Drainage or Water Table Control.

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PIPE SIZE

ACRES DRAINED

PIPE SIZE REQUIREMENTS PER ACRES EXCLUSIVE OF COLLECTOR LINES

Spacing (ft)	Depth (in)	Spacing (ft)	Depth (in)
20'	3.0"	30'	3.0"
30'	3.0"	40'	3.0"
40'	3.0"	50'	3.0"
50'	3.0"	60'	3.0"
60'	3.0"	70'	3.0"
70'	3.0"	80'	3.0"
80'	3.0"	90'	3.0"
90'	3.0"	100'	3.0"

INSTRUCTIONS:
Set FLOW in ACRES INCHES 24 HRS. Read ACRES DRAINED for selected DRAINAGE COEFFICIENT.

PIPE SIZE:
Select DRAINAGE COEFFICIENT. Set ACRES to be DRAINED. Read FLOW in ACRES INCHES 24 HRS.

DRAINAGE COEFFICIENTS:
vary with climate, soils and crop grown. Contact local S.C.S. or Soil University Extension office for appropriate DRAINAGE COEFFICIENTS for your area.

ADVANCED DRAINAGE SYSTEMS, INC.
U.S. Bureau of Reclamation Sales


Design Charts & Tables

Grade (%)	Drain Size (inches)							
	4	5	6	8	10	12	15	18
0.1	2.5	4.5	7.3	16	25	41	63	103
0.2	3.5	6.4	10.4	22	36	58	89	145
0.3	4.3	7.8	12.7	27	44	71	110	178
0.4	5.0	9.0	14.6	32	50	82	126	206
0.6	6.1	11.0	17.9	39	62	101	155	252
0.8	7.0	12.7	20.7	45	71	116	179	291
1	7.9	14.2	23.2	50	80	130	200	325
1.5	9.6	17.4	28.4	61	98	159	245	398
2	11.1	20.1	32.8	71	113	184	283	460

On-line Calculators


D-OUTLET: Drainage Calculators - Microsoft Internet Explorer

Address: <http://d-outlet.coates.umn.edu/design/drancalc.htm>



Drainage Calculators

These calculators are based on corrugated polyethylene pipe. Calculations for concrete and clay pipe can be approximated by using the smooth pipe option.

[Home](#)
[Up](#)


[Calculate pipe diameter](#)
[Calculate area drained](#)
[Flowrate calculator/convertor](#)
[Prinsco Drainage Calculators](#)

Pipe Diameter (inches)

Use this calculator to compute the required pipe size for a given area and % grade.

Smooth Interior Pipe? Yes No

Area Drained (acres): % Grade*


*%Grade is the feet of fall per 100 feet of length.

Required Pipe Diameter (inches):*	Drainage Coefficient (inches/day)				
	1/4"	3/8"	1/2"	3/4"	1"
	16.2	18.8	21.0	24.4	27.2
Full pipe flow (cu ft/sec)	6.30	9.45	12.61	18.91	25.21
Velocity (ft/sec)**	4.42	4.89	5.25	5.81	6.25

*Use commercially available size equal to or larger than size shown
 **A minimum velocity of 1.5 ft/sec should be used when fine sands and silts are present-- otherwise a velocity of 0.5 ft/sec is sufficient.

The Prinsco Drainage Calculator - Netscape

Address: <http://www.prinsco.com/farm/>



March 01, 2001

FARM DRAINAGE DRAINAGE CALCULATOR

Calculate by Pipe Size

Welcome to our drainage calculator. While this tool is good for looking at basic design needs, we encourage you to contact your local contractor and design professional for your installation and design needs.

We would appreciate your comments and suggestions on how it may be a benefit to you and any improvements you would suggest. E-mail your suggestions to info@prinsco.com.

Please read our [instructions on how to use this calculator](#).

1. Definition

Enter the Diameter of the pipe (inches)

Enter the Grade (%) %

G. Flow **Velocity**

c.f.e. **g.p.m.** **acre-in./24 hrs.** **ft./sec.**

GOLDLINE (Single Wall)

GOLDPLO (Dual Wall)

Acres Drained

Drainage Coefficient (in./24 hours)

16" 18" 20" 24" 30" 36"

GOLDLINE (Single Wall)

GOLDPLO (Dual Wall)

Nomograph - How to Use It

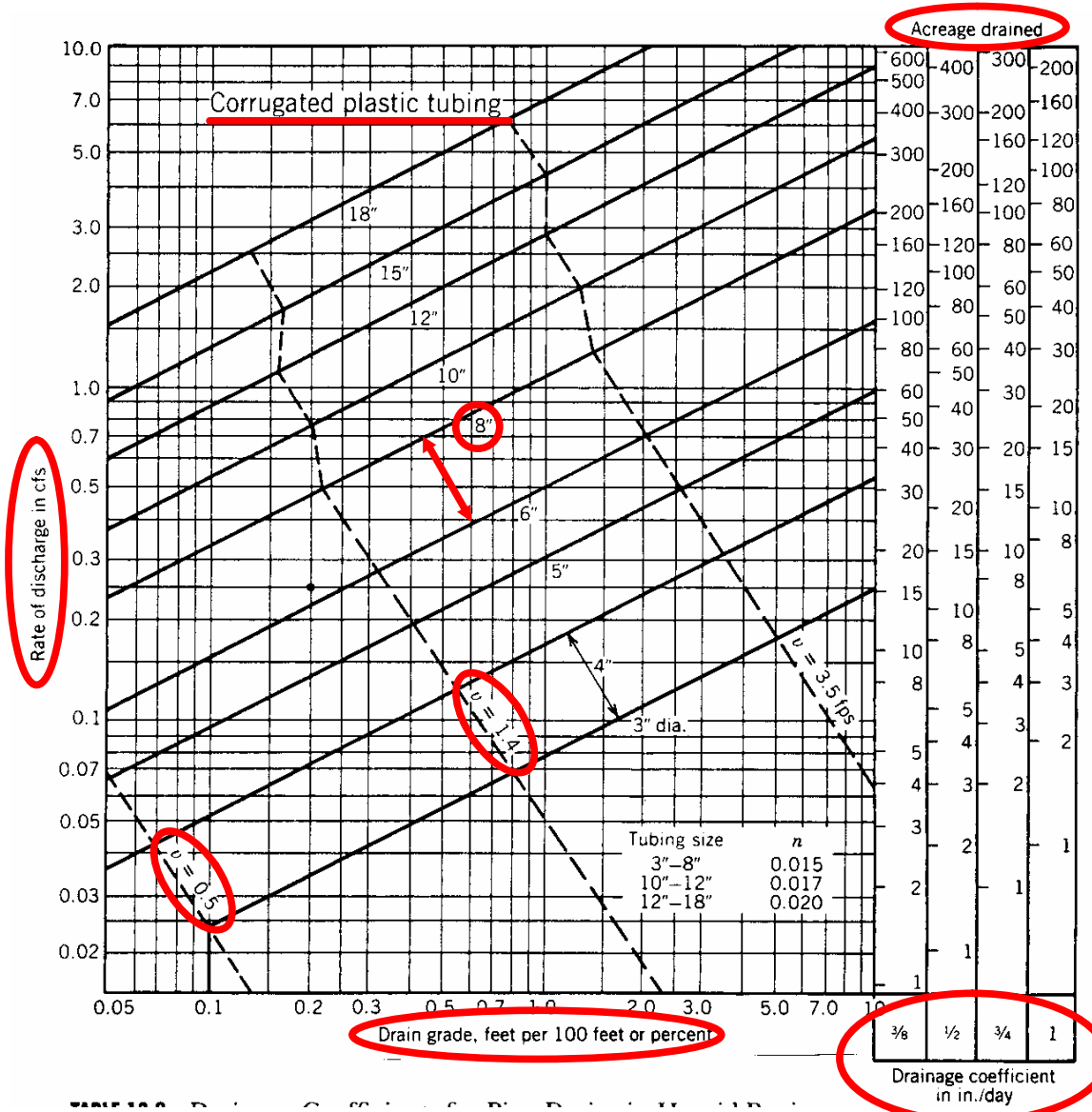
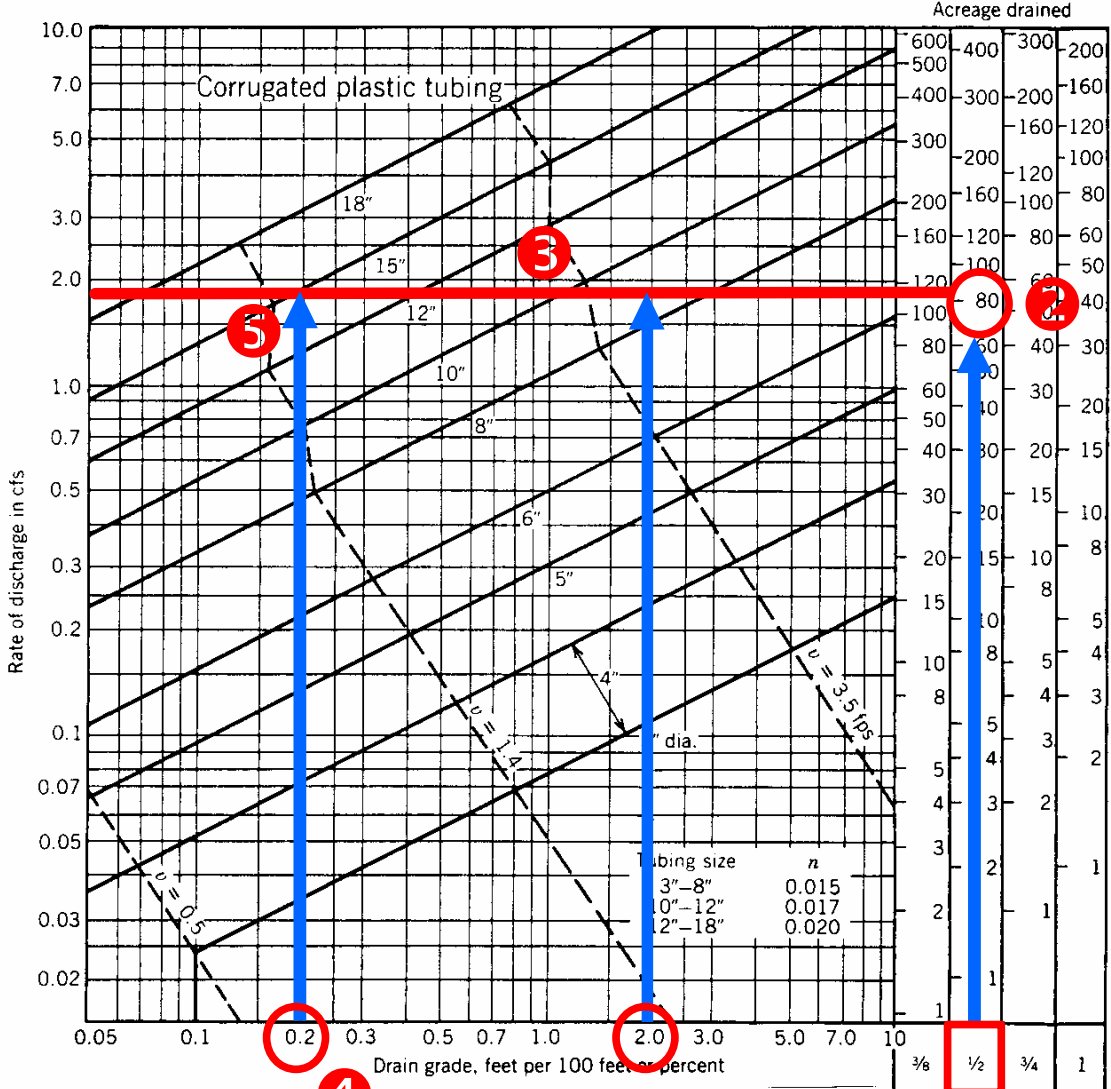


FIGURE 100. Drainage Coefficient, CFS, and Acreage Drained by Corrugated Plastic Tubing

Nomograph - Finding Drain Size



5

3

80

1/2

0.2

4

2.0

1

Nomograph – Acres Drained

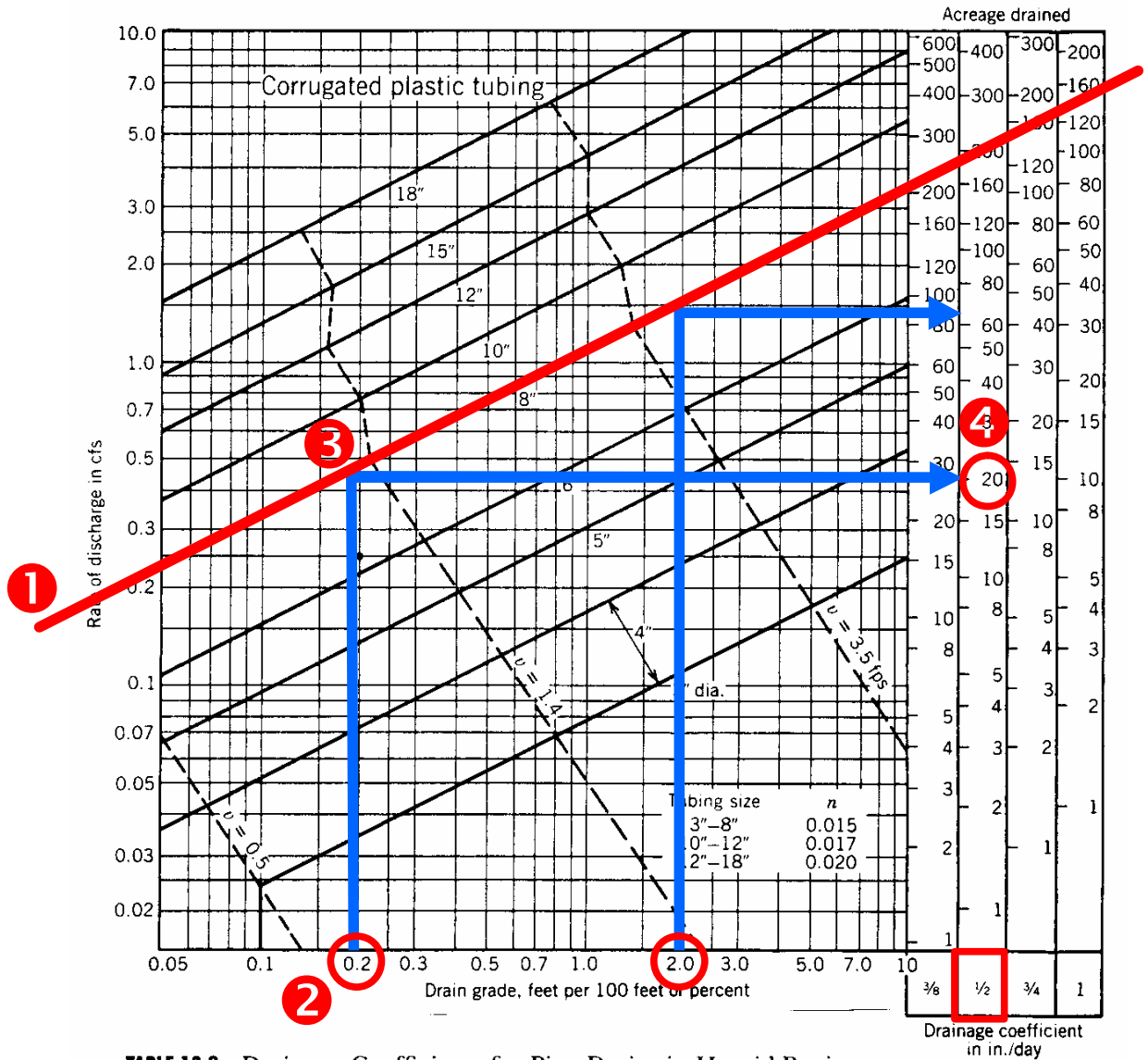
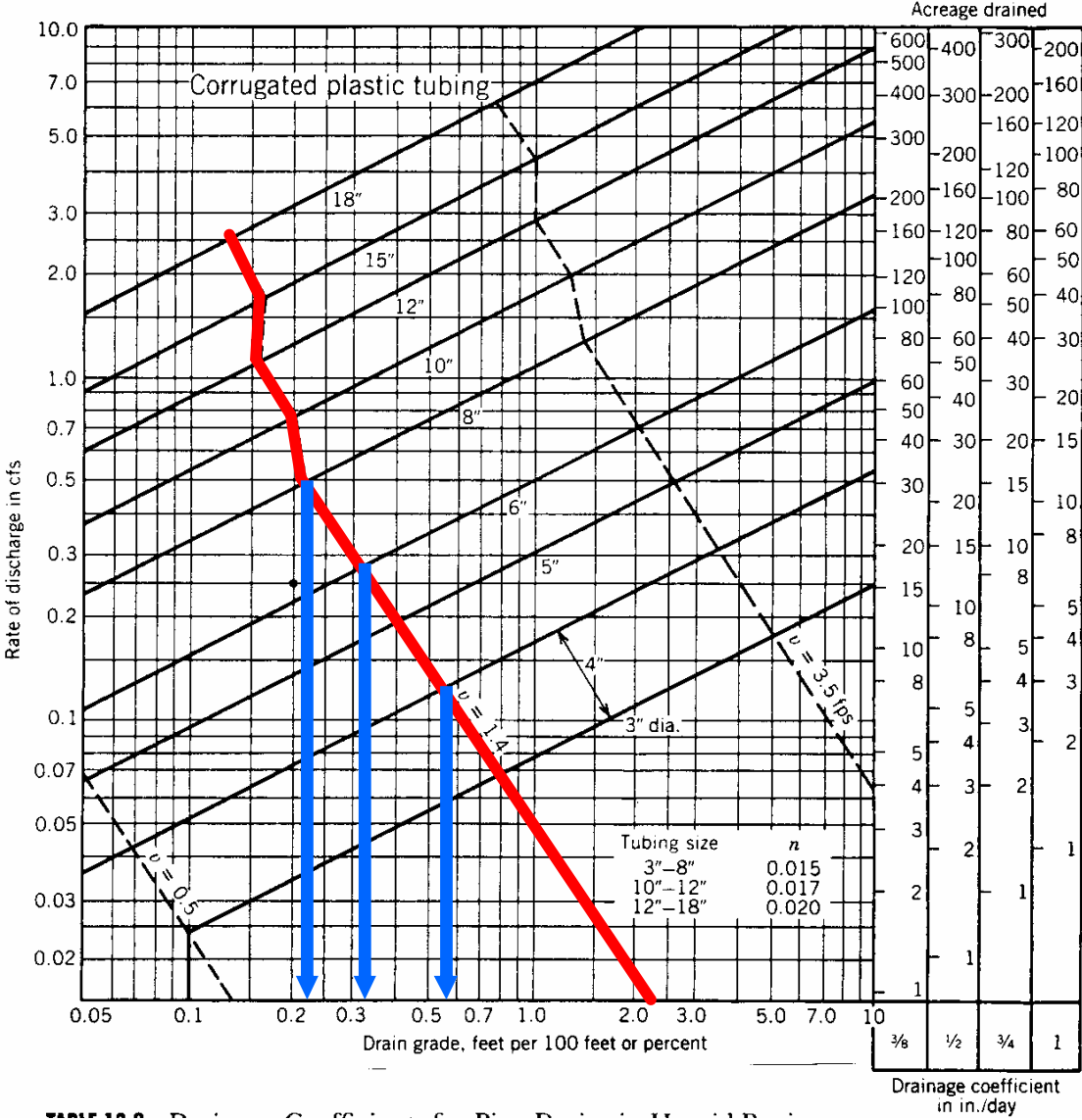


FIGURE 100 Drainage Coefficient and Acres Drained by Tubing

Nomograph - Minimum Grade



Nomograph - Example

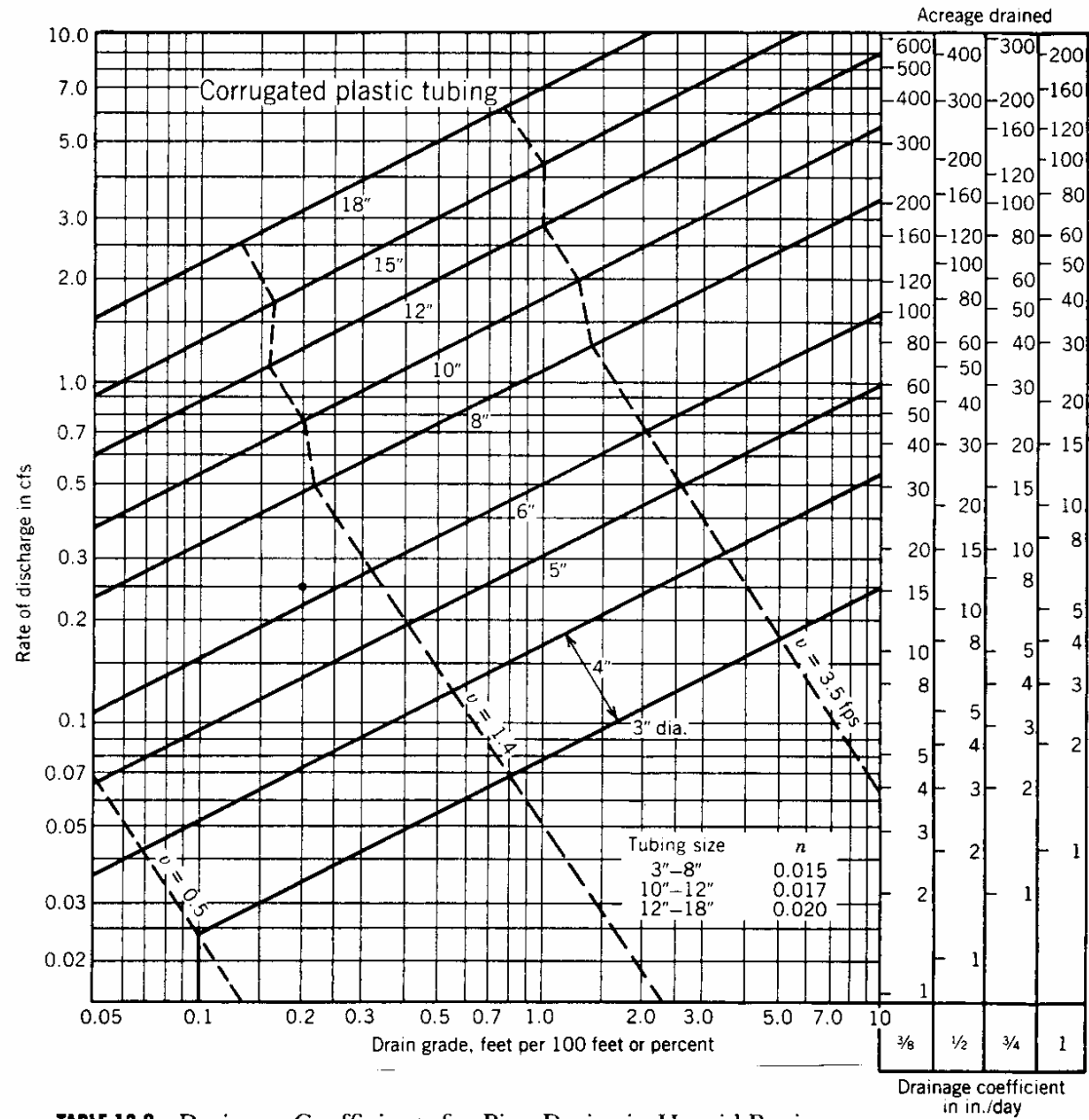


FIGURE 10-10. Drainage characteristics of corrugated plastic tubing.

Slide Rules/Charts

PIPE SIZE & ACRES DRAINED CALCULATOR
For Corrugated Polyethylene Pipe

PRINSCO
Prinsburg, MN Chateworth, IL
(800) 952-1725 (800) 868-7712
www.prinsco.com

UNIVERSITY OF MINNESOTA
Extension
Service of the University of Minnesota
with the University of Minnesota
Extension Service (800) 625-6226
Visit us for more educational information
at www.extension.umn.edu

DRAINAGE COEFFICIENT
CROPS DRAINED

INSTRUCTIONS:
1. Set arrow on the wheel at drainage coefficient in inches per hour.
2. Read acres drained on the outer scale.
3. Read pipe size on the inner scale.

GOLDLINE Single Wall PIPE SIZE (in. x ft.)

GOLDFLO Dual Wall PIPE SIZE (in. x ft.)

GENERAL DRAINAGE COEFFICIENTS (inches/hour)

Without Surface Inlets	Field Crops	Truck Crops
Mineral 28 to 1.0	1.0 to 0.4	0.4 to 0.1
Organic 1.0 to 0.4	0.4 to 0.1	0.1 to 0.05

PIPE COIL LENGTHS

Number of Wires: 100, 200, 300, 400, 500, 600, 700, 800, 900, 1000

FLOW RATE AND VELOCITY CALCULATOR
For Corrugated Polyethylene Pipe

PRINSCO

INSTRUCTIONS:
1. Read flow rate (GPM) and velocity (ft. per sec.) at pipe diameter for appropriate type of pipe.

GOLDLINE Single Wall PIPE SIZE (in. x ft.)

GOLDFLO Dual Wall PIPE SIZE (in. x ft.)

PIPE COIL LENGTHS

When America Moves Water, It Relies on ADS

ADS
ADVANCED DRAINAGE SYSTEMS, INC.
CORRUGATED PLASTIC DRAINAGE PIPE AND FITTINGS

INDUSTRY RECOMMENDED Manning's "n" Values

Pipe Size (in.)	n
3"	0.15
4"	0.15
6"	0.15
8"	0.15
10"	0.15
12"	0.15
15"	0.15
18"	0.15
24"	0.15
30"	0.15
36"	0.15
42"	0.15
48"	0.15
60"	0.15
72"	0.15
84"	0.15
96"	0.15
108"	0.15
120"	0.15

INSTRUCTIONS:
Set PIPE SIZE at % SLOPE. At appropriate "n", read FLOW in GALLONS/MIN. or CU. FT./SEC. ACRE-INCHES/24 HRS. Record and turn over to find ACRES DRAINED.

PIPE SIZE: Set FLOW in ACRE-INCHES/24 HRS. at appropriate "n". Read PIPE SIZE at % SLOPE. Record FLOW in GALLONS/MIN. or CU. FT./SEC.

FLOW CAPACITY: Set PIPE SIZE at % SLOPE. At appropriate "n", read FLOW in GALLONS/MIN. or CU. FT./SEC. ACRE-INCHES/24 HRS. Record and turn over to find ACRES DRAINED.

ACRES DRAINED: Set FLOW in ACRE-INCHES/24 HRS. Read ACRES DRAINED for selected DRAINAGE COEFFICIENT.

PIPE SIZE: Set ACRES to be DRAINED. Read FLOW in ACRE-INCHES/24 HRS.

DRAINAGE TUBING REQUIREMENTS PER ACRE EXCLUSIVE OF COLLECTOR LINES

Spacing	Pipe/Acre	Spacing	Pipe/Acre
20'	2,300	90'	607
30'	1,530	100'	557
40'	1,150	150'	398
50'	900	200'	299
60'	750	250'	240
70'	630	300'	197
80'	550		(Estimated)

DRAINAGE COEFFICIENTS vary with rainfall, soils and crops grown. Contact local S.C.S. or State University Extension offices for appropriate DRAINAGE COEFFICIENTS for your area.

At ADS pipe exceeds the standards in the following specifications:
ASTM F-406 (8"-24")
S.C.S. Code 606
Pipe also meeting the specifications below is available:
AASHTO M-252
AASHTO M-254
U.S. Bureau of Reclamation Stds.

INSTRUCTIONS:
Set FLOW in ACRE-INCHES/24 HRS. Read ACRES DRAINED for selected DRAINAGE COEFFICIENT.

PIPE SIZE: Set ACRES to be DRAINED. Read FLOW in ACRE-INCHES/24 HRS.

DRAINAGE COEFFICIENT INCHES/24 HRS.

ACRES DRAINED

SUBSURFACE DRAINAGE WITH PIPE

Q: Discharge rate: gal per second for pipe flowing full on a given grade.

V: Velocity in feet per second for pipe flowing full on a given grade.

Q	V	DRAINAGE COEFFICIENT					
c.f.s.	ft./sec.	3/8"	1/2"	3/4"	1"	1.5"	2"
0.08	0.95	5	4	3	2	1	1

ACRES DRAINED

GRADE FALL IN FEET PER 100 FEET

PIPE DIAMETER

PROPER DRAINAGE MAKES A DIFFERENCE
A properly installed drainage system raises investments pay off fast by getting you in the field earlier in the Spring. And, crops can be harvested at their peak in the Fall, while keeping moisture content at a minimum. Hancor pipe is manufactured according to ASTM F426 and F687.

BENEFITS:

- Herbicides and fertilizers will be more effective for increasing yields.
- If salinity control is required to reclaim land and productivity, subsurface drainage is ideal.
- Better livestock farming, as improved drainage of pastures also leads to improved grazing management.

OTHER APPLICATIONS:

- Golf courses
- Land reclamation
- Ponds/dams
- Culverts

INSTALLATION:
Bedding material must be properly placed and compacted to provide lateral restraint against deflection in the pipe and to protect the pipe against damage during backfilling. The trench bottom must be smooth and free of exposed rocks. A freely slaked groove is needed in the trench bottom when a gravel envelope is not used. The groove provides side support for the pipe and controls alignment during installation. The groove may be a 90° semi-circle or trapezoid. The strength of black corrugated pipe is reduced by as much as 40% on a hot sunny day. Therefore, precautions must be taken to prevent the impact of sharp, heavy objects and reduce excessive soil during installation. The maximum allowable slack is 5 percent. At low temperatures pipe flexibility decreases and there is a danger of cracking if the pipe is uncoiled too rapidly. The outlet for any drainage system is important for successful operation. It must be deep enough so that the flow line of the main at the outlet will be at least one foot above normal low water flow in the ditch. If an existing main is used for the outlet, it should be in good condition, free of failures, and large enough to handle the additional flow of the new system. A rigid pipe should be used at the outlet with at least 25' of the pipe embedded in the bank. Plastic pipe should not be used as an outlet pipe into an open ditch if exposed to fire, livestock or equipment. An animal guard is needed at the end of the outlet pipe.

REQUIRED DRAINAGE COEFFICIENT (INCHES)

SOILS	WITHOUT SURFACE INLETS		WITH BLIND SURFACE INLETS	
	FIELD CROPS	TRUCK CROPS	FIELD CROPS	TRUCK CROPS
MINERAL ORGANIC	1/2 to 1"	1/2 to 1/4"	MINERAL ORGANIC	1/2 to 1"
	1/2 to 1/4"	1/2 to 1/4"		1/2 to 1"

SOILS WITH OPEN SURFACE INLETS

FIELD CROPS	TRUCK CROPS
MINERAL ORGANIC	1" to 1 1/2"
	2" to 4"

WITHOUT SURFACE INLETS REQUIRE ONLY THE AREA TO BE SUBSURFACE DRAINED AS THE DRAINAGE AREA. WITH SURFACE INLETS USE ENTIRE CONTRIBUTING WATERSHED AS THE DRAINAGE AREA.

HOW TO USE SLIDE RULE: Problem: A main is needed for 25 acres of mineral soil to produce field crops without surface inlets. Solution: From coefficient table read 3/8". Grade is 0.20%. On front of rule move arrow to 0.20 opposite 0" pipe. Read 14 acres at 3/8" so 5" is too small. Now try 1/2" at 0.20 grade. Read 28 acres at 3/8". 5" is proper size.

The slide rule has been prepared in accordance with Soil Conservation Service standards; ASAE Recommendations EP 260.3 Design and Construction of Subsurface Drains in Humid Areas; and ASTM F-440 Recommendations for Underdrain Installation of Corrugated Thermoplastic pipe for Agricultural Drainage or Water Table Lowering.

Hancor
401 Olive Street, Findlay, OH 45840
1.888.FOR PIPE (367-7473)
1.888.FAX PIPE (329-7473)
INNOVATIVE DRAINAGE SOLUTIONS

Prinsco-U_{ofM} Slide Rule

PIPE SIZE & ACRES DRAINED CALCULATOR

PRINSCO
The pipe with the gold stripe.
Prinsburg, MN (800) 992-1725
Chatsworth, IL (800) 869-7712
www.prinsco.com

UNIVERSITY OF MINNESOTA
Extension SERVICE
Item # C7088. Produced in cooperation with the University of Minnesota Extension Service (800) 876-8836. Look for more educational information at www.extension.umn.edu

PIPE COIL LENGTHS

Number of Wraps	4	5	6	8	10	12
1	135	100	90	93	80	90
2	290	250	190	137	120	195
3	490	440	167	165	150	320
4	730	670	205	200	175	
5	1000	940	242	235	525	
6	1315	1250	273	625		
7	1685	1600	343			
8	2095	1980	1450			
9	2500	2300				
10	3000					

GENERAL DRAINAGE COEFFICIENTS (inches/24 hours)

Soil Type	Field Crops		Truck Crops
	Blind Inlets	Open Inlets	Blind Inlets
without surface inlets	Mineral 3/8 to 1/2	1/2 to 3/4	3/4 to 1-1/2
with surface inlets	Mineral 3/8 to 3/4	1/2 to 1	1/2 to 1, 1 to 1-1/2
	Organic 1/2 to 1	3/4 to 1-1/2	3/4 to 2, 2 to 4

FLOW RATE AND VELOCITY CALCULATOR
For Corrugated Polyethylene Pipe

Velocity should exceed 1.4 fps where drains are subjected to fine sand or silt. Otherwise, velocity should exceed 0.5 fps.

APPROXIMATE PIPE REQUIREMENTS

SPACING ft/ac	20	30	40	50	60	70	80	90	100
2180	1450	1080	870	725	620	545	485	435	
110	120	140	150	160	180	200	220	250	175

0.6% GRADE

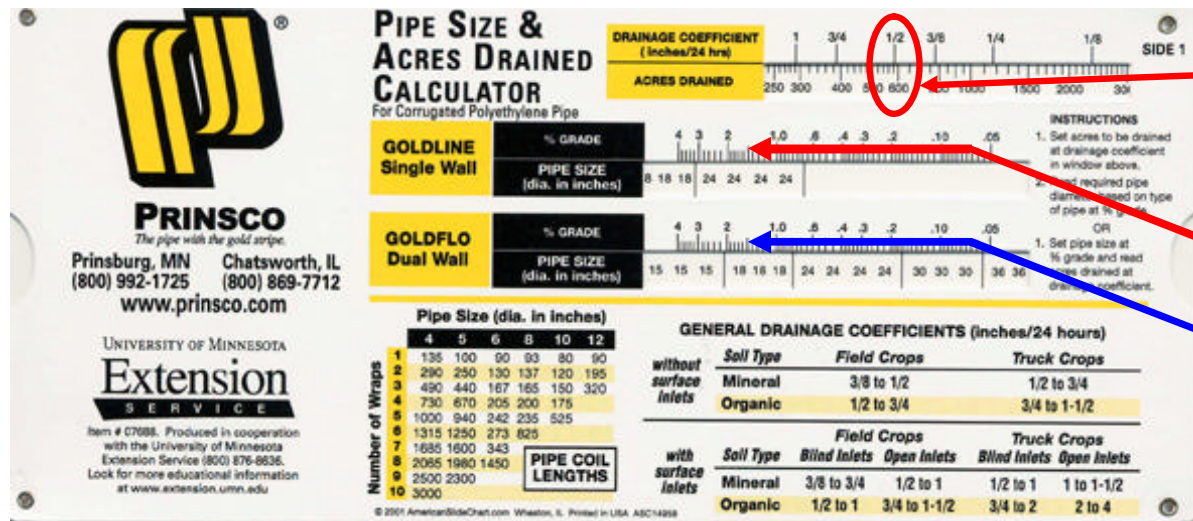
Length of run in ft	200	400	600	800	1000
Feet of Fall	1.2	2.4	3.6	4.8	6.0
Length of run in ft	1200	1400	1600	1800	2000
Feet of Fall	7.2	8.4	9.6	11	12

MINIMUM RECOMMENDED GRADES (PERCENT) FOR DRAINAGE PIPES

Drain Inside Dia.	Drains not subjected to fine sand or silt (min velocity 0.5 fps)		Drains where fine sand or silt may enter (min velocity 1.4 fps)	
	Concrete	Plastic	Concrete	Plastic
3"	0.60	0.10	0.60	0.81
4"	0.05	0.07	0.41	0.55
5"	0.04	0.05	0.30	0.41
6"	0.03	0.04	0.24	0.32
8-12"	0.07			
12" +	0.05			

Prinsco-U_{of}M Slide Rule

◆ pipe size → acres drained



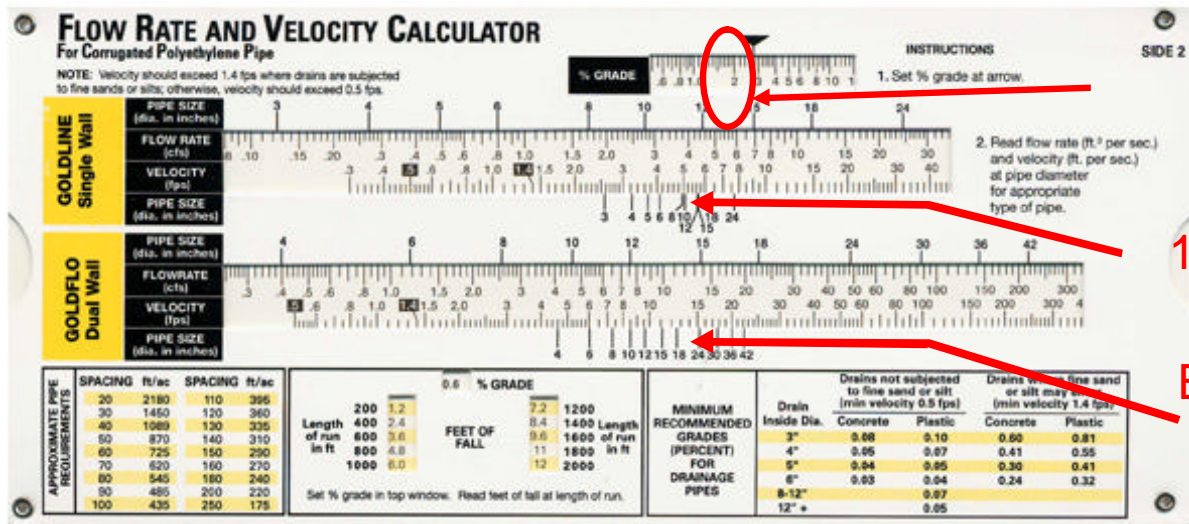
600 acres at 1/2" drain. coefficient

1.5% grade - 24"

dual wall - 18"

Prinsco-U_{ofM} Slide Rule

◆ grade/pipe size → flowrate/velocity



0.1% grade

10" pipe < 1.4 fps

But 10" pipe > 1.5 fps if dual wall

Drain Sizing - Grade & Size

- ◆ Always round up to next larger size
- ◆ Don't create bottlenecks in system

Potential Acres Drained by Selected Tile Sizes and Grades <i>Drainage Coefficient = 1/2-inch/day</i>						
% Grade	4"	5"	6"	8"	10"	12"
.10	2	4.5	8	15	25	40
.25	4	7.5	12	25	40	65
.50	6	11	17	36	58	92
1.00	8	14	23	50	80	130
2.00	12	20	32	72	118	185

Spreadsheets

Microsoft Excel - Drain Cut Sheet Aid.xls

U68

Date: December 18, 2008

Range: 0 Section: 0

Reach: 0

	Enter Drain Station	Enter Drain Hub Elevation	Ground Grade (%)	Enter Outlet Elev	Drain Elev	Enter Drain Grade (%)
Begin Data Entry →	CLEAR	CLEAR		CLEAR		CLEAR
	100.0	101.00			96.5	
	150.0	100.50	1.000		96.1	
	250.0	99.25	1.250		95.2	
	350.0	98.00	1.250		94.3	
	500.0	96.56	0.960		92.9	0.9
	600.0	95.80	0.760		92.3	
	675.0	96.00	(((0.267)))		91.8	
split	800.0	96.10	(((0.080)))		91.0	
	925.0	94.75	1.080		90.1	
	1000.0	94.00	1.000		89.7	
	1100.0	93.50	0.500	89	89.0	0.65

Drain Cut (ft)	Drain Grade ft/ft	Drain Diam. (in)	Drain Cover (ft)	COMMENTS
4.5			4.5	
4.4	0.900		4.4	
4.1	0.900		4.1	
3.8	0.900		3.8	
3.7	0.900		3.7	
3.6	0.850		3.6	
4.2	0.850		4.2	
5.1	0.850		5.1	
4.6	0.850		4.6	
4.3	0.850		4.3	
4.5	0.850		4.5	

split

split

Top Top Top

INSTRUCTIONS - Read Me First! / Cut Sheet Data Entry / Tile Cut Graph / Example / FORMULAS /

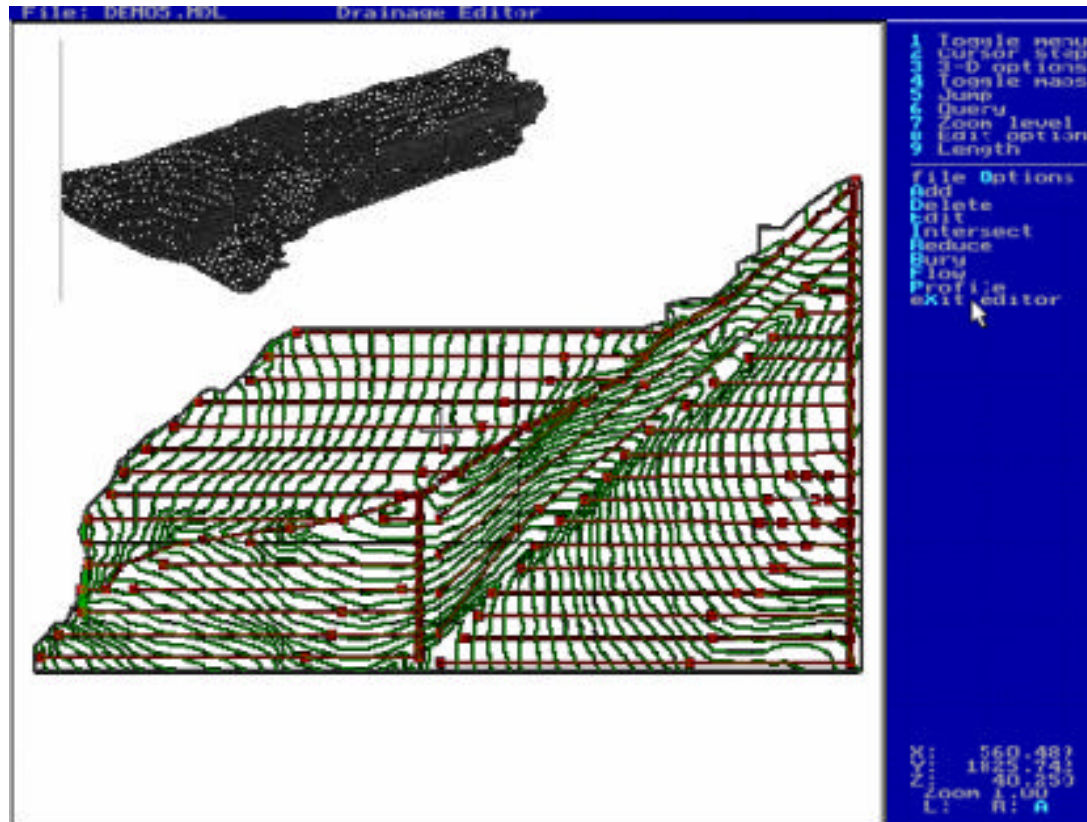
Ready

Microsoft Excel - Drain Cut Sheet Aid.xls

3:31 PM

The graph, titled 'Tile Profile Elevation', plots Elevation (ft) on the y-axis (ranging from 88 to 102) against Station (ft) on the x-axis (ranging from 0 to 1000). Two data series are shown: 'Ground Elev.' (red line) and 'Tile Elev.' (blue line). The ground elevation starts at approximately 101.00 ft at station 0 and generally decreases to about 93.50 ft at station 1100. The tile elevation starts at 96.50 ft at station 0 and decreases to 89.00 ft at station 1100. The tile elevation is consistently below the ground elevation, indicating the drain is below the ground surface.

Computer Aided Drainage



Questions?

On-line Calculators

Prinsco - Financial Calculator - Netscape
File Edit View Go Communicator Help

PRINSCO
The pipe with the gold stripe.

June 20, 2000

GOLDFLO
GOLDLINE
GOLDLINE GLP

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FARM DRAINAGE

DRAINAGE CALCULATOR

Please read our instructions on how to use this calculator.

? = Definition

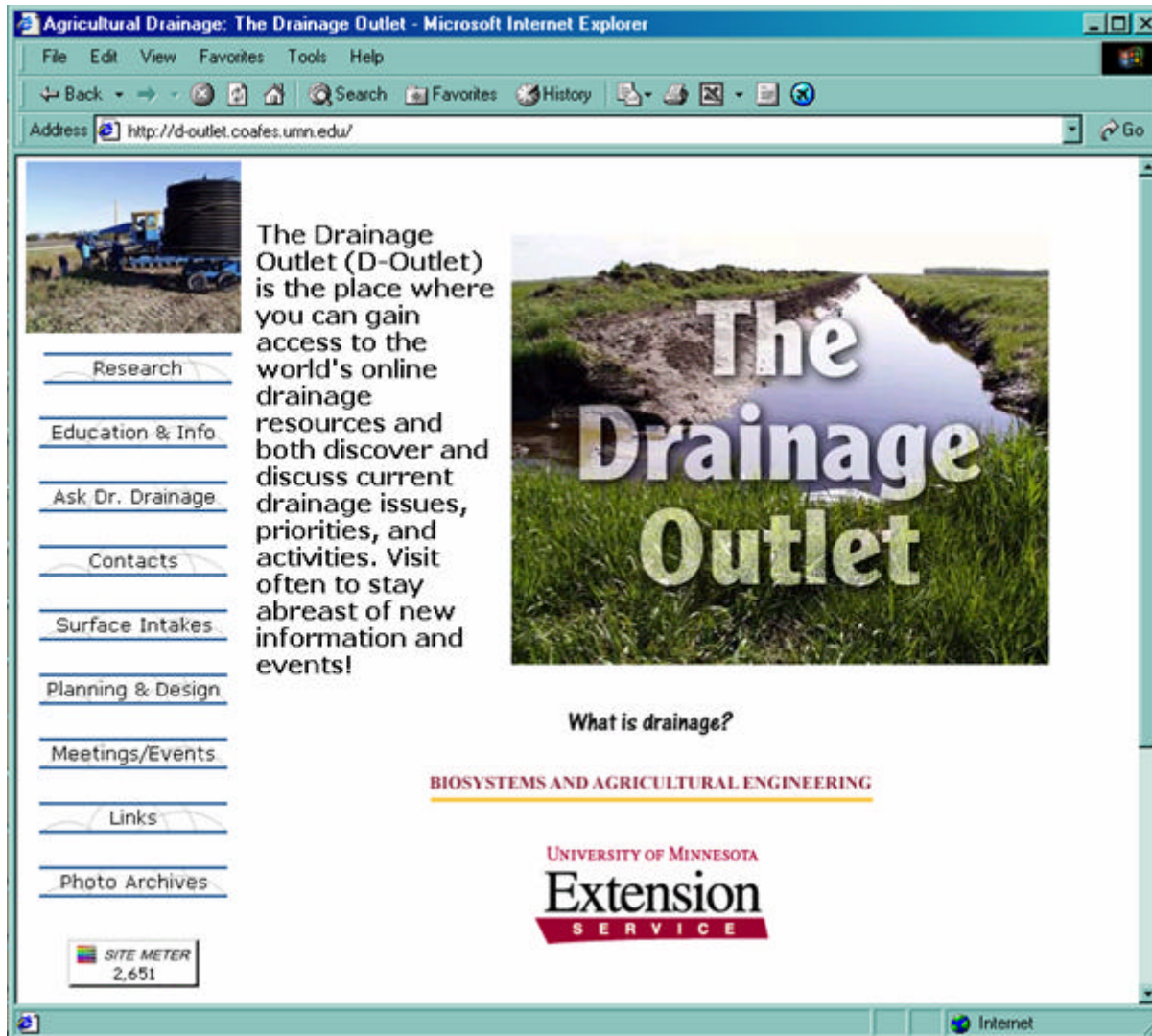
Enter the Projected Job Cost (\$) ?	48000
Enter the Acres to be drained	160
Enter Projected Corn Yield Improvements (bu/acre) ?	22
Enter Projected Soybean Yield Improvements (bu/acre) ?	10
Enter Current Corn Price (\$/bu.)	1.60
Enter Current Soybean Price (\$/bu.)	4.5
Enter Interest Rate ?	8

Calculate

Before Tax Rate of Return (%)	10.2
Payback Period (years)	7
Breakeven Yield, Corn (bu./acre)	19.2
Breakeven Yield, Soybeans (bu./acre)	8.7

Document: Done

Internet Resources



The screenshot shows a Microsoft Internet Explorer browser window with the title bar "Agricultural Drainage: The Drainage Outlet - Microsoft Internet Explorer". The address bar contains the URL "http://d-outlet.coafes.umn.edu/". The main content area features a navigation menu on the left with links for Research, Education & Info, Ask Dr. Drainage, Contacts, Surface Intakes, Planning & Design, Meetings/Events, Links, and Photo Archives. A central text block describes the site as a resource for drainage information. To the right is a large image of a drainage ditch with the text "The Drainage Outlet" overlaid. Below the image is a link "What is drainage?". At the bottom, the text "BIOSYSTEMS AND AGRICULTURAL ENGINEERING" is underlined, followed by the "UNIVERSITY OF MINNESOTA Extension SERVICE" logo. A "SITE METER 2,651" badge is visible in the bottom left corner of the page content.

Agricultural Drainage: The Drainage Outlet (D-Outlet) is the place where you can gain access to the world's online drainage resources and both discover and discuss current drainage issues, priorities, and activities. Visit often to stay abreast of new information and events!

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The Drainage Outlet

[What is drainage?](#)

BIOSYSTEMS AND AGRICULTURAL ENGINEERING

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