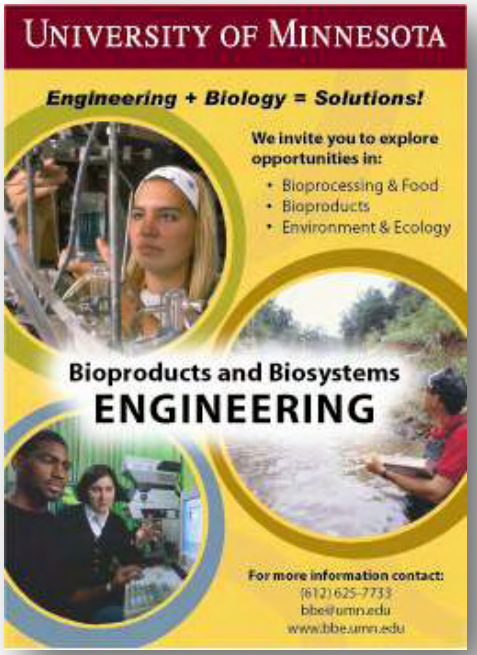
UNIVERSITY OF MINNESOTA
EXTENSION



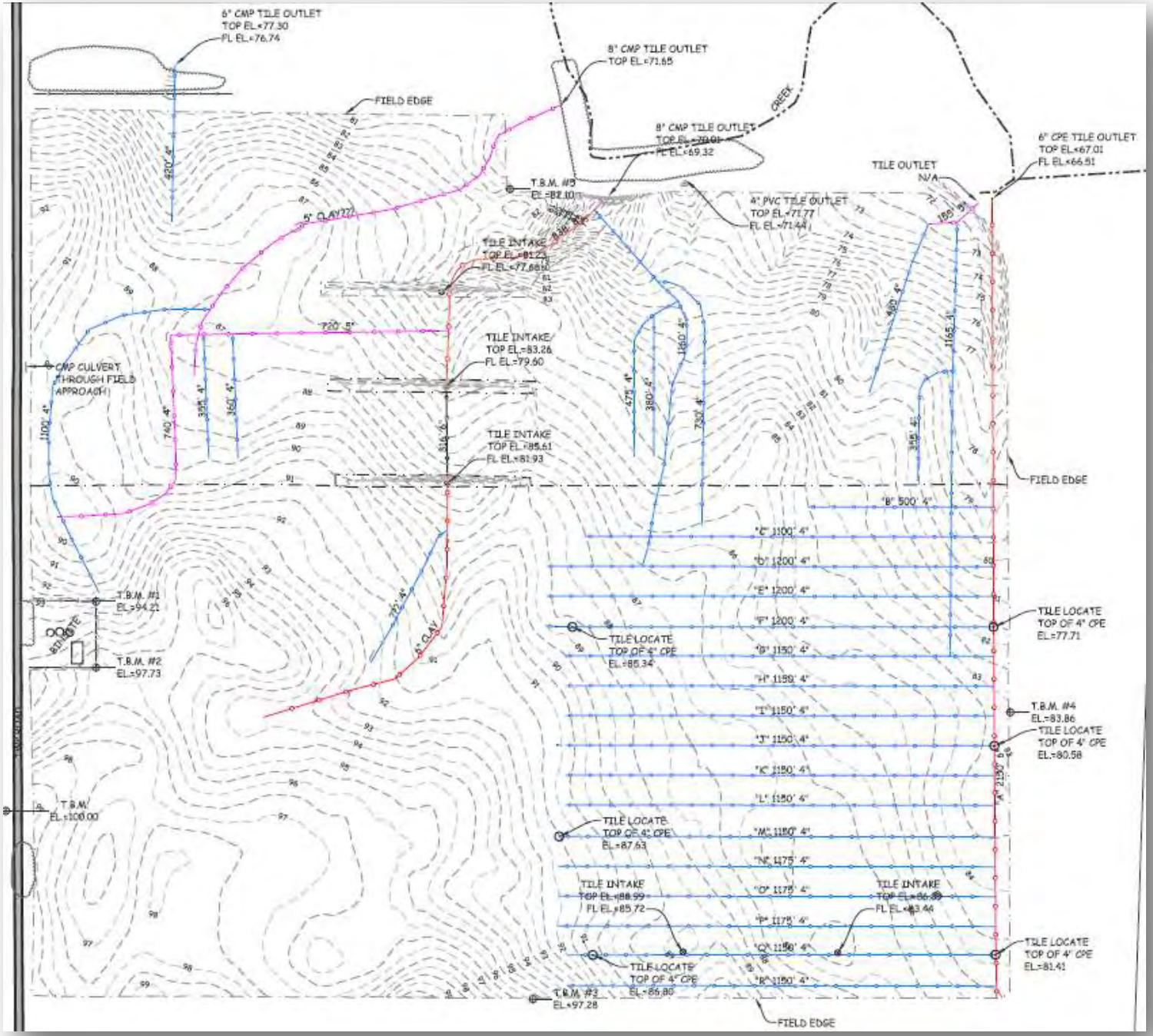
Gary R. Sands

Associate Professor & Extension Engineer

Bioproducts & Biosystems Engineering

UNIVERSITY OF MINNESOTA

Subsurface (Tile) Drainage Design


6" CMP TILE OUTLET
TOP EL.=77.30
FL EL.=76.74
8" CMP TILE OUTLET
TOP EL.=71.65
FIELD EDGE
CREEK
8" CMP TILE OUTLET
TOP EL.=70.01
FL EL.=69.32
6" CPE TILE OUTLET
TOP EL.=67.01
FL EL.=66.51
TILE OUTLET
N/A
T.B.M. #5
EL.=82.10
4" PVC TILE OUTLET
TOP EL.=71.77
FL EL.=71.44
5" CLAY
TILE INTAKE
TOP EL.=81.23
FL EL.=77.66
720' 5"
TILE INTAKE
TOP EL.=83.26
FL EL.=79.60
CMP CULVERT
THROUGH FIELD
APPROACH
TILE INTAKE
TOP EL.=85.61
FL EL.=81.93
FIELD EDGE
"B" 500' 4"
"C" 1100' 4"
"D" 1200' 4"
"E" 1200' 4"
"F" 1200' 4"
"G" 1150' 4"
"H" 1150' 4"
"I" 1150' 4"
"J" 1150' 4"
"K" 1150' 4"
"L" 1150' 4"
"M" 1150' 4"
"N" 1175' 4"
"O" 1175' 4"
"P" 1175' 4"
"Q" 1150' 4"
"R" 1150' 4"
T.B.M. #1
EL.=94.21
T.B.M. #2
EL.=97.73
TILE LOCATE
TOP OF 4" CPE
EL.=77.71
TILE LOCATE
TOP OF 4" CPE
EL.=85.34
T.B.M. #4
EL.=83.86
TILE LOCATE
TOP OF 4" CPE
EL.=80.58
T.B.M.
EL.=100.00
TILE LOCATE
TOP OF 4" CPE
EL.=87.63
TILE INTAKE
TOP EL.=88.99
FL EL.=85.72
TILE INTAKE
TOP EL.=86.89
FL EL.=83.44
TILE LOCATE
TOP OF 4" CPE
EL.=81.41
TILE LOCATE
TOP OF 4" CPE
EL.=86.80
T.B.M. #3
EL.=97.28
FIELD EDGE

What are the Characteristics of a Good Drainage Design?

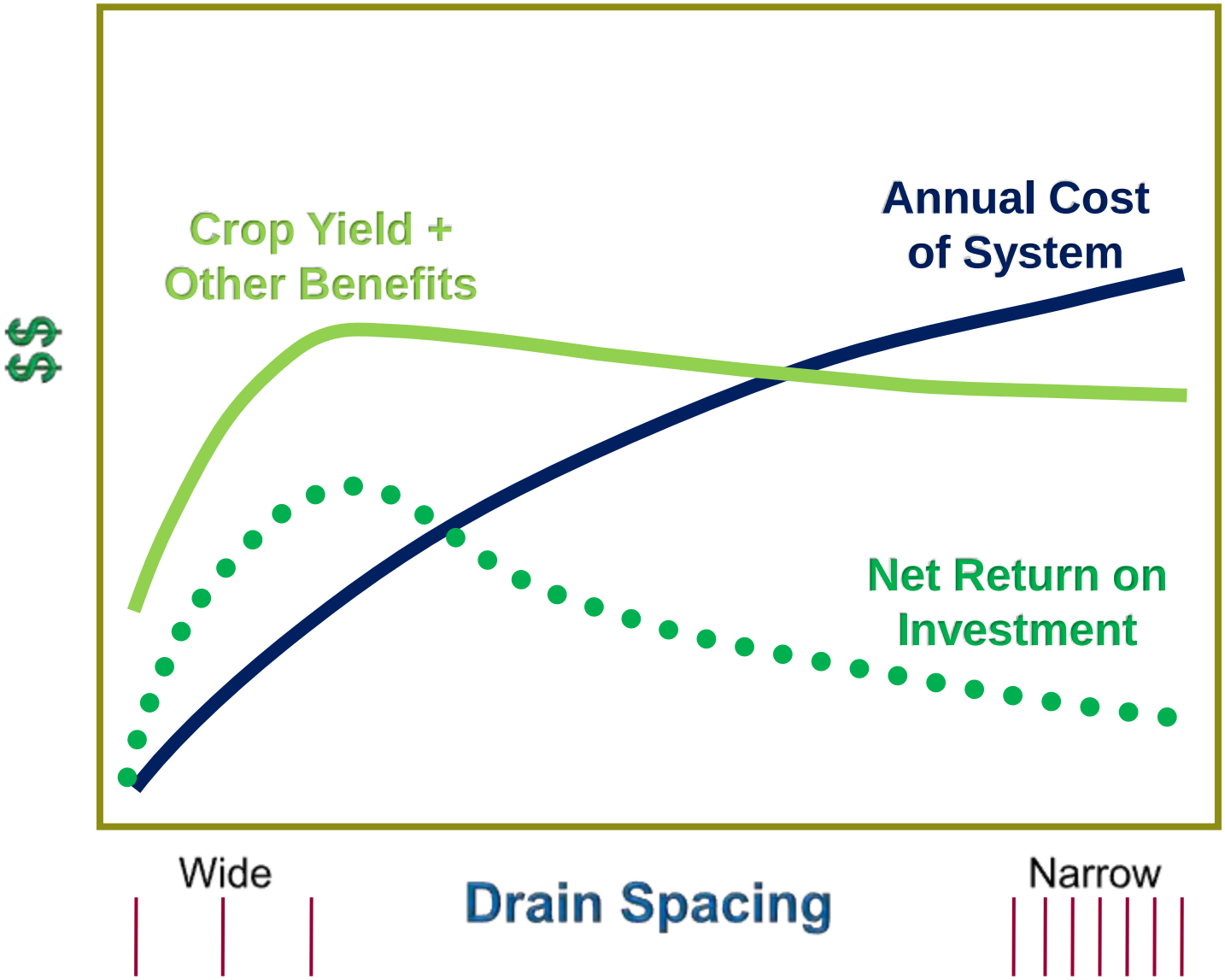
How Do You Know When Your Work is Done?

What are the Characteristics of a Good Drainage Design?

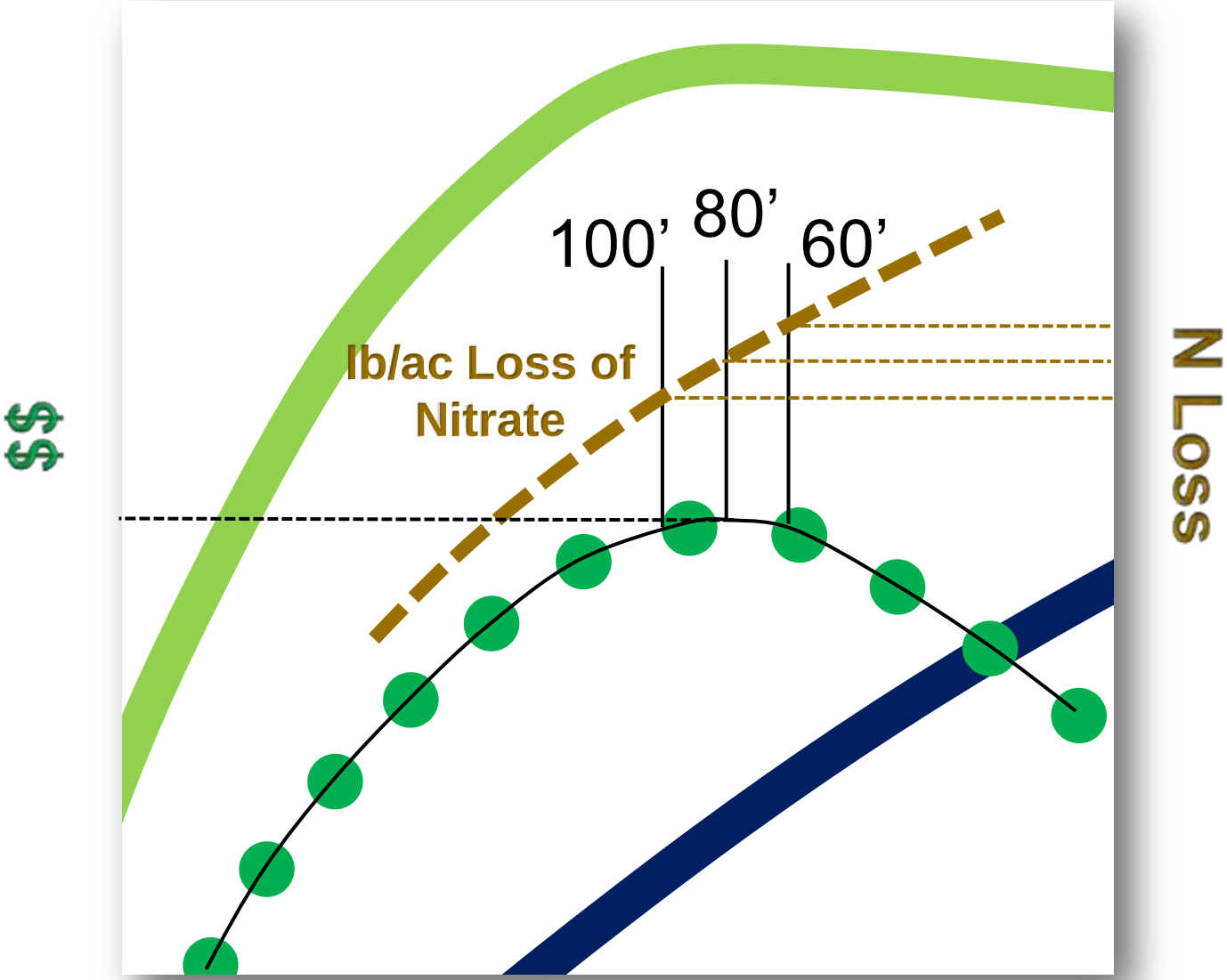
How Do You Know When Your Work is Done?

- Maximizes net returns?
- Reduced annual variability? Reduced Stess?
- Maintenance free?
- Reduces risk of crop loss?
- Improves field operations?
- Incorporates water quality goals?

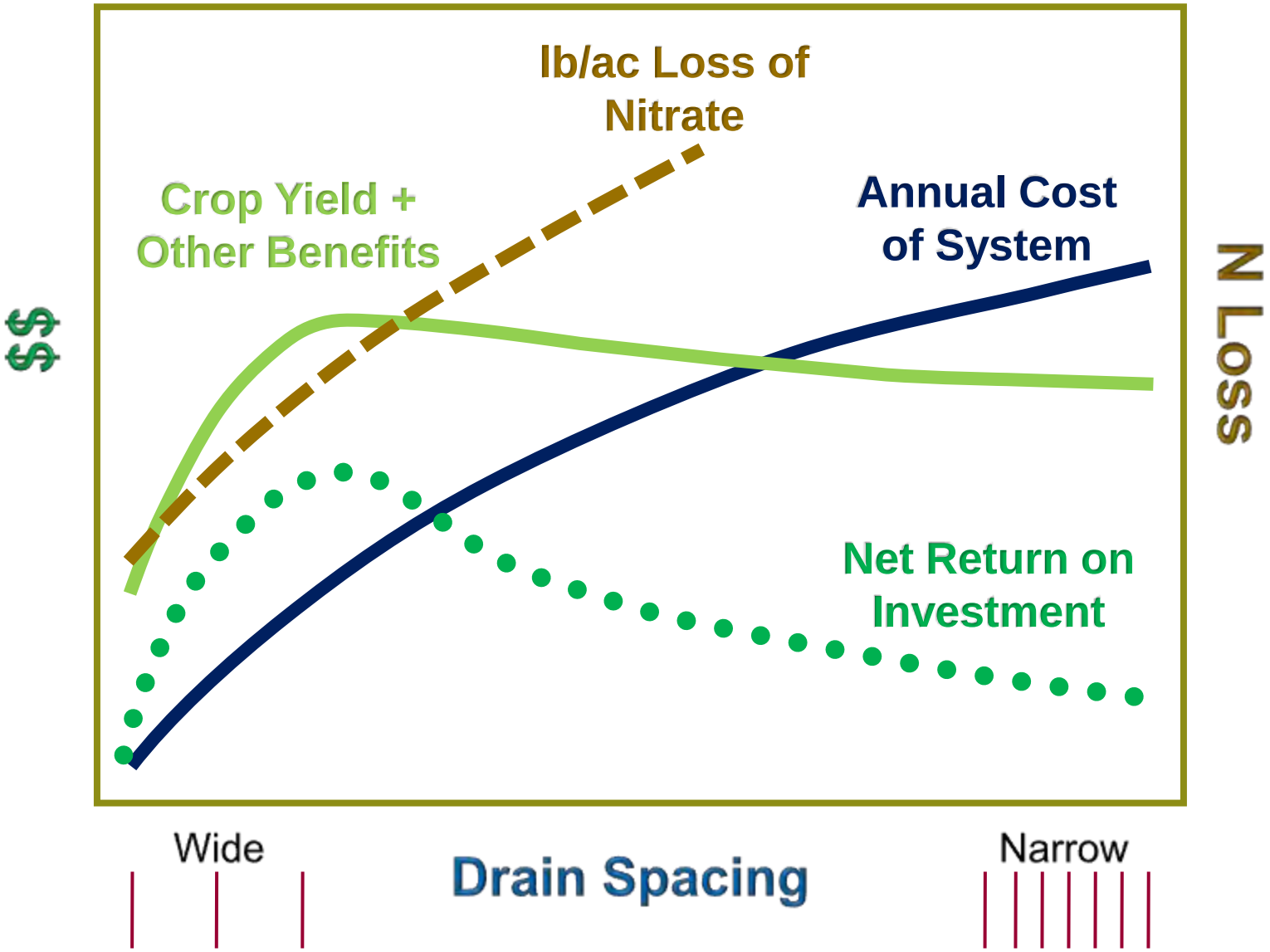
"Optimized" Drainage Design



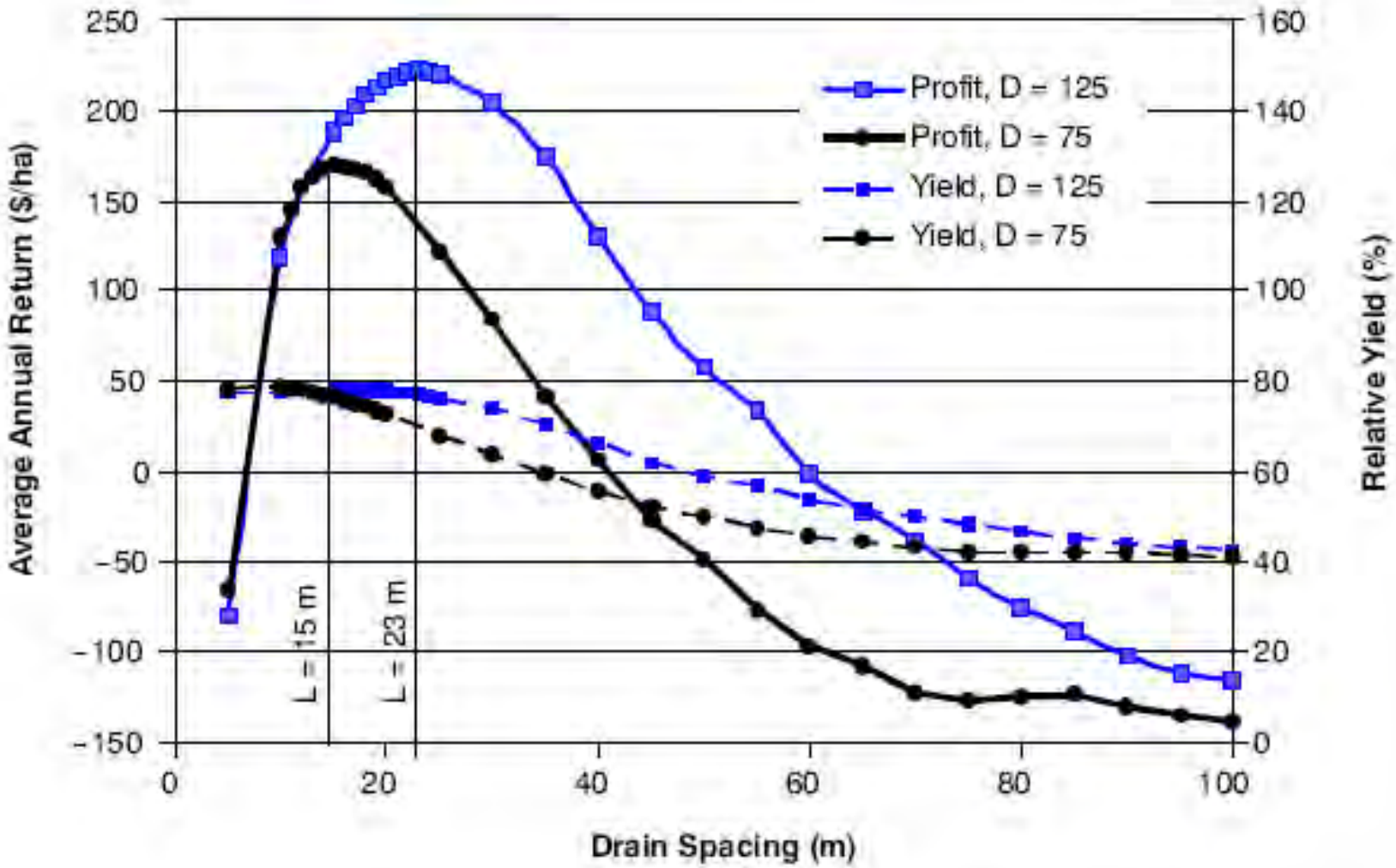
“Optimized” Drainage Design



"Optimized" Drainage Design

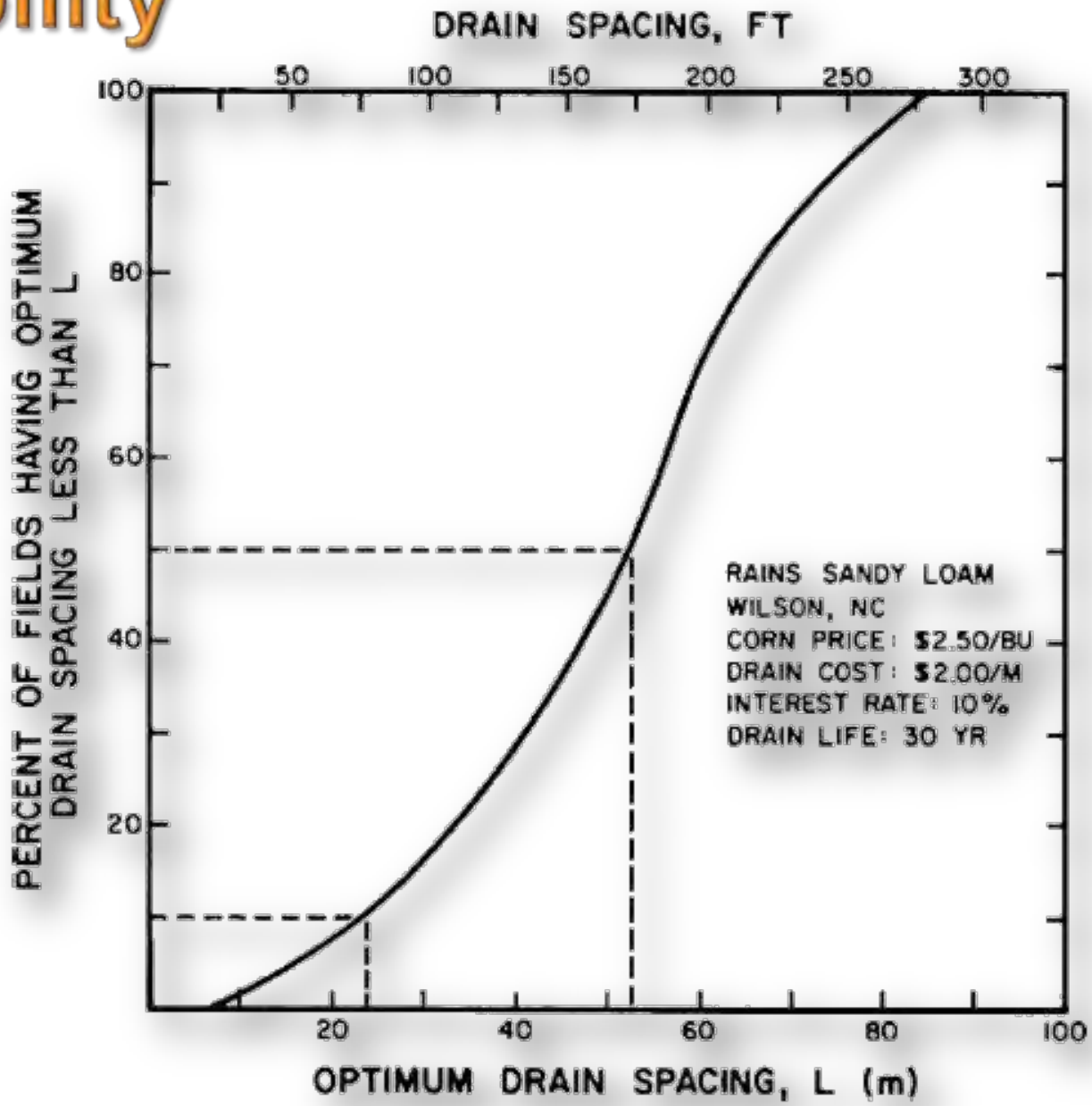


Drainage Design Objectives



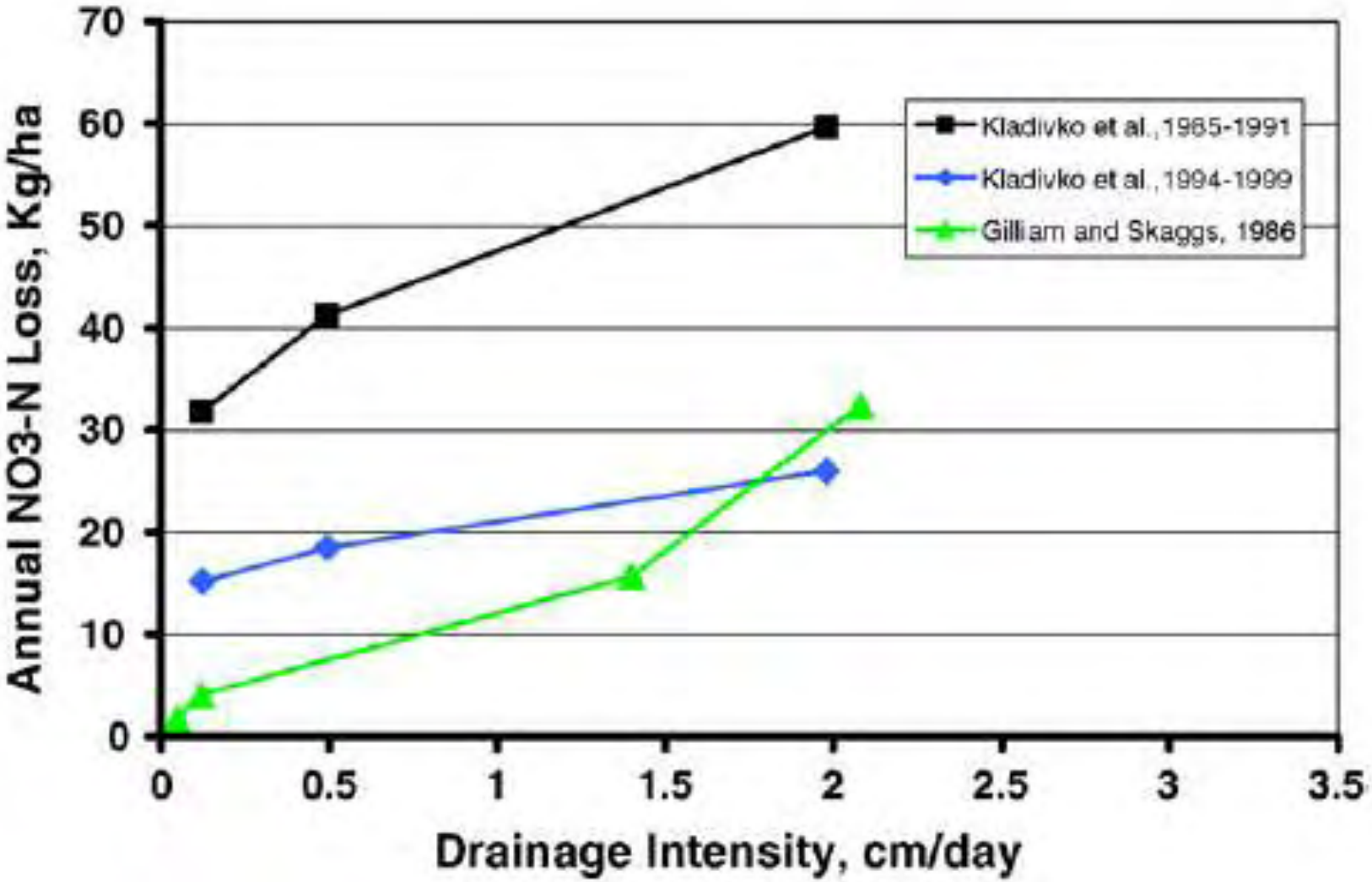
Skaggs, et al (2006)

Soil Variability



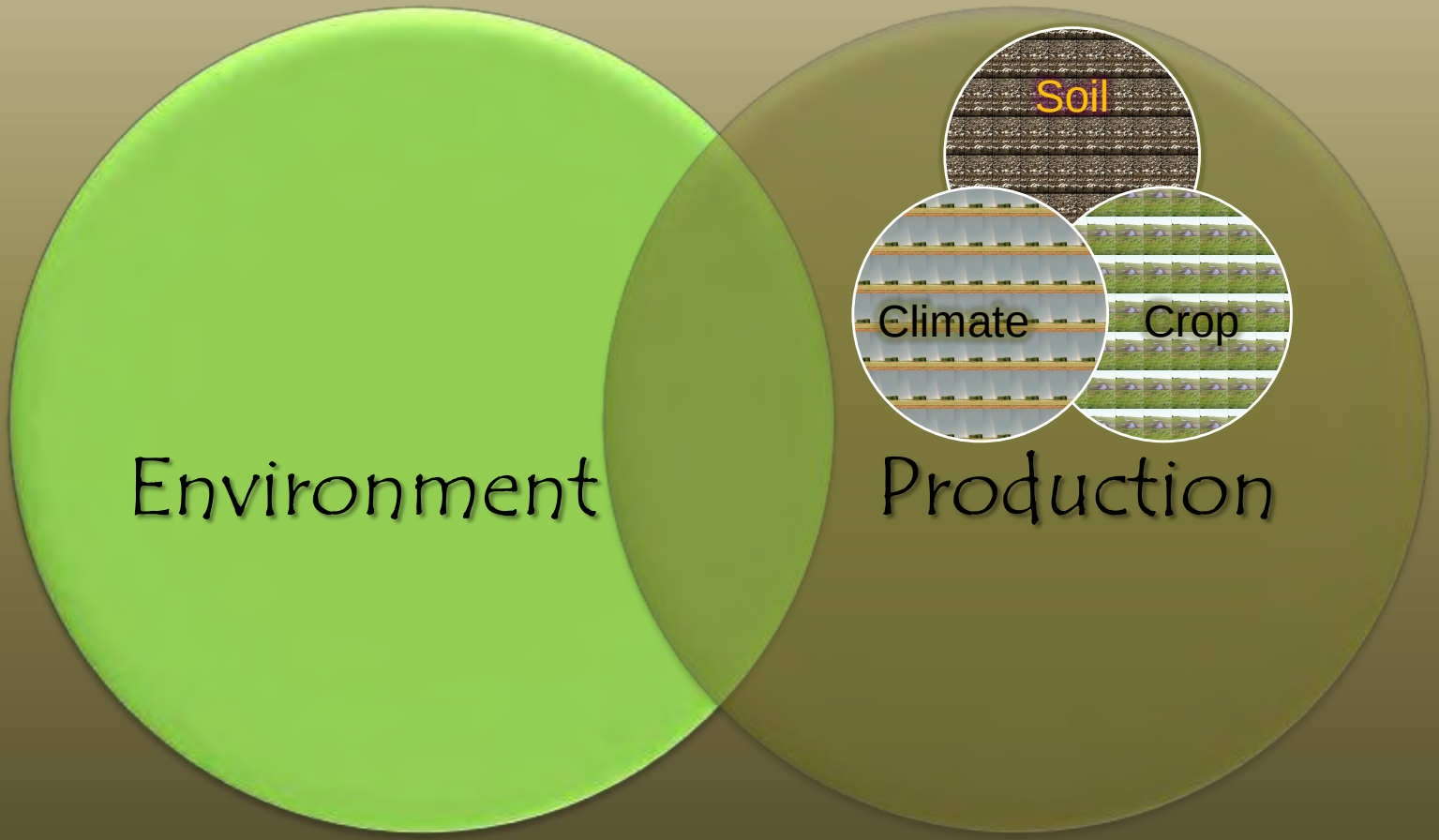
Skaggs, et al (2006)

Environmental Considerations



Skaggs, et al (2007)

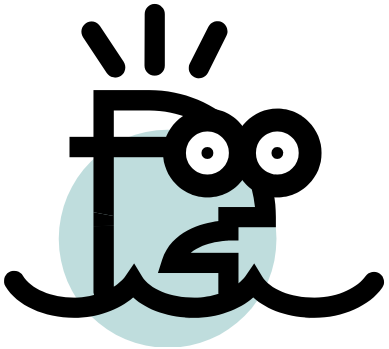
Conservation Drainage



Objectives

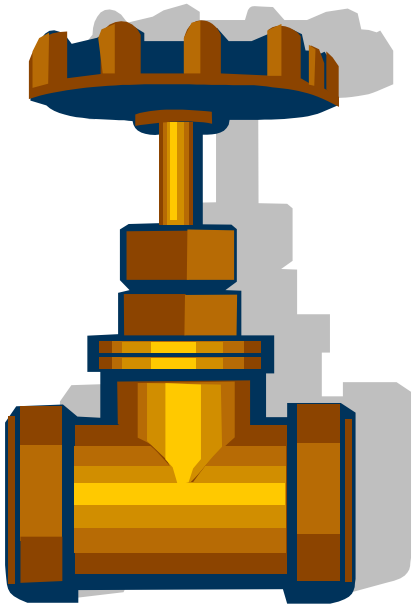
How Drainage Works	*Drainable soil-water*	*What's a water table?*	*Drainage flow*		
The Design Process	*Design Objectives*	*Layout & location of lines*	*Spacing, depth & grade*	*Drain Sizing*	
Design Tools	*Equations*	*Charts*	*Spread-sheets*	*Web*	

How Drainage Works

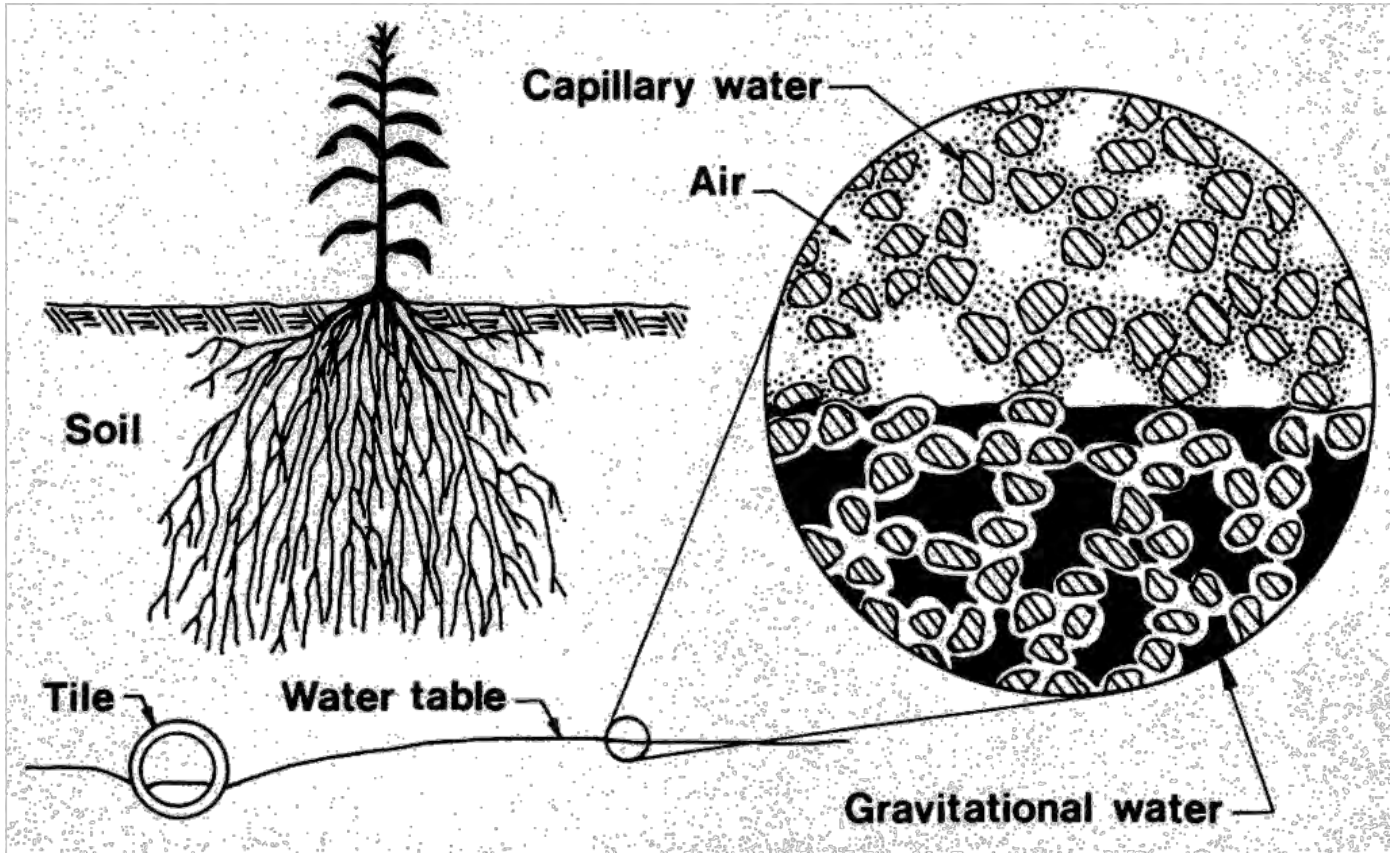


How Drainage Works

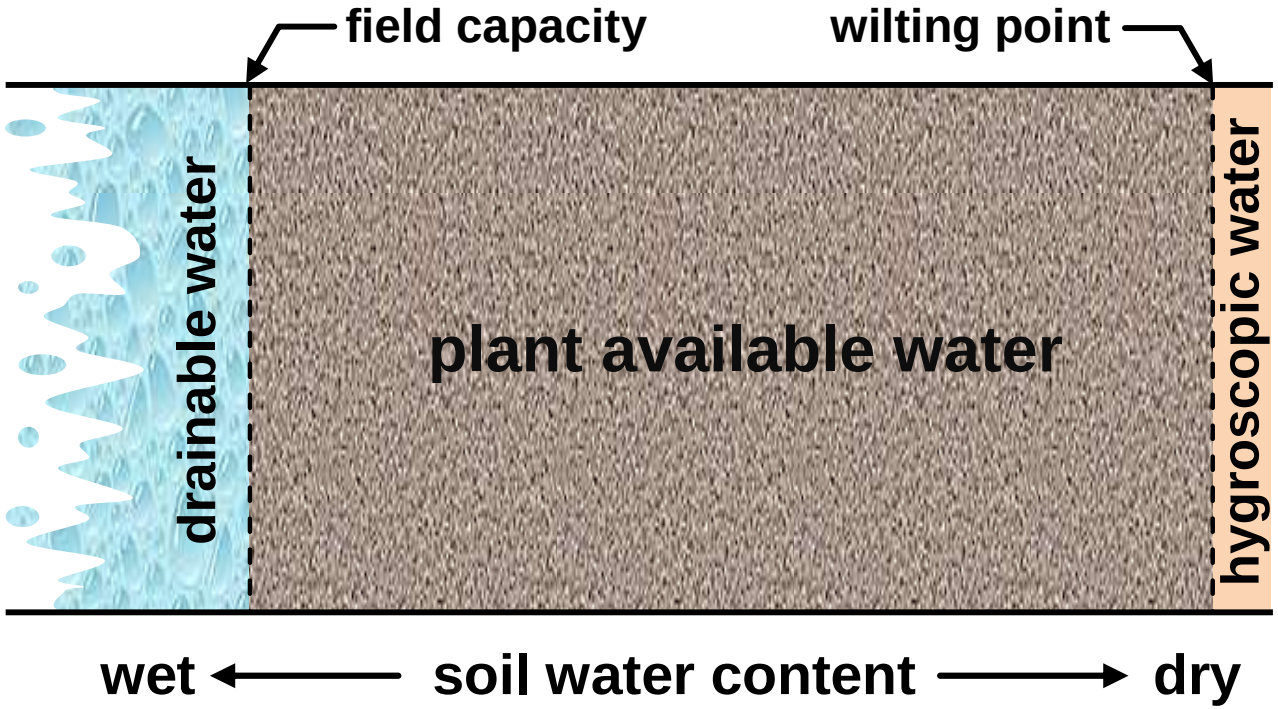
- Drainable water
- What is a water table?
- Physics (uh oh!) of drain flow
- How our design choices influence drainage

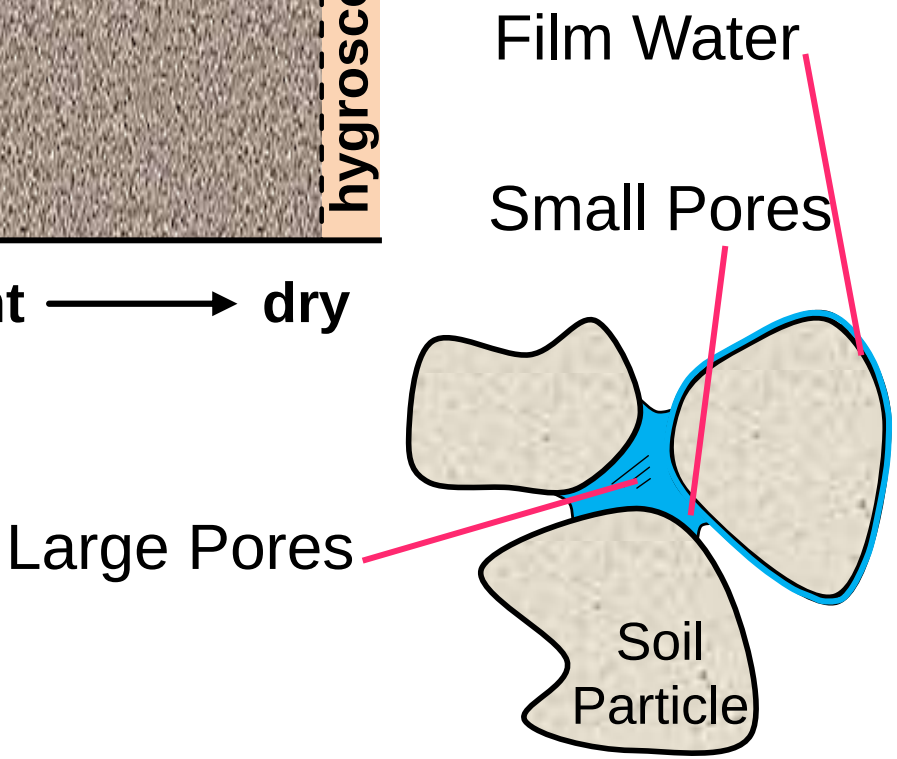


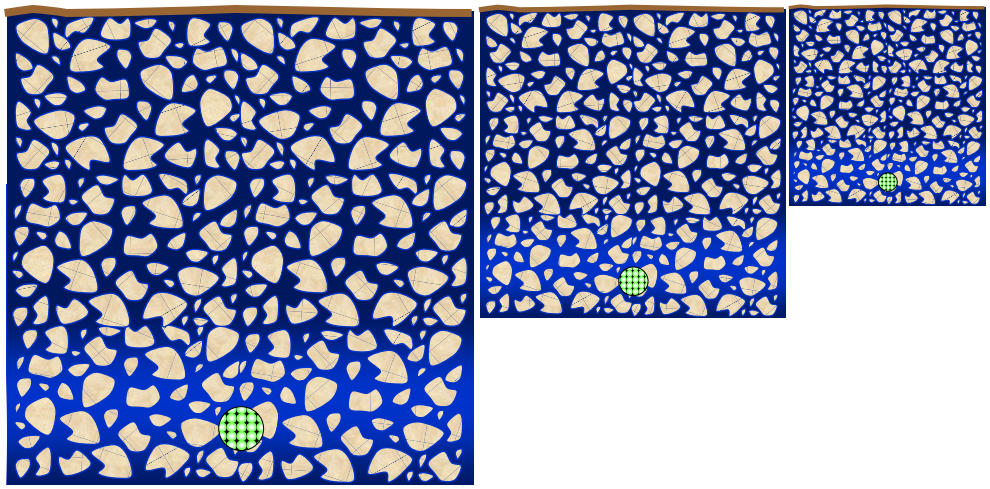
Drainable Water



Forms of Soil Water

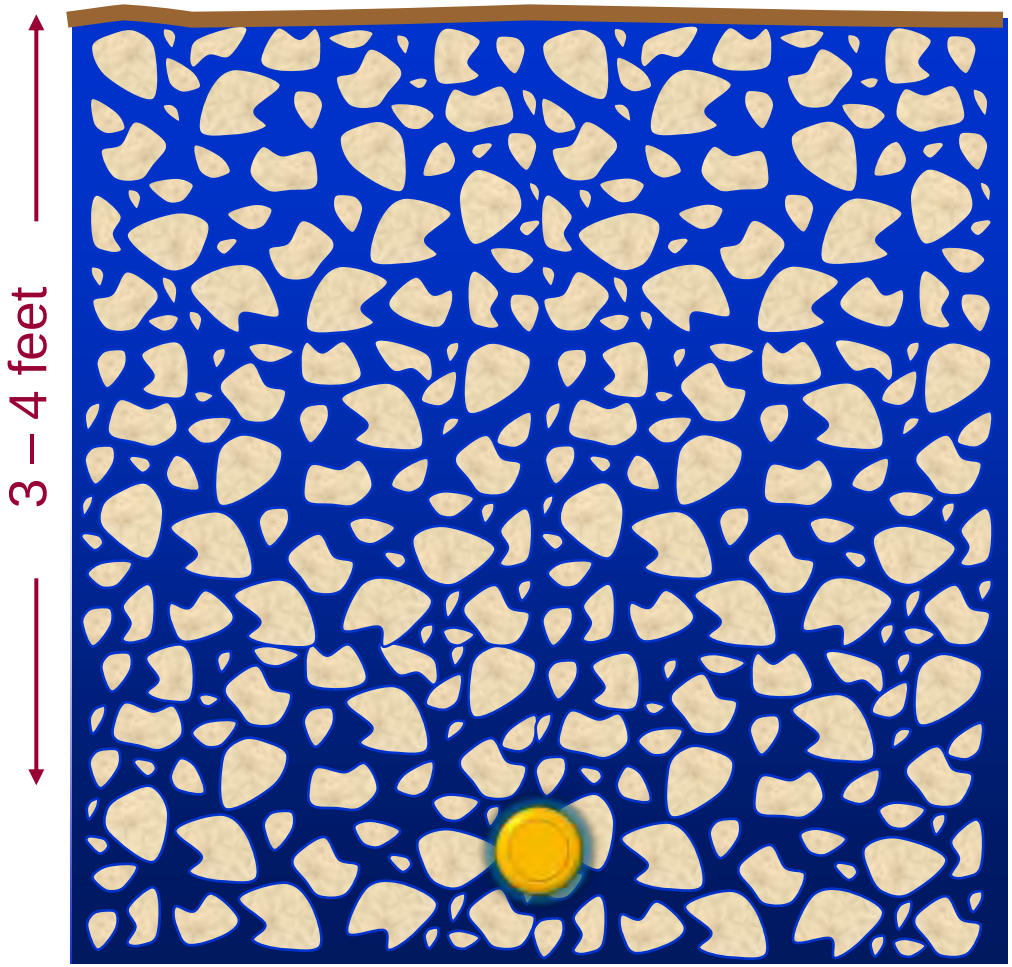






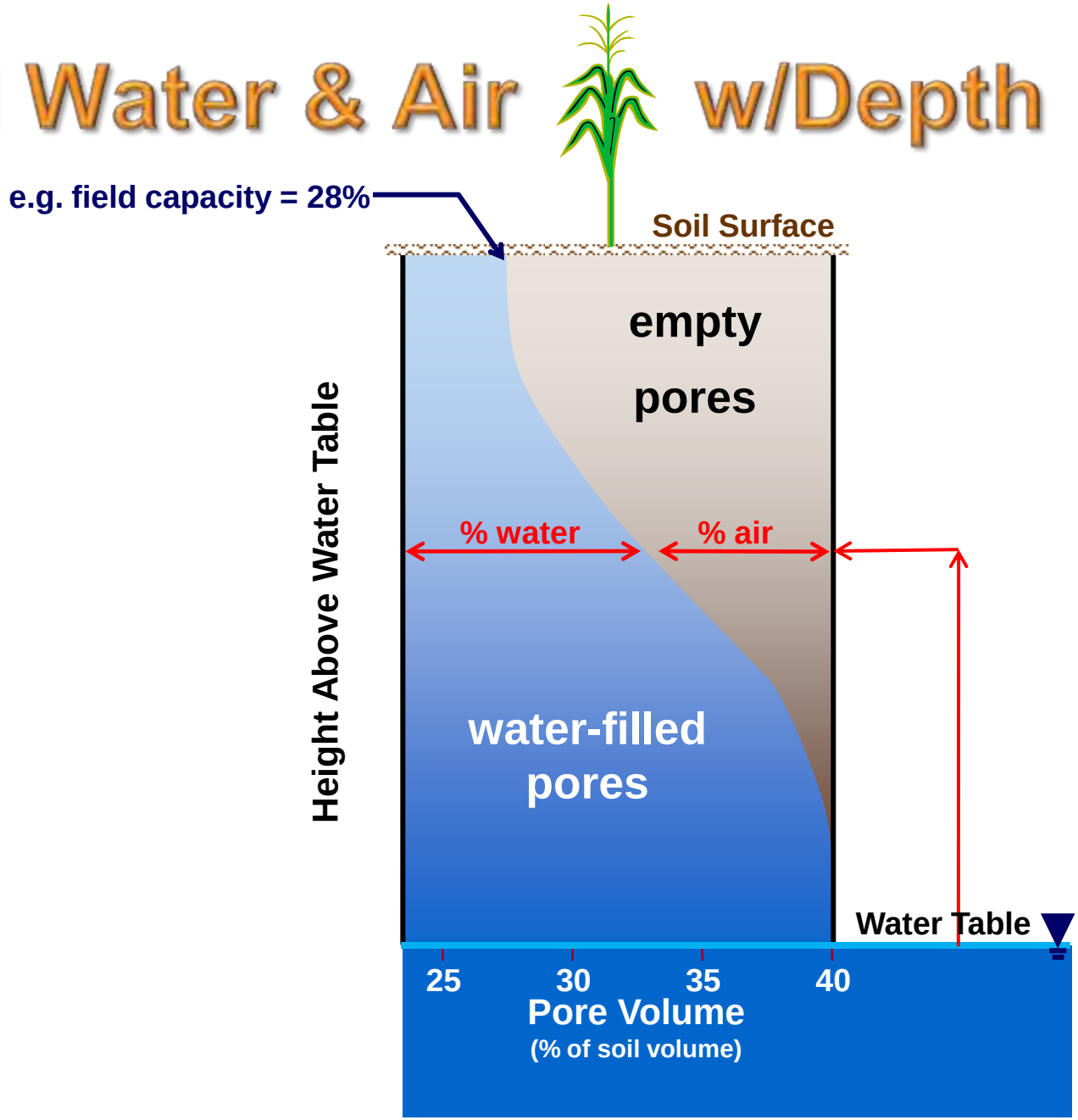
DRAINABLE WATER

What is a Water Table?



- “Gravitational” water removed (from largest pores)
- Water remains in smallest pores
- Drier toward surface
- Water table drop occurs over hours to days
- Doesn’t take much water for fine soils

Soil Water & Air w/Depth



Drainable Water

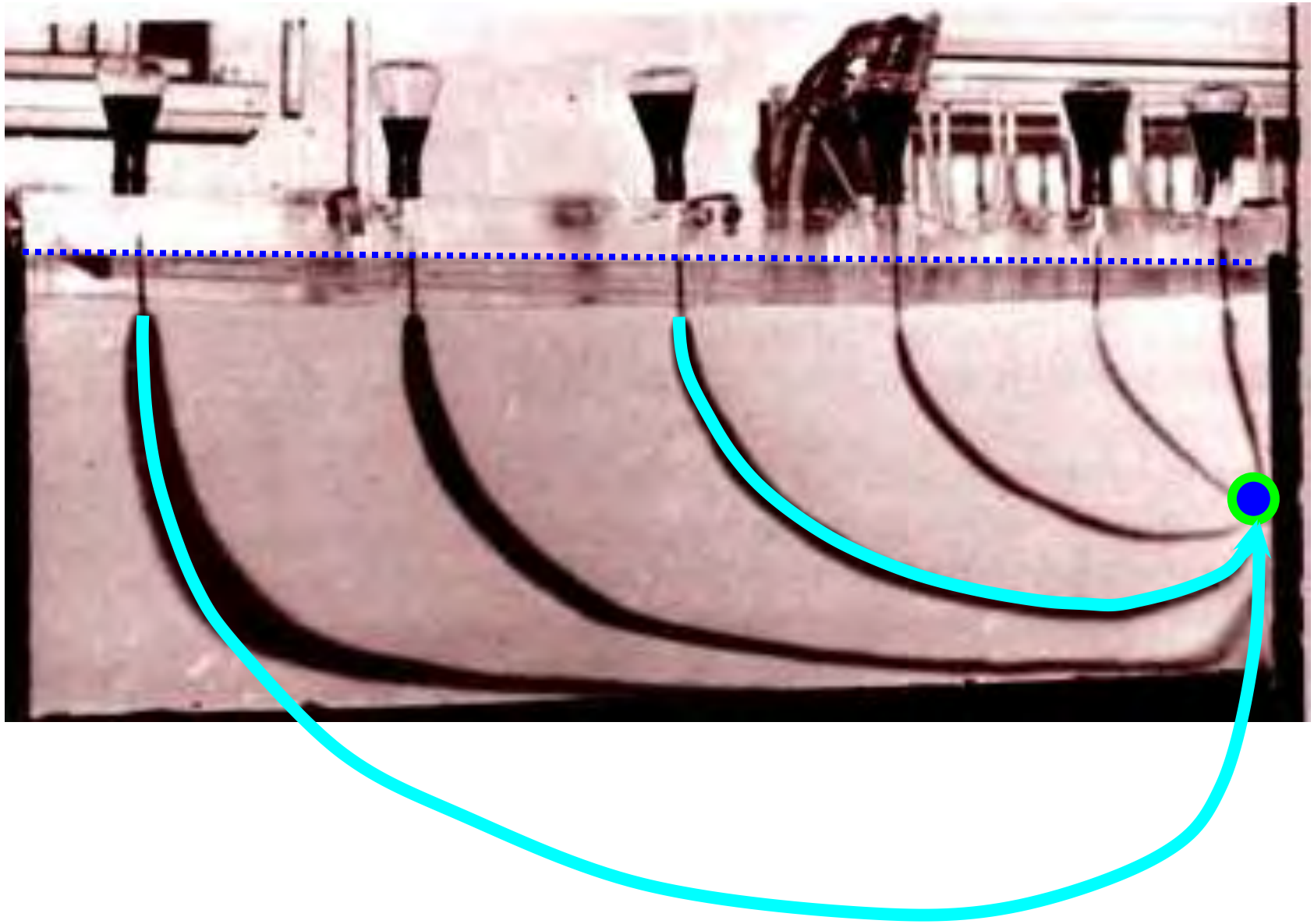
Soil Texture	Field Capacity *(% by vol)*	Wilting Point *(% by vol)*	Drainable Porosity *(% by vol)*
clays, clay loams, silty clays	30-50%	15-24%	3-11%
well structured loams	20-30%	8-17%	10-15 %
sandy	10-30%	3-10%	18-35 %

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

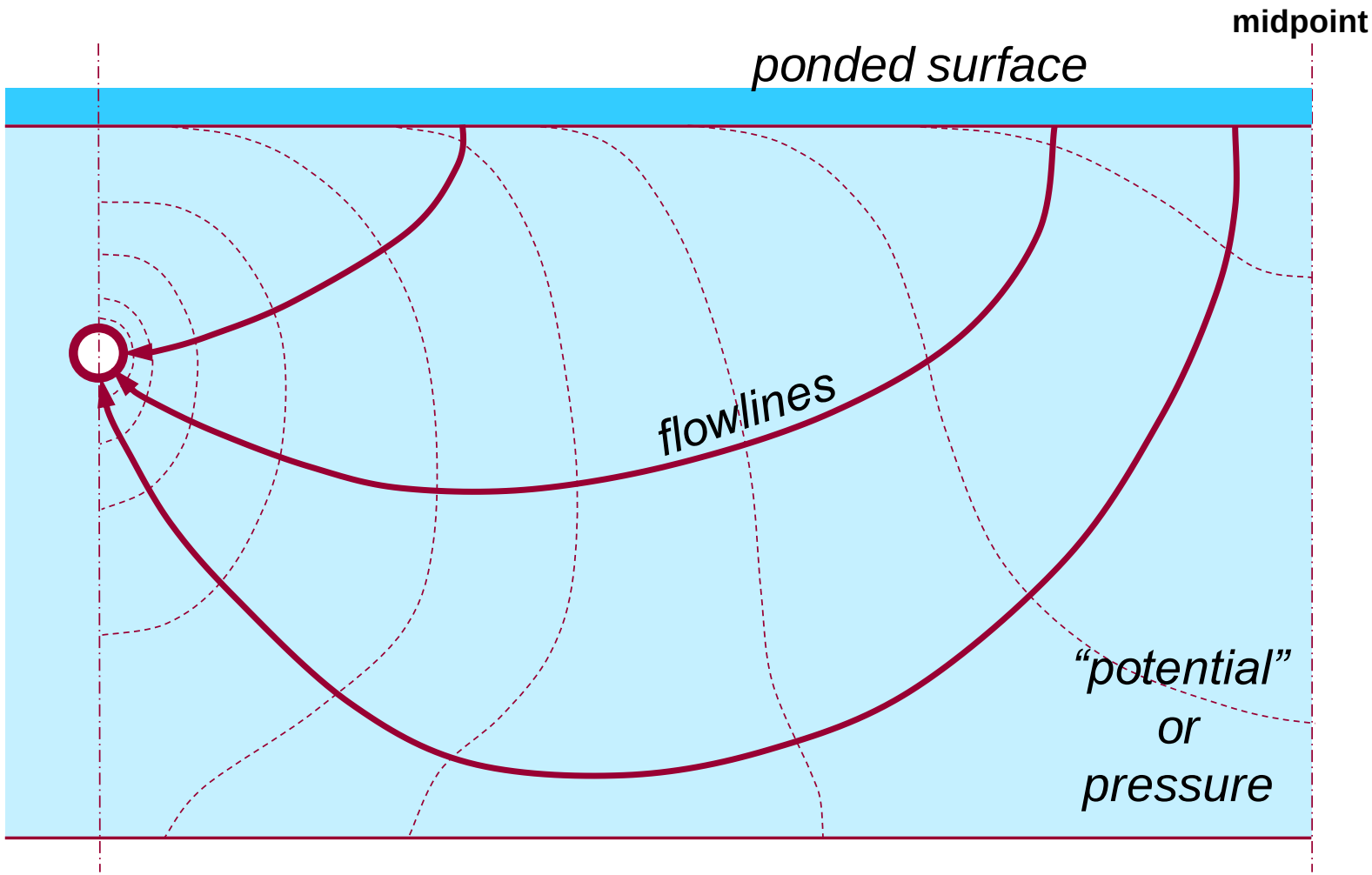
Drainable Water

- 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:
- vol = 8% × (3.5’ - .5’) ÷ 100 = 0.24’ = 2.88”

“Physics” of Drainage Flow



Drainage Flow…Relax, It's Just Physics!



The Design Process

Drainage Design Objectives

Possible Design Objectives

University of Minnesota Extension

- 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

Drainage Design Choices

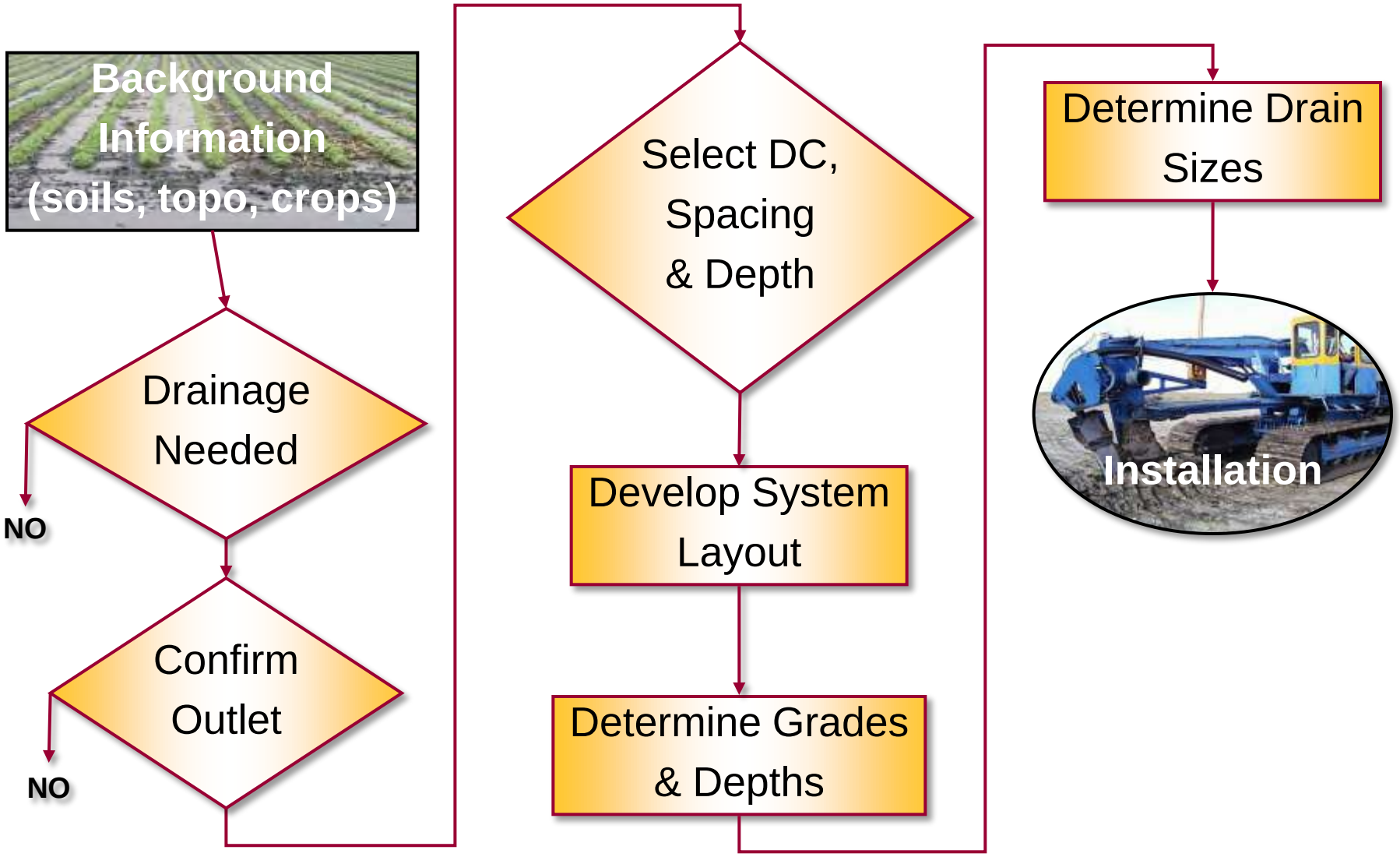
- Design choices (controllable factors):
  - *Areas to be drained*
  - *Drainage rates (coefficients)*
    - Drain depth
    - Drain spacing
  - *Drain size*
- Which choices are most important?

- Design Choices (cont.)
  - *Drain grades*
  - *Drain materials*
  - *Drainage system layout*
  - *Outlet configuration*
    - (elev, pumped, natural)

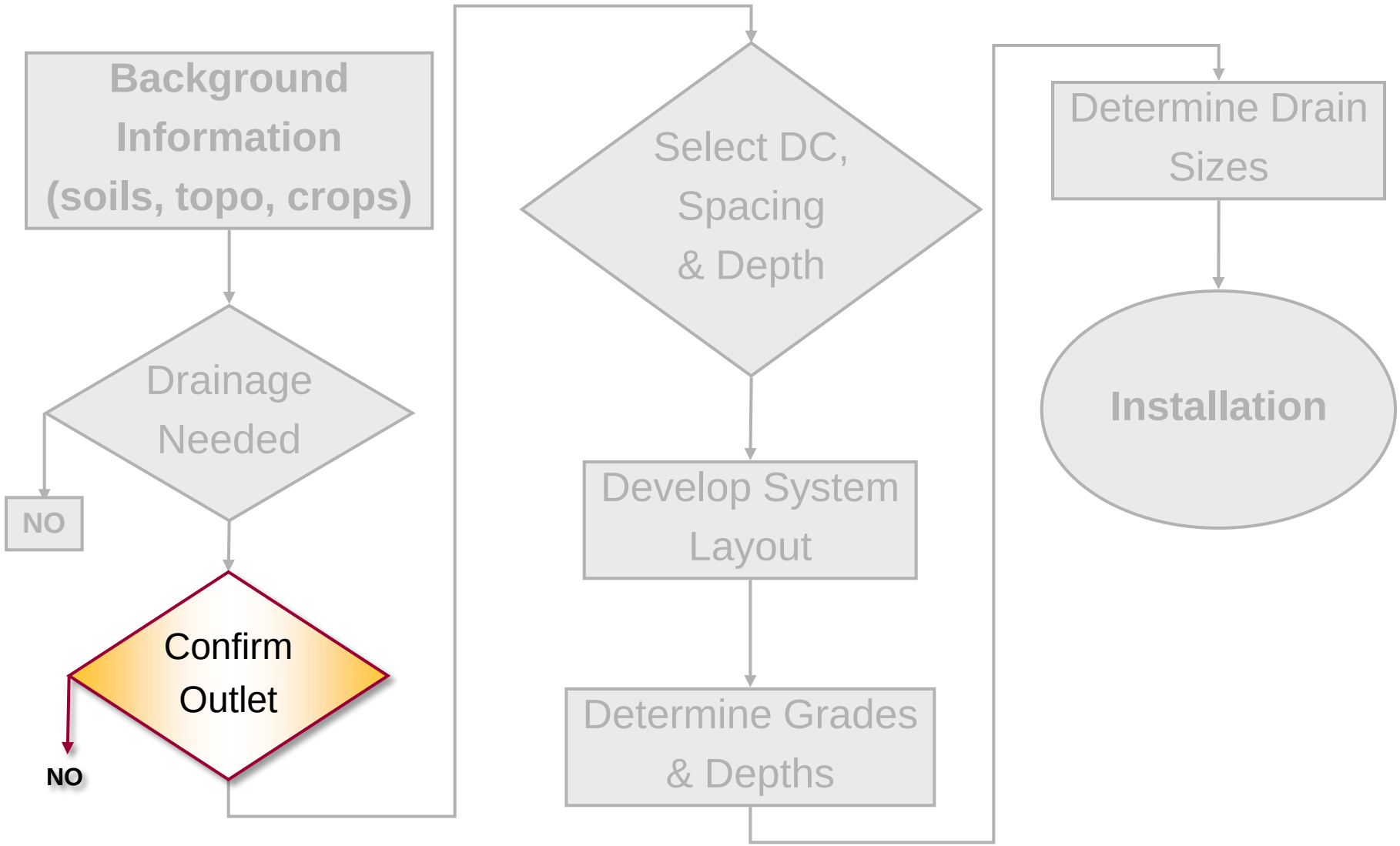
Uncontrollable Factors

- Rainfall/climate factors
- Soils
- Topography
- Outlet condition
- Legal/regulatory framework

Design Process Flowchart



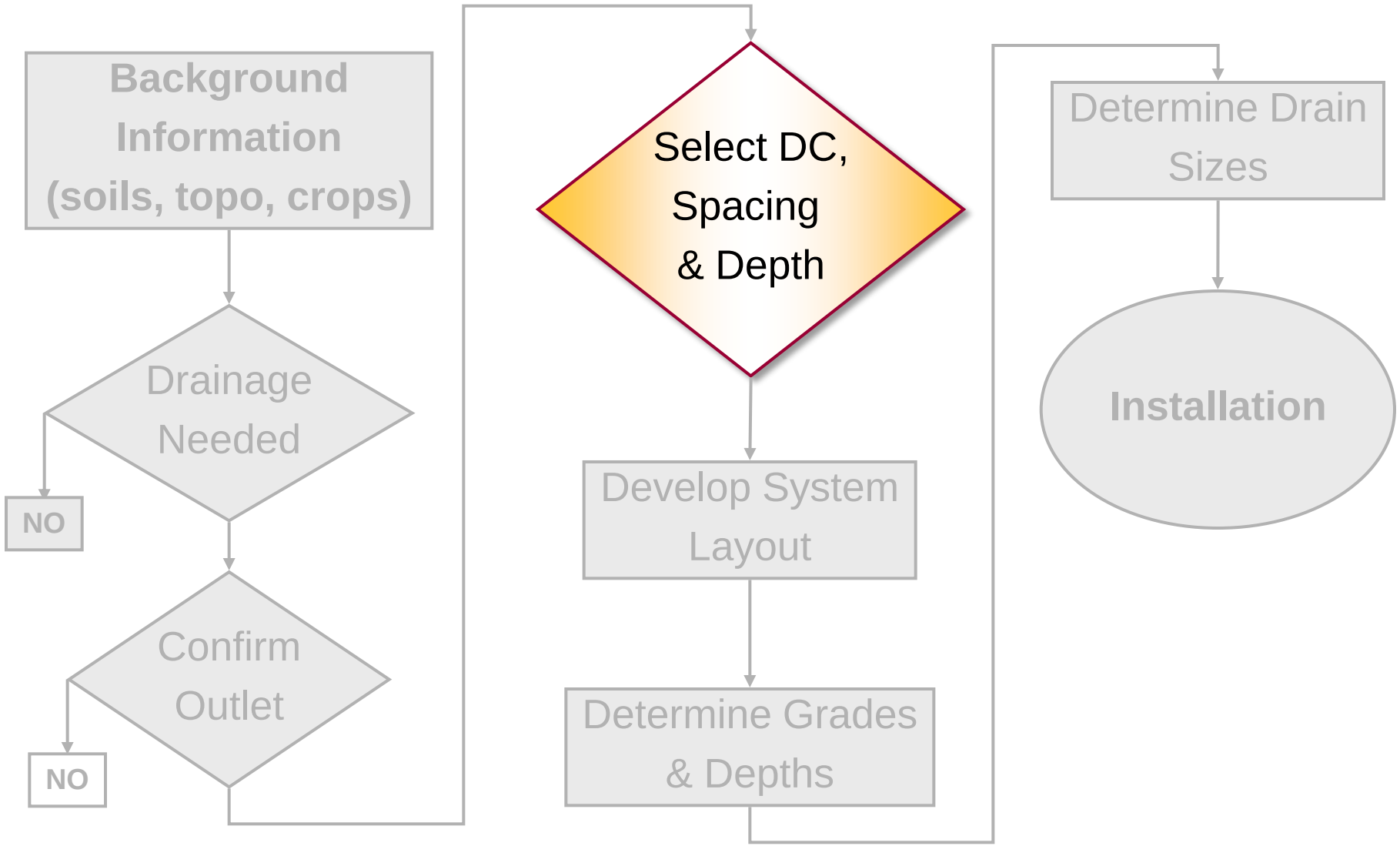
Design Process Flowchart



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

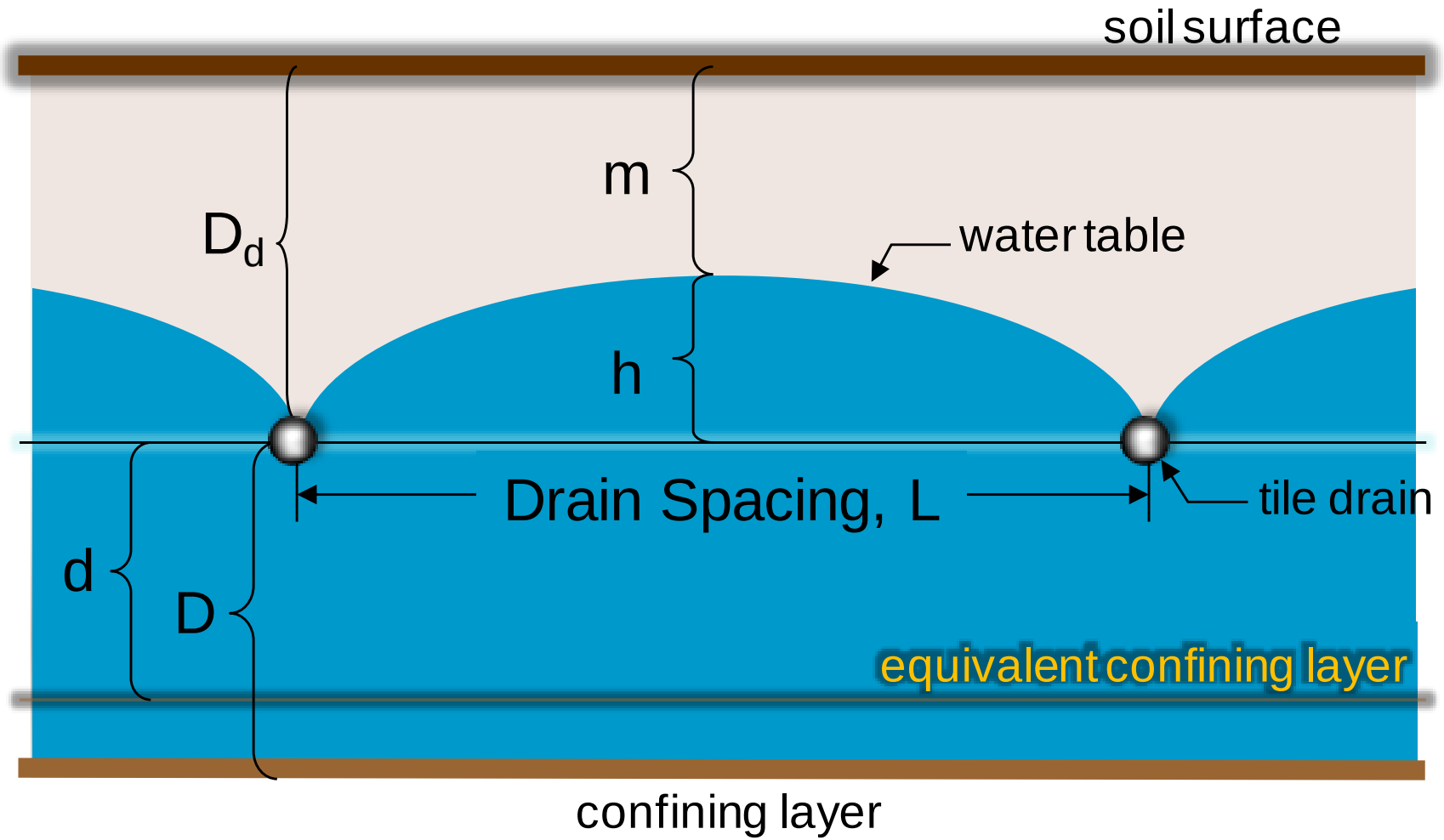


Drain Spacing & Depth

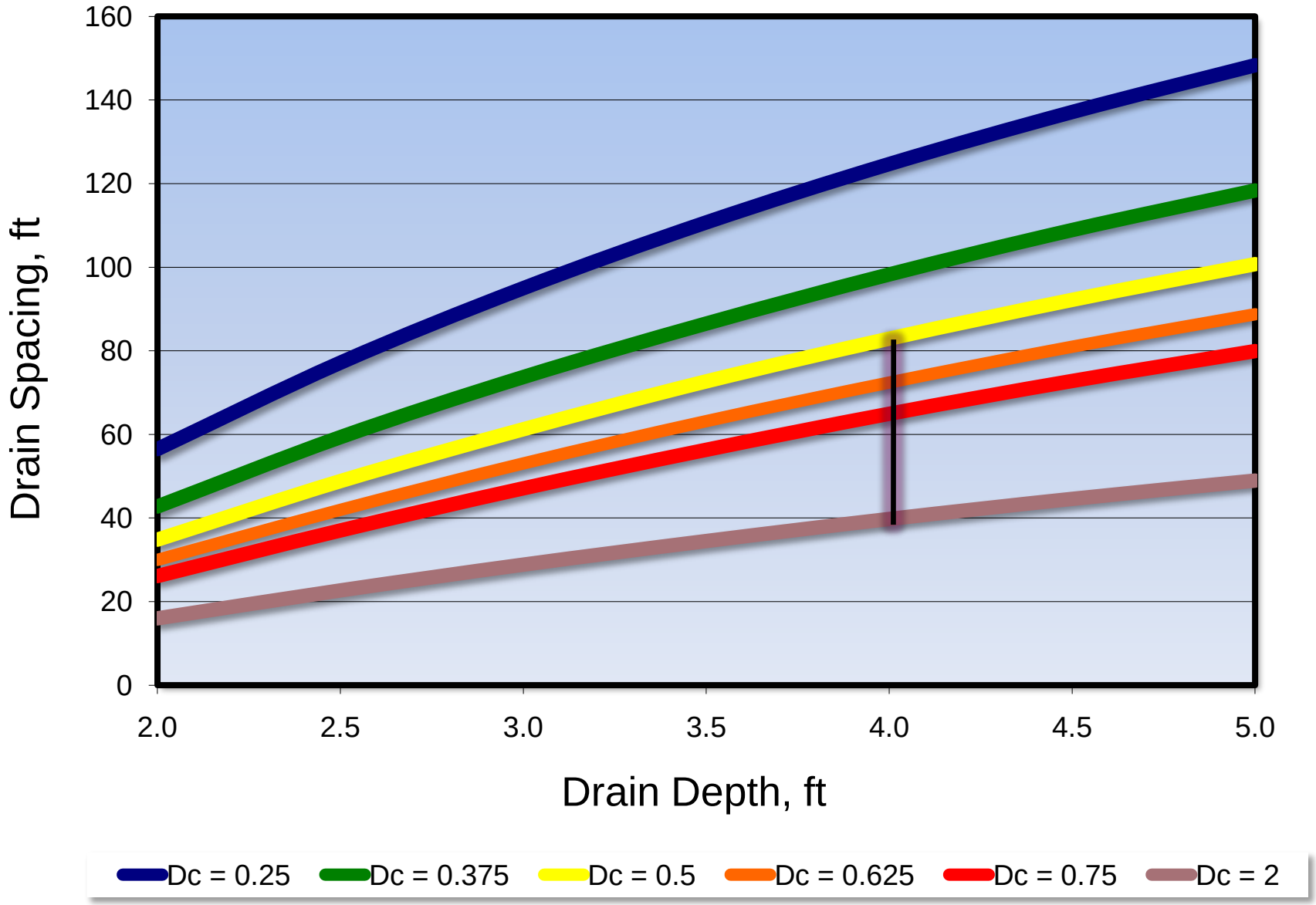
University of Minnesota
EXTENSION

- What are we doing by selecting spacing & depth?
  - Choosing a *"DRAINAGE COEFFICIENT"*
- What is a Drainage Coefficient (DC)?
- How do depth & spacing affect DC?

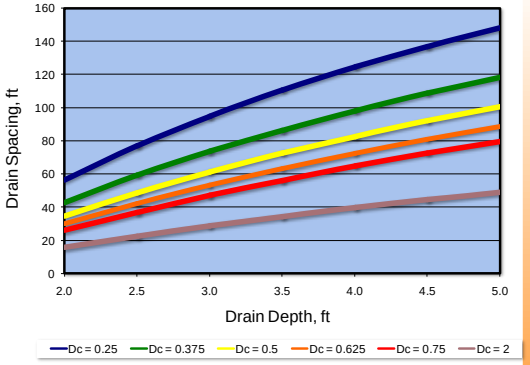
Depth, Spacing & DC



Spacing, Depth, and DC



Drain Spacing Equation

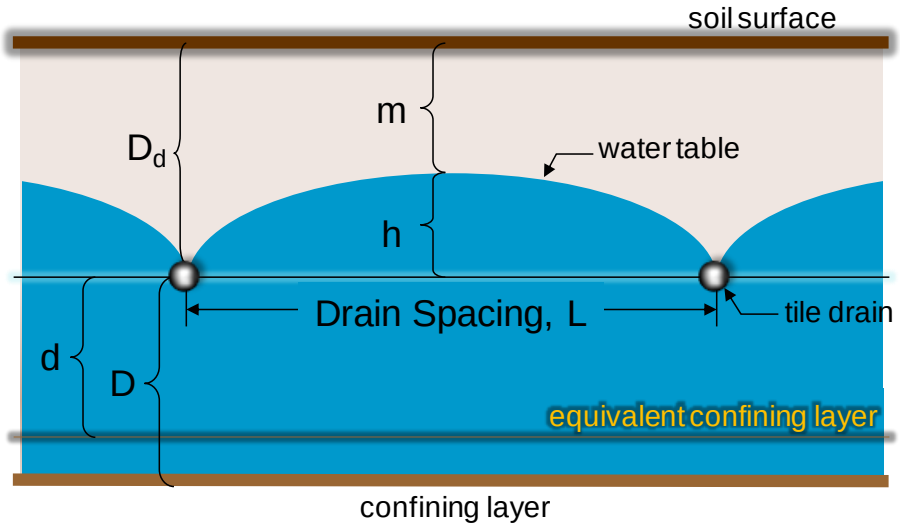


$$DC = \frac{(8 \times k_2 \times d \times h)}{L^2} + \frac{(4 \times k_1 \times h^2)}{L^2}$$

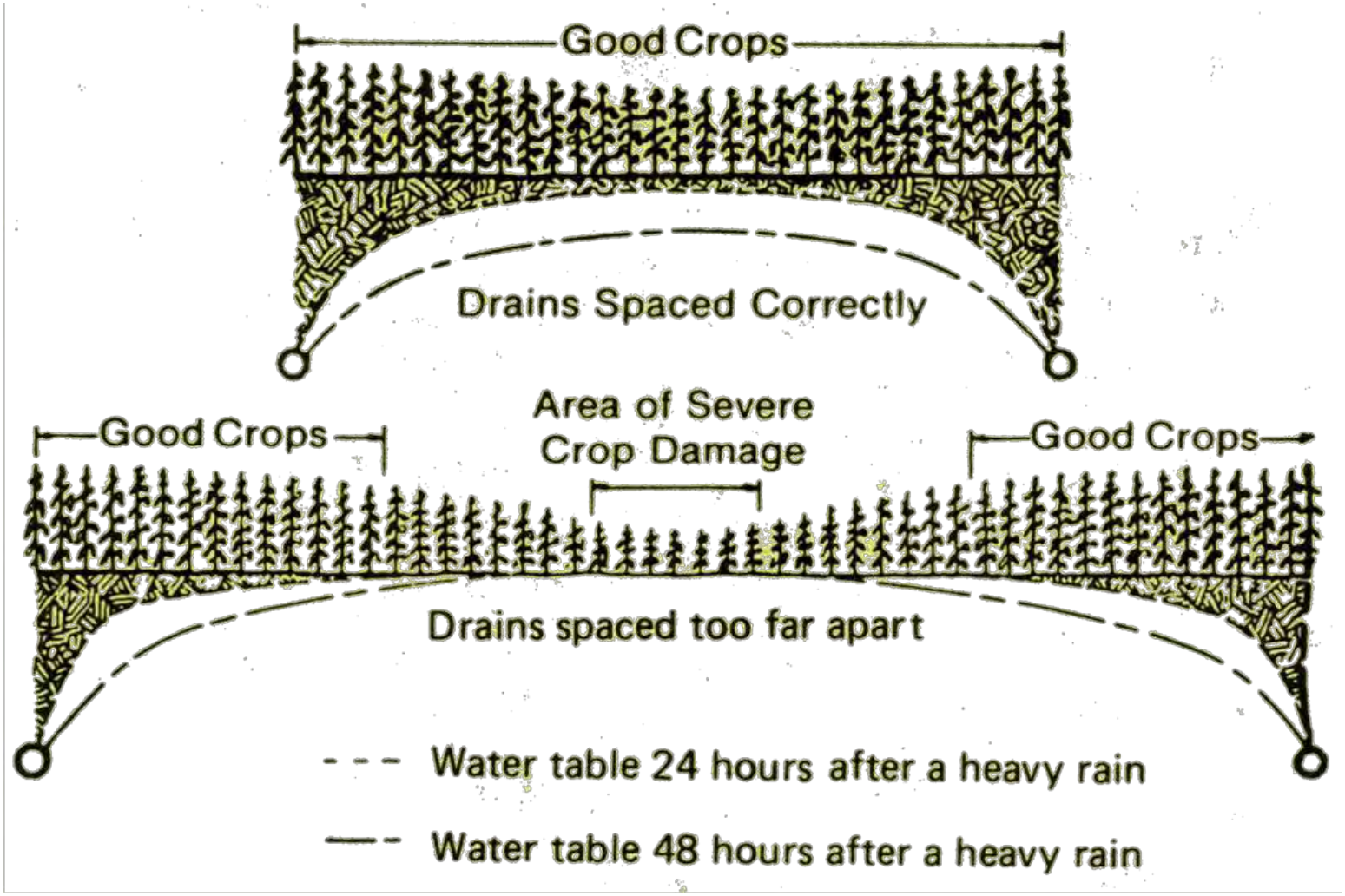
Hooghoudt (1940)

Soil

Water



Drain Spacing: How Close is Close Enough?



Generalized Drainage Coefficients

	Inches to be removed in 24 hours	
Soil Type	***Field Crops***	***Truck Crops***
Mineral	$^{3}/_{8}$ – ½	½ – ¾
w/ surface inlets	½ – 1	1 – 1-½
Organic	½ – ¾	¾ – 1-½
w/ surface inlets	1 – 1-½	2 – 4

Minnesota Drainage Guide

DRAINAGE GUIDE DATA FOR MINNESOTA

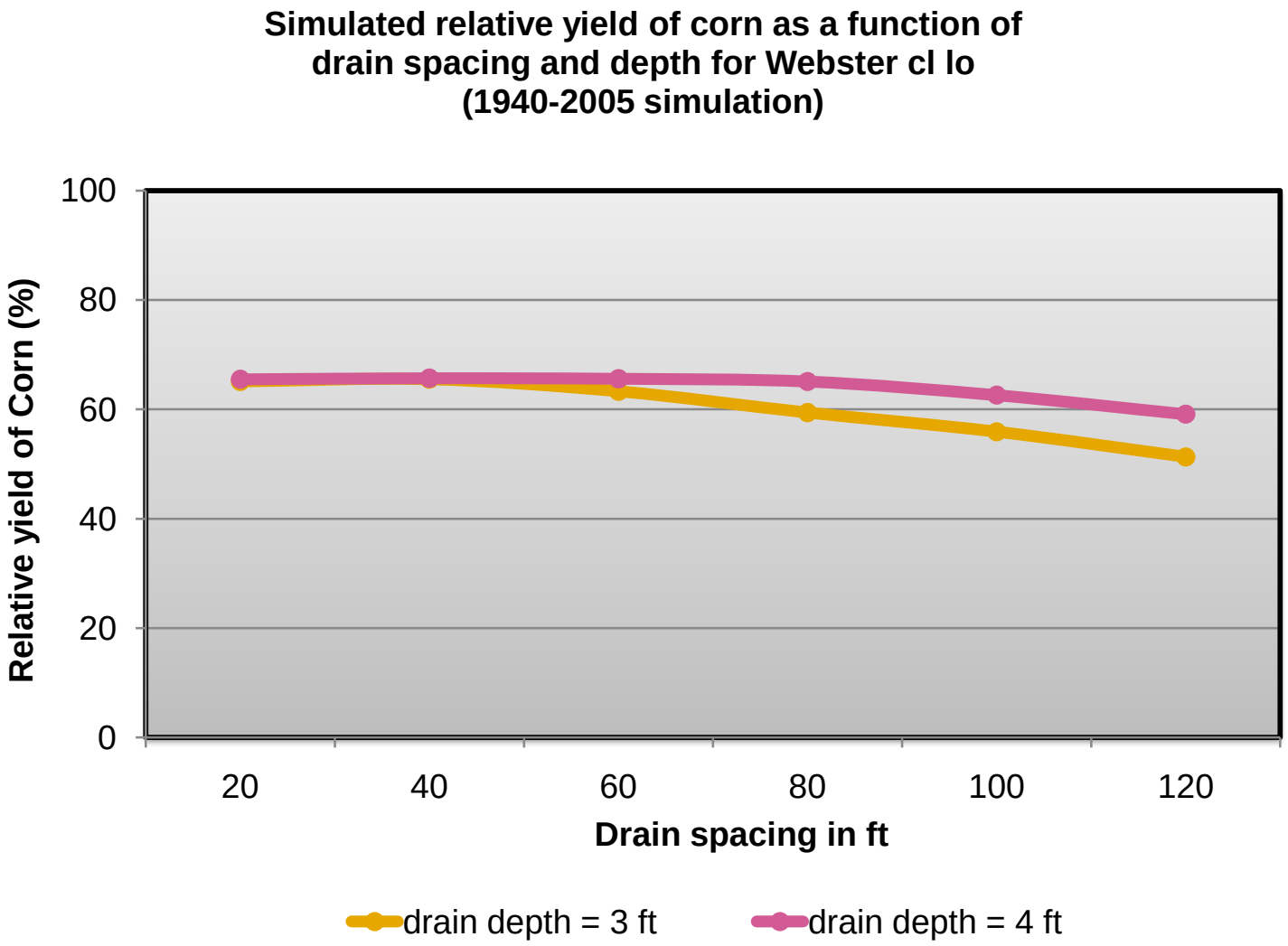
SOIL NAME UNIT KIND MODIFIER	ID NO.	COMMENTS	DSN GRP	DRAIN DEPTH In.	SPACINGS, Ft. DRAINAGE COEFF. In./24 Hrs. 1/4	3/8	1/2	3/4	HORIZ DEPTH In.	UNIFIED SOIL CLASSIFICATION	PERMEABILITY In./Hr.	pH RANGE	DEPTH TO WATER TABLE ft.	DEPTH TO BED-ROCK In.
BLOMFORD SERIES	MN0239		1						0-9	SM	6.0-20	5.1-7.3	0.5-1.5	>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	MN0150		7						0-8	ML,CL,CL-ML	0.6-2.0	5.6-6.5	>6.0	>60
									8-15	CL	0.6-2.0	5.6-6.5		
									15-48	CL,CL-ML,SC,SM-SC	0.6-2.0	5.1-7.3		

SOIL NAME UNIT KIND MODIFIER	ID NO.	COMMENTS	DSN GRP	DRAIN DEPTH In.	SPACINGS, Ft. DRAINAGE COEFF. In./24 Hrs. 1/4	3/8	1/2	3/4	HORIZ DEPTH In.	
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

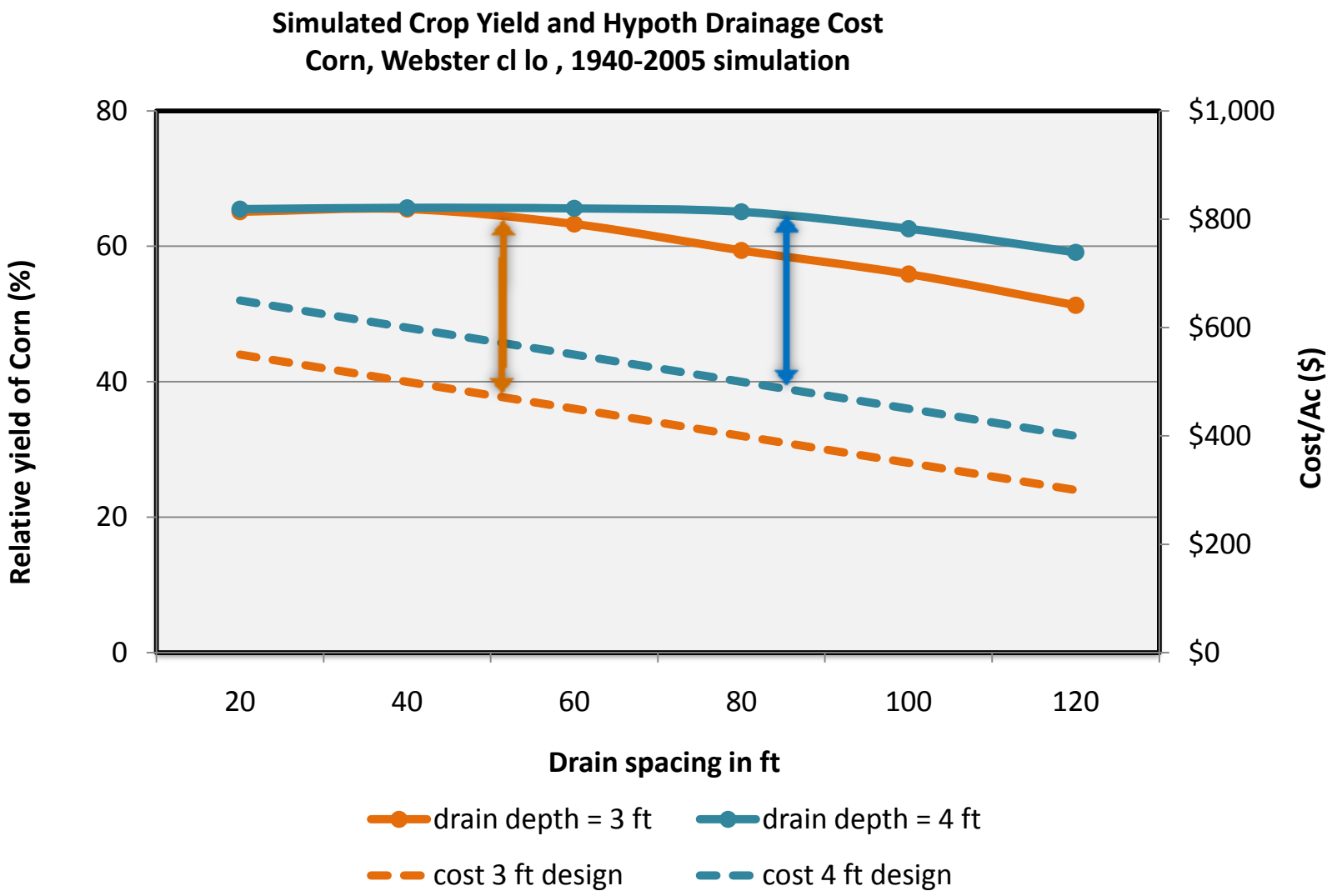
SOIL NAME UNIT KIND MODIFIER	ID NO.	COMMENTS	DSN GRP	DRAIN DEPTH In.	SPACINGS, Ft. DRAINAGE COEFF. In./24 Hrs. 1/4	3/8	1/2	3/4	HORIZ DEPTH In.	UNIFIED SOIL CLASSIFICATION	PERMEABILITY In./Hr.	pH RANGE	DEPTH TO WATER TABLE ft.	DEPTH TO BED-ROCK In.
SLOPING														
BLUE EARTH VARIANT	MN0177		1						0-16	OL	0.6-2.0	7.4-8.4	+1-1.0	>60
			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	MN0442		5	36	346	276	235	186	0-28	OL	2.0-6.0	7.4-8.4	+2-1.0	>60
			5	48	424	341	292	234	28-33	CL-ML,CL	0.6-2.0	7.4-8.4		
									33-60	SP-SM	6.0-20	6.1-8.4		
BLUFFTON SERIES	MN0184		1						0-19	CL	0.6-2.0	5.6-6.5	+2-2.0	>60
		L,SIL	5	36	58	46	39	30	0-19	SC,SM,SM-SC	0.6-6.0	5.6-6.5		
			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

“Optimum” Drain Design



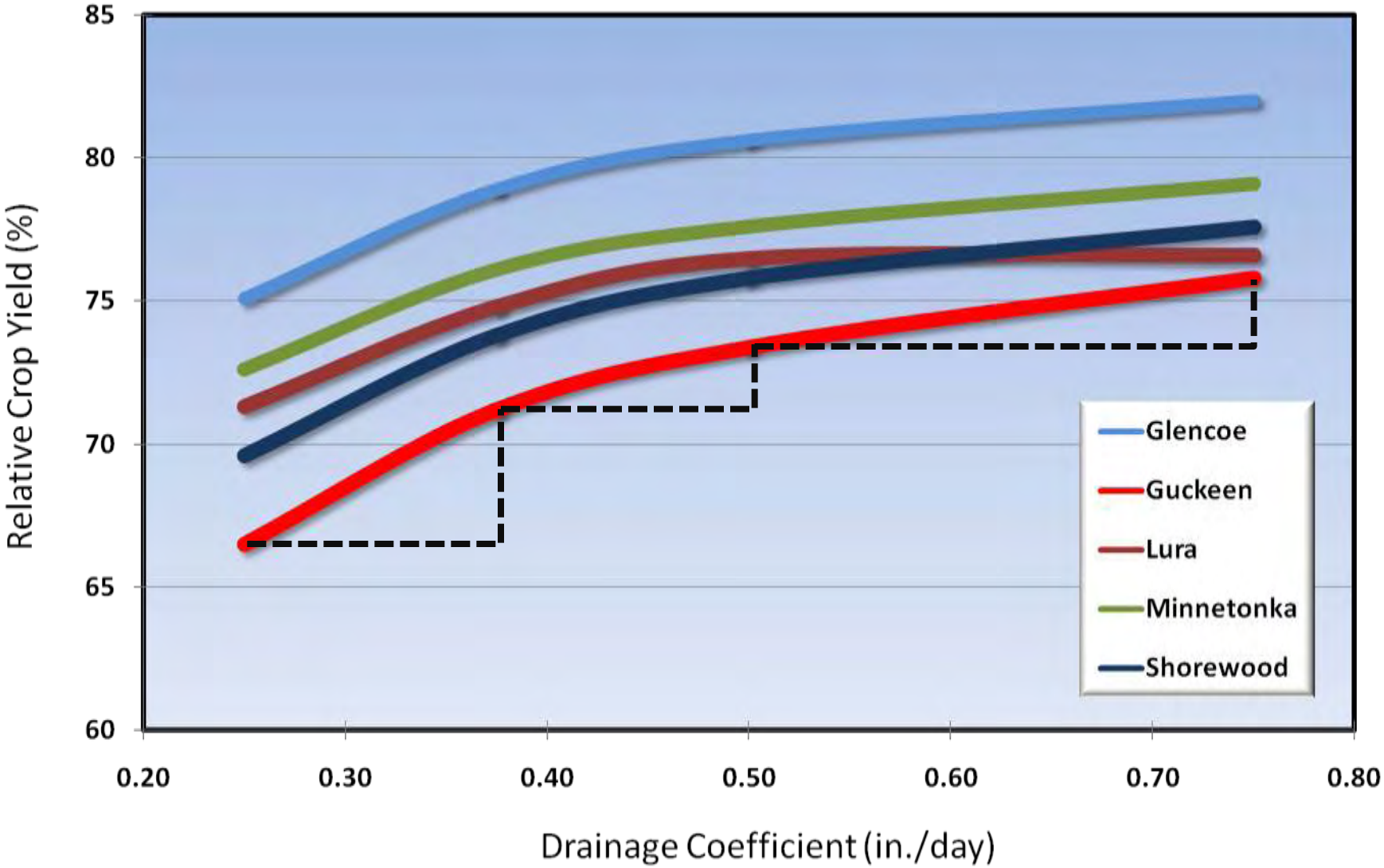
“Optimum” Drainage Design



Optimum Drainage Design

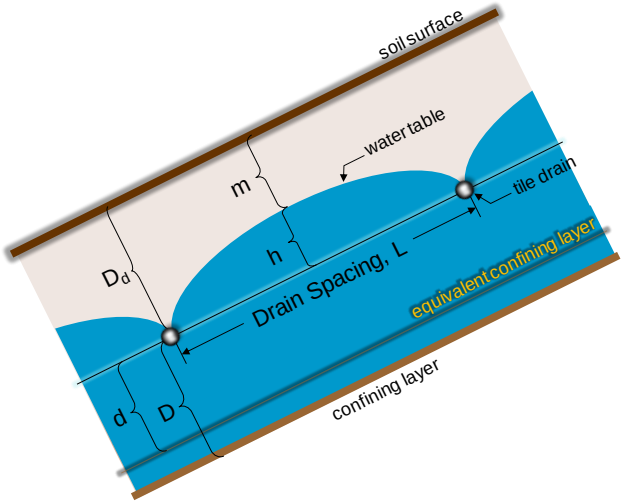
- 2 to 5 year event is probably what we want
  - *Controlling larger events too costly*
- Every soil will be different
- Crop selection matters
- Climate regions will differ
- Costs/benefits will vary from year to year
- Climate trends will cause an optimum point shift

85-Year Computer Simulations:
Waseca Climate Data



Optimum Drainage Design

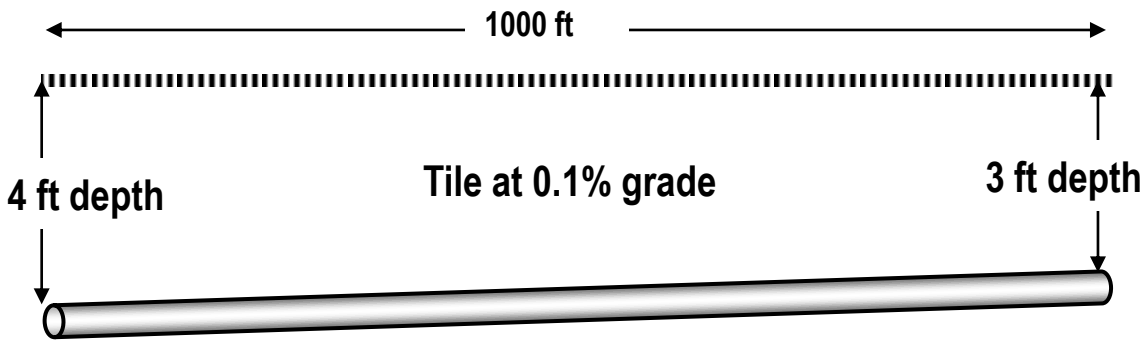
- We don’t really know what the “best” DC is for our soil, crop, and region
- Experience and long-term observations important
- Risk management for farmer
  - *Protect crop for any condition?*
  - *Protect crop for average condition?*
  - *How risk averse am I?*
- Please send $$ so we can run simulations for all soils in MN! ☺

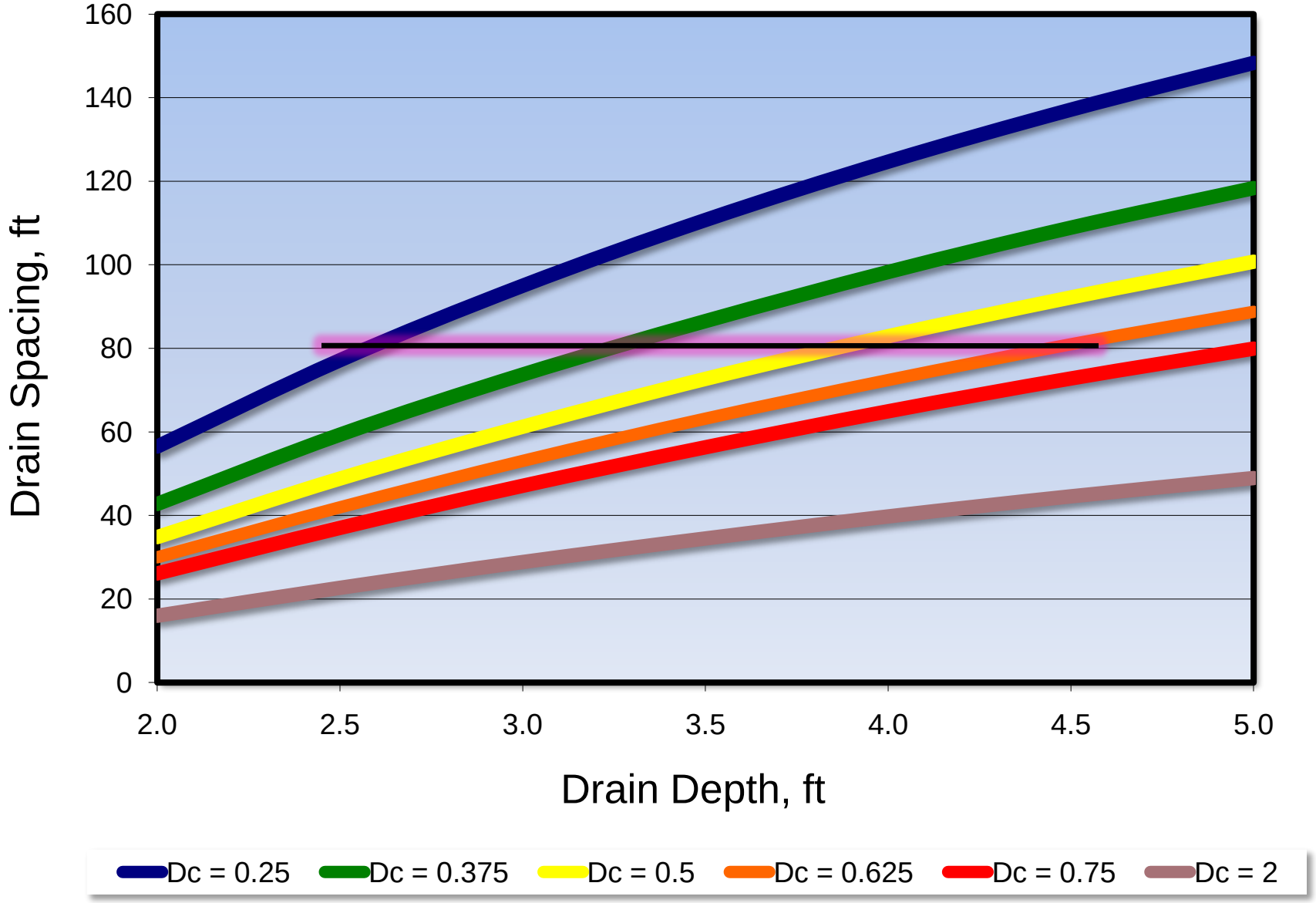


DC &THE IMPORTANCE OF UNIFORM DRAINAGE (AS A GOAL)

Drain Spacing & Depth

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




160
140
120
100
80
60
40
20
0
Drain Spacing, ft
2.0
2.5
3.0
3.5
4.0
4.5
5.0
Drain Depth, ft
Dc = 0.25
Dc = 0.375
Dc = 0.5
Dc = 0.625
Dc = 0.75
Dc = 2

Spacing & Depth

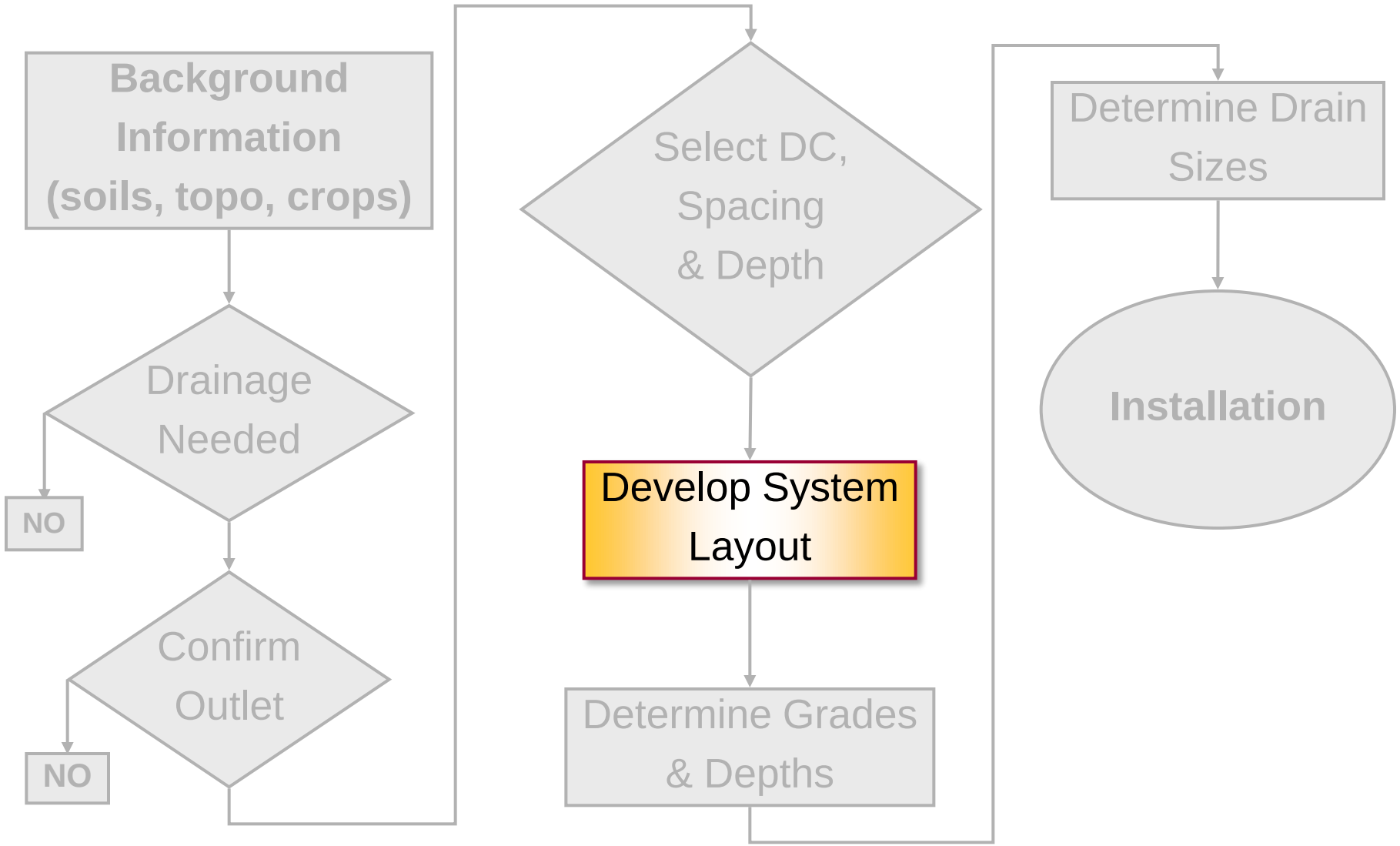
University of Minnesota EXTENSION

- 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

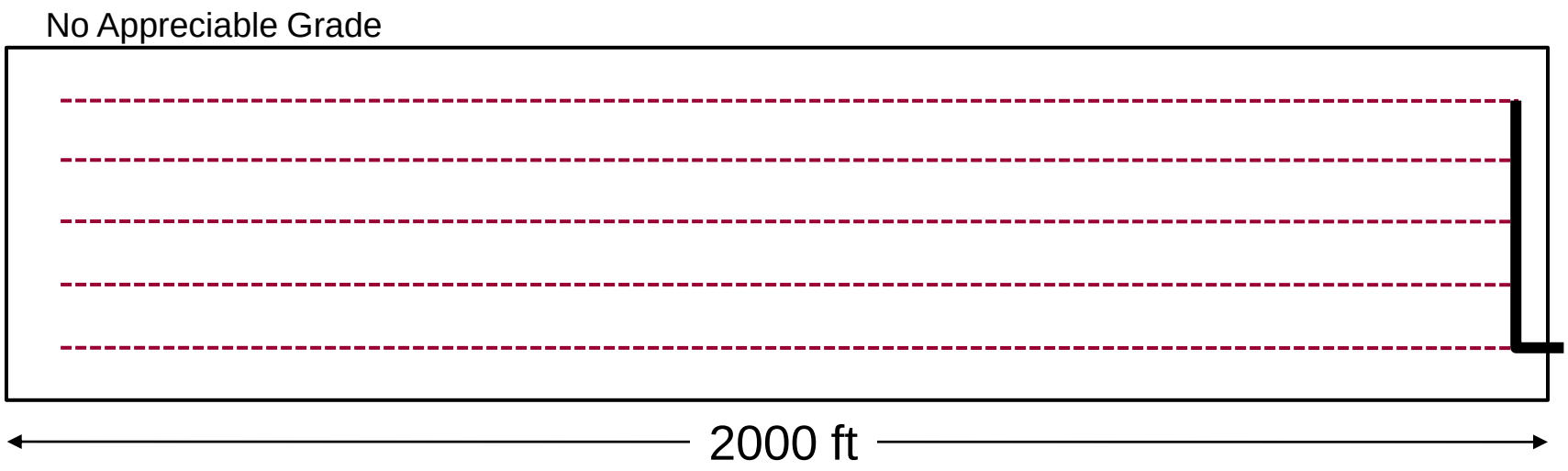
Design Process Flowchart



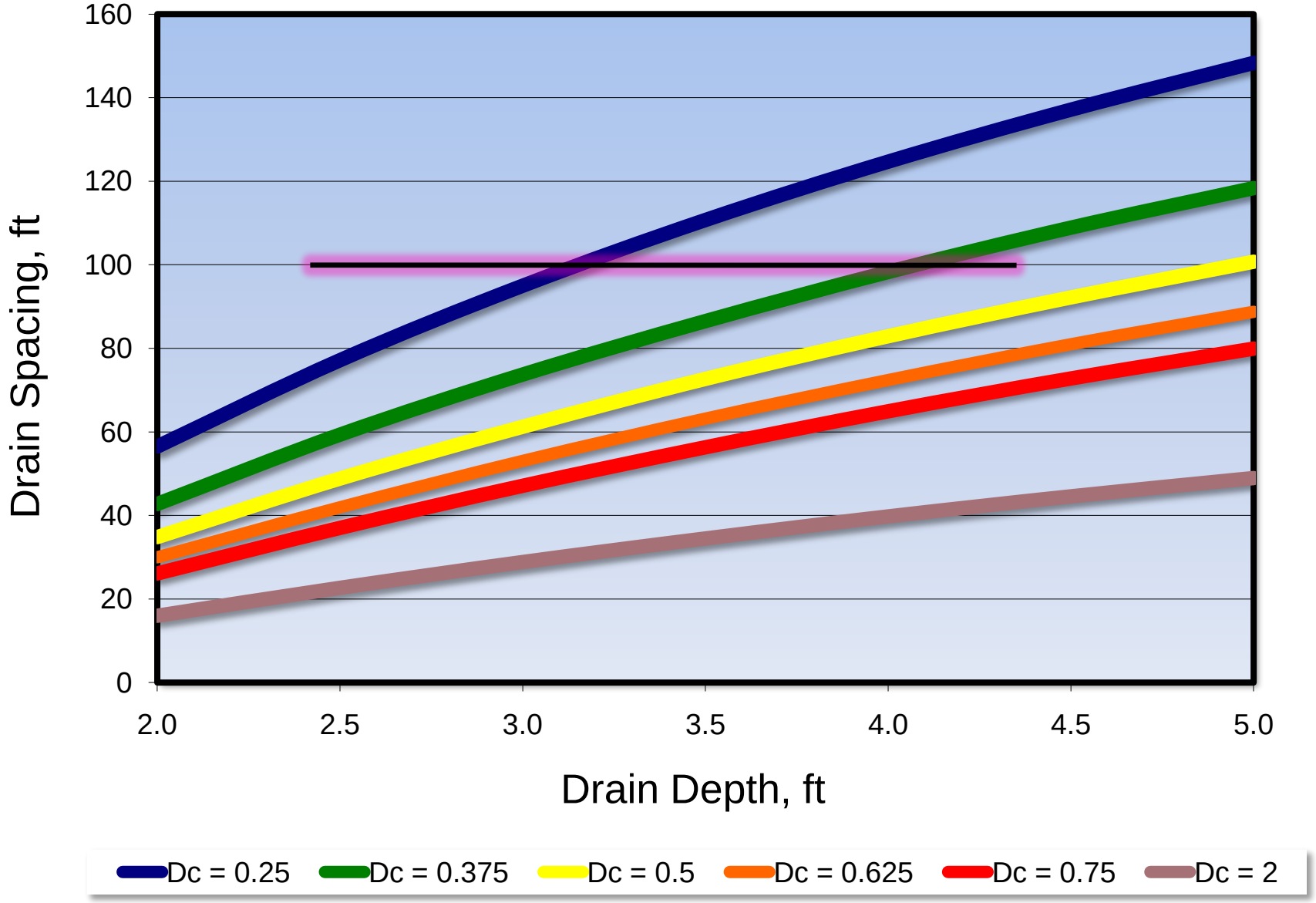
Layout

- **Most important step** (besides determining an outlet!
- Where the real brains are needed!
- Layout determines uniformity of drainage
  - *Consistent depth throughout field*

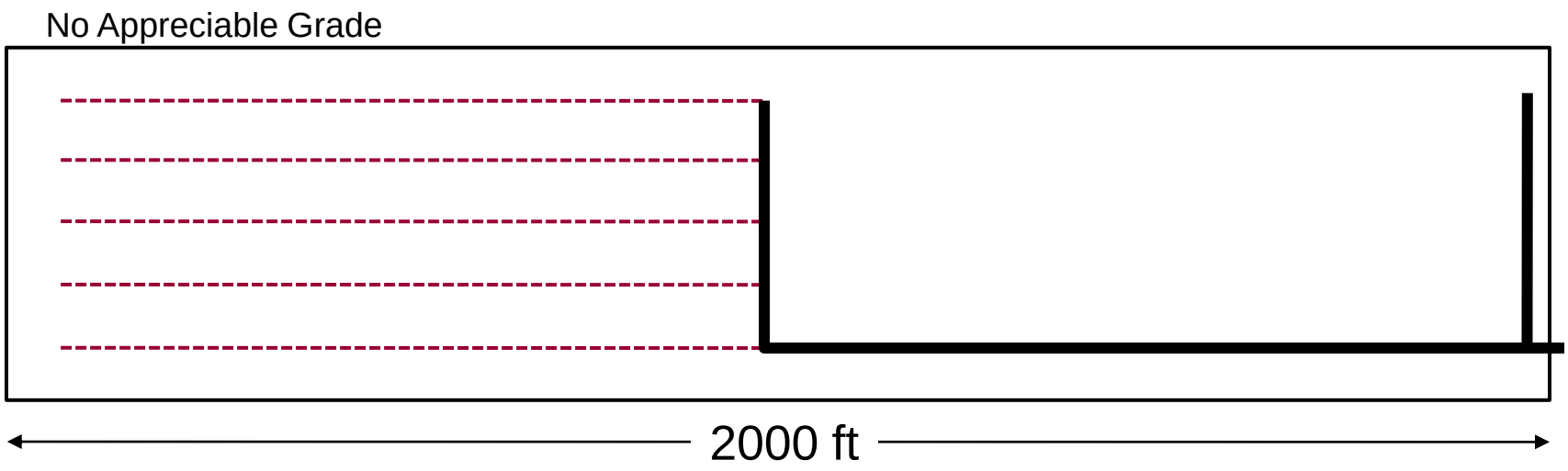
Uniform Drainage Example: Long Fields



- 2000-ft laterals:
  - *@ 0.08% = 1.6 ft of fall*
  - *@ 0.1 % = 2.0 ft of fall*


160
140
120
100
80
60
40
20
0
Drain Spacing, ft
2.0
2.5
3.0
3.5
4.0
4.5
5.0
Drain Depth, ft
Dc = 0.25
Dc = 0.375
Dc = 0.5
Dc = 0.625
Dc = 0.75
Dc = 2

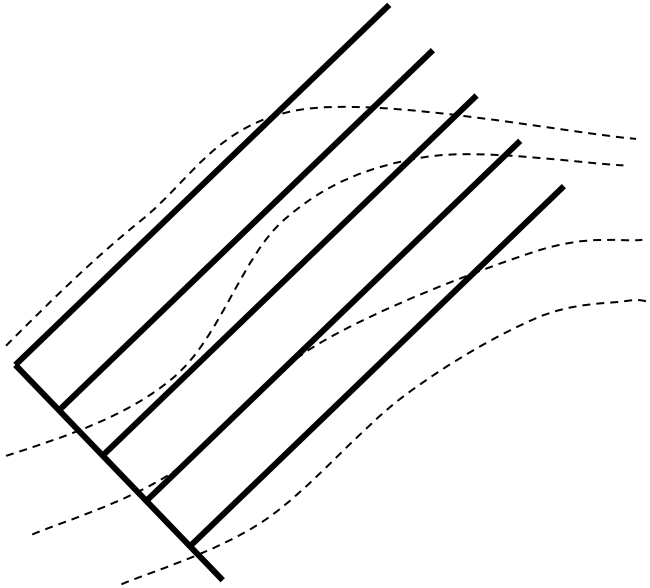
Possible Solution: Long Fields

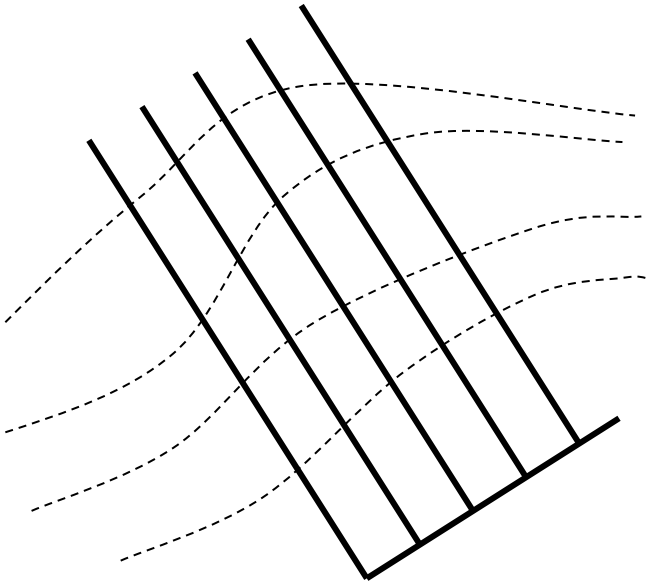


- Split the ft of fall in half
- More uniform drainage coefficient
- Yes, more connections and ft of main

Layout

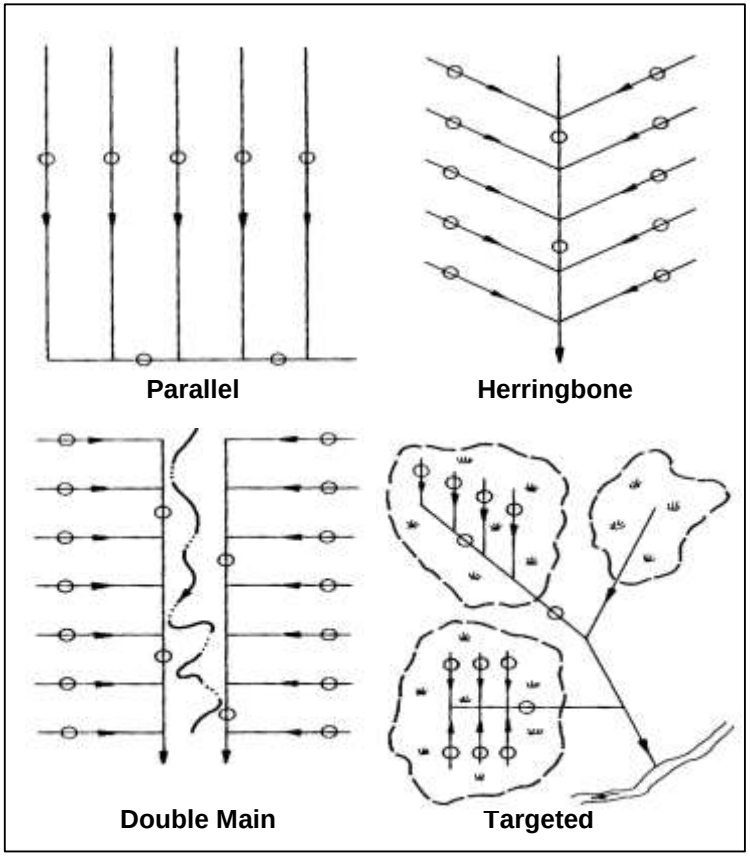
- Should start with contour (topo) map of field
  - *Only way to look at entire field at once*
- Put (sub)mains on steepest grades
- Field laterals more on contours (intercept water)



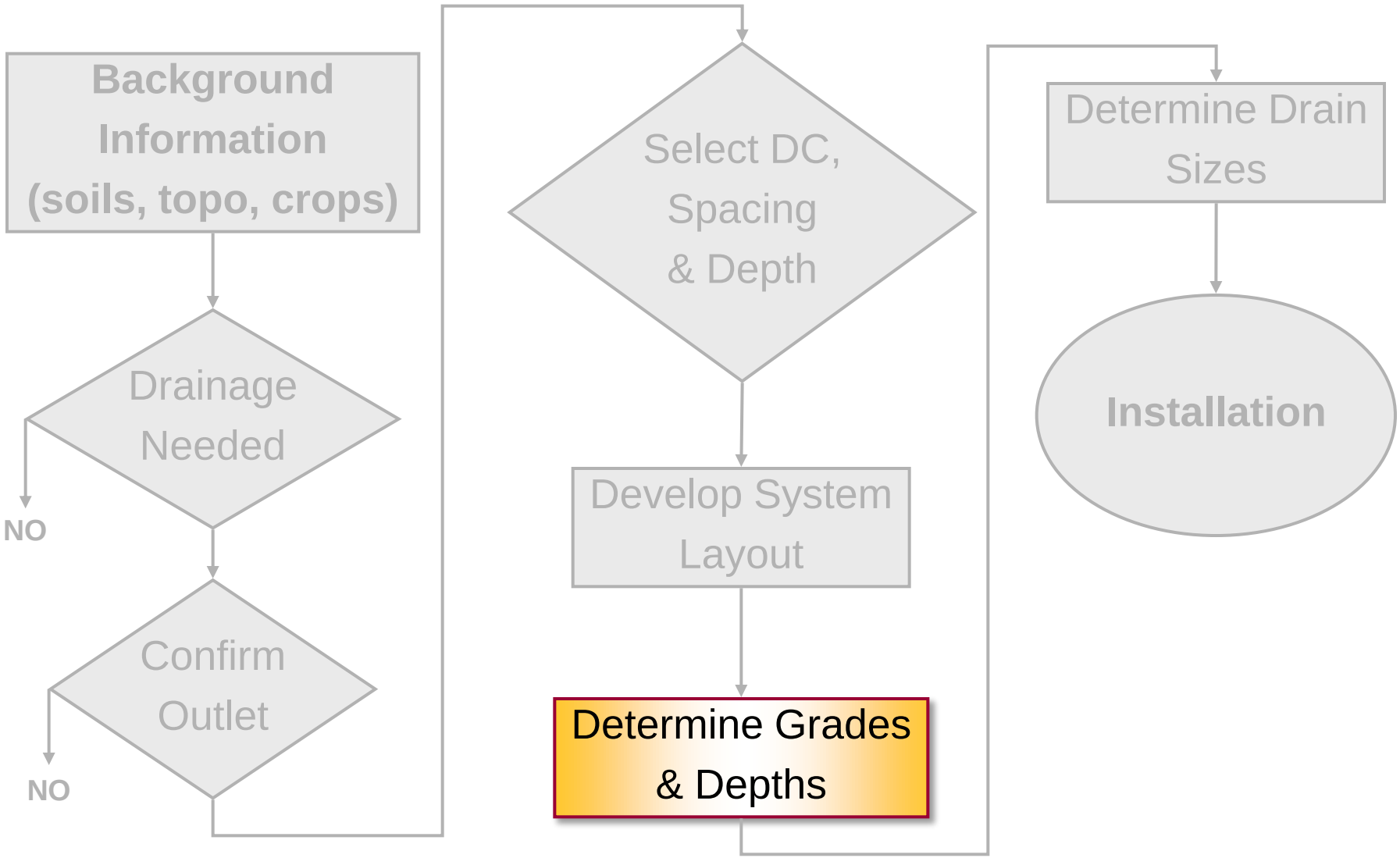


Layout

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



Design Process Flowchart



Tile Grades

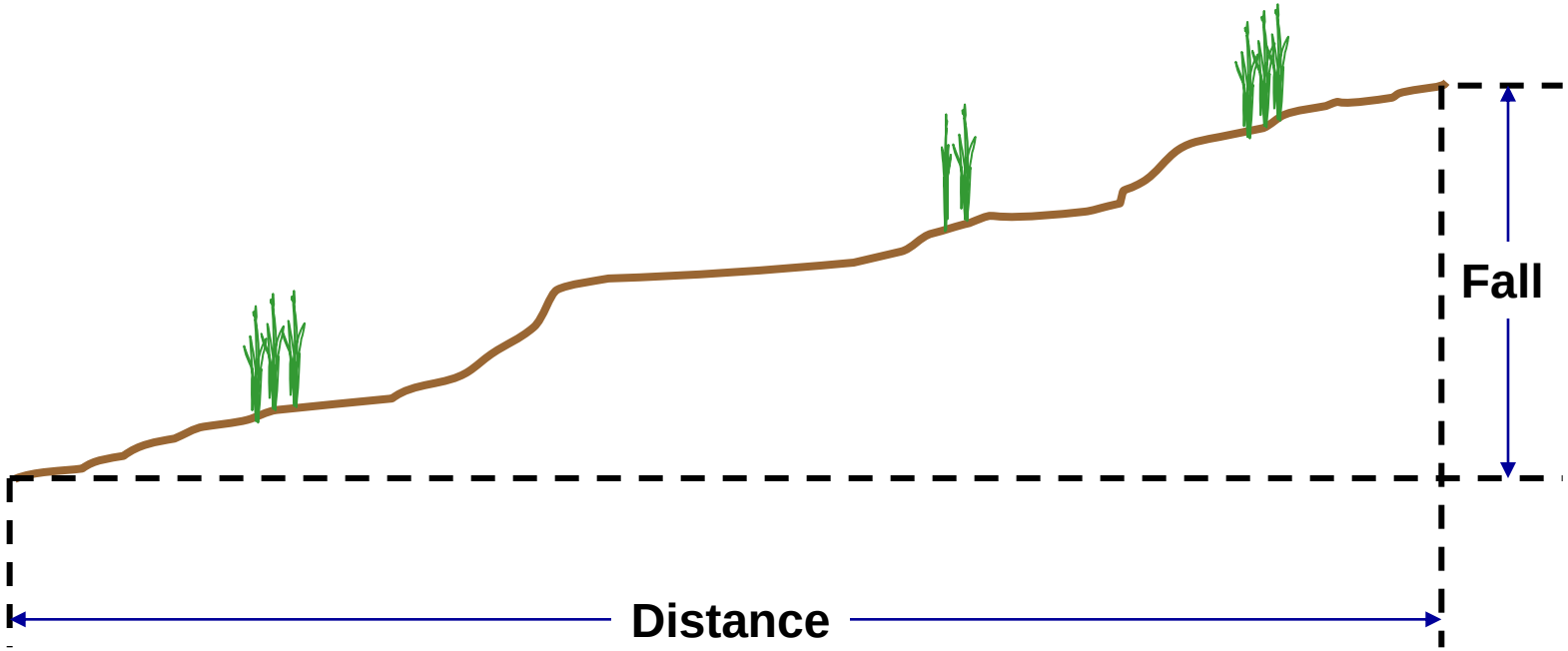
- Enough grade to:
  - *Keep the water moving*
  - *Keep sediment suspended in the water*
- Flat grades
  - *More prone to sediment build up*
  - *Smaller margin for installation error*
  - *Installation errors more costly*
- Steep grades -- Higher Velocities
  - *Increase tile capacity*
  - *Too steep -- 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!
- Must pay attention to minumum grades

Minimum Grades

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.

Difference Between "Fall" & "Grade"



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

Grade

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

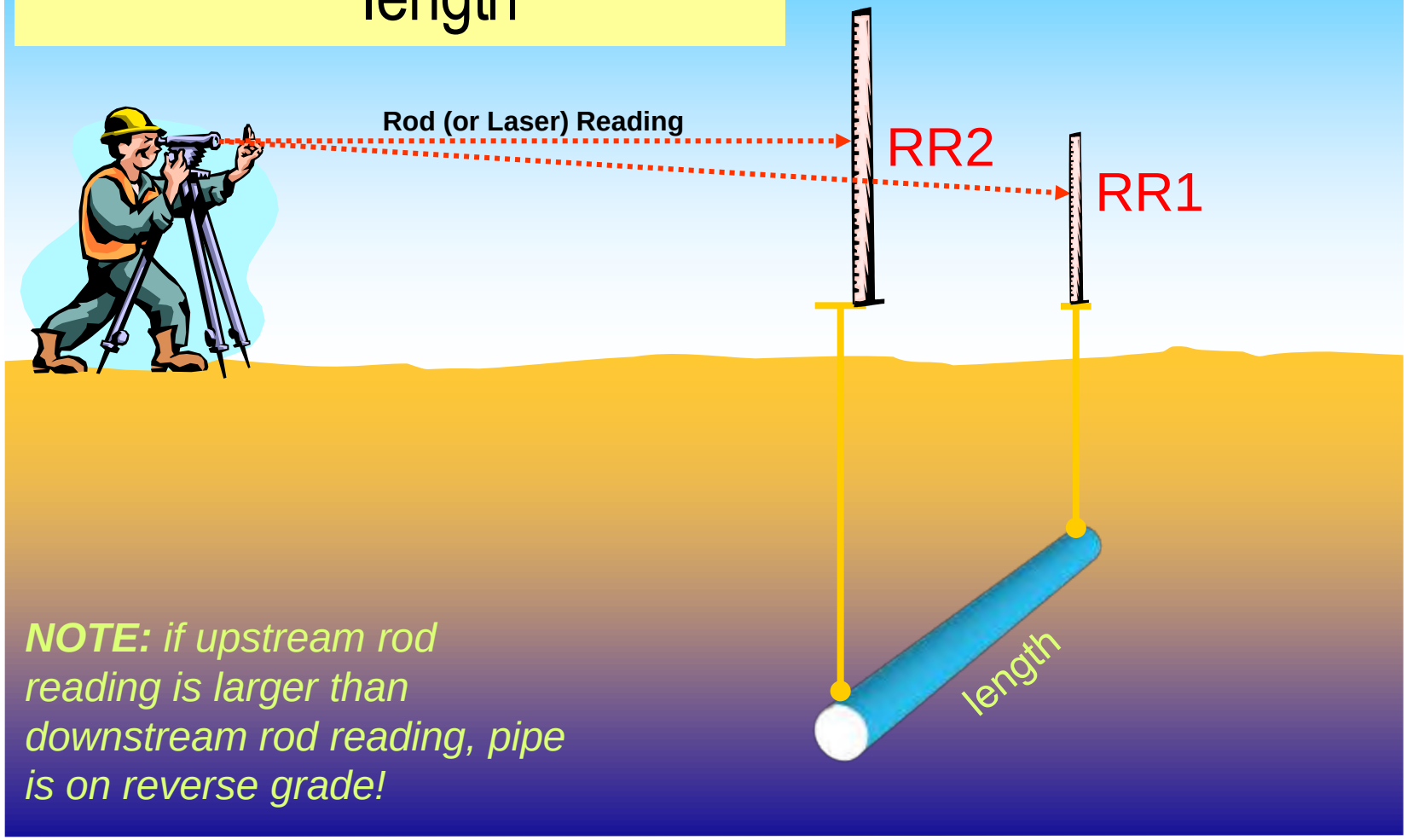
6 ft fall/mile = what % grade?

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

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

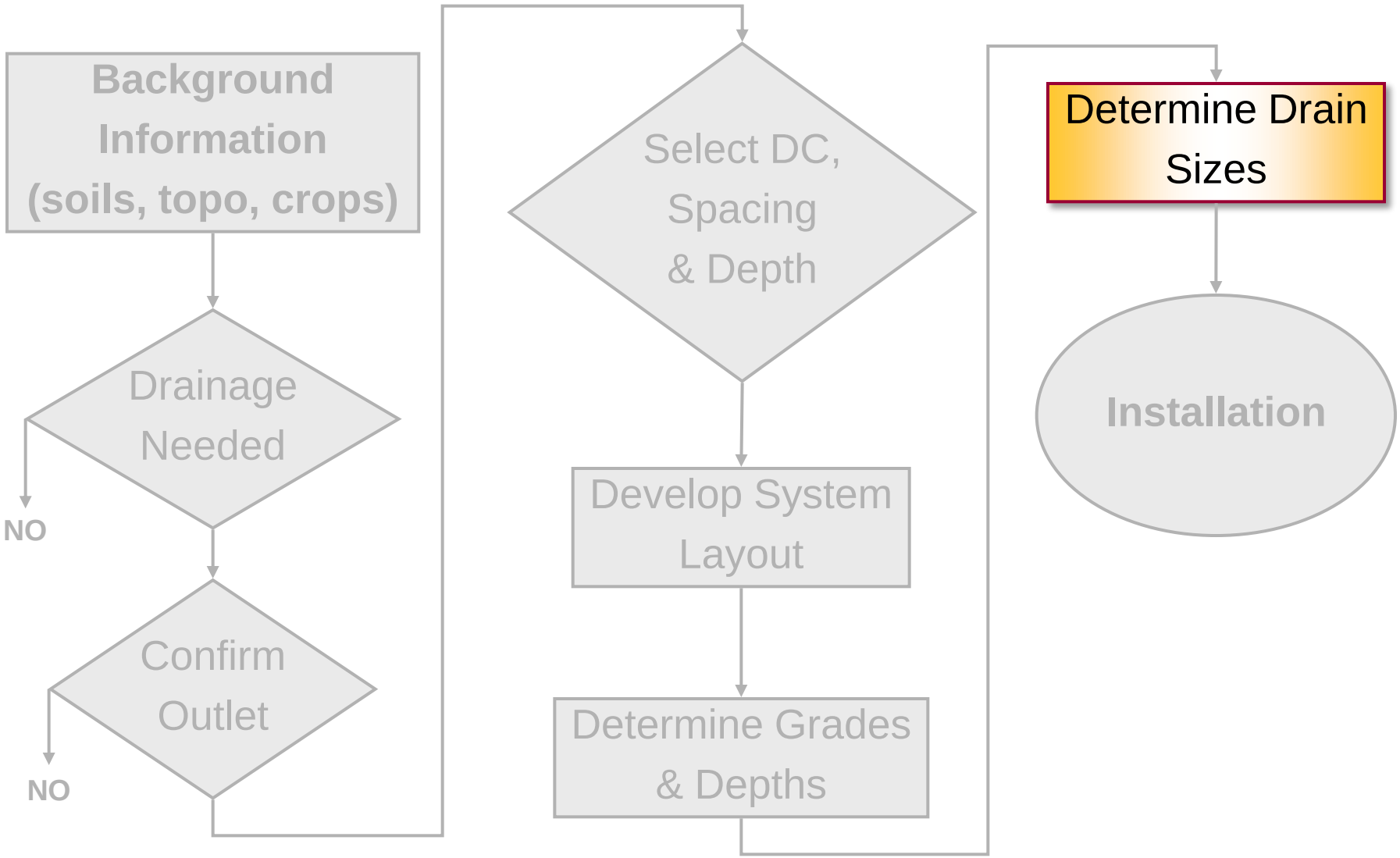
Checking Grade

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



NOTE: *if upstream rod reading is larger than downstream rod reading, pipe is on reverse grade!*

Design Process Flowchart

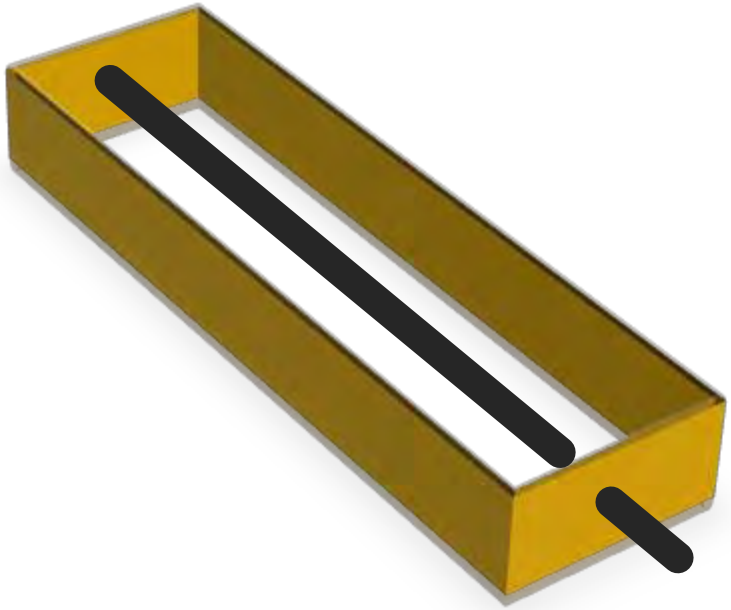


Drain Sizing

University of Minnesota EXTENSION

- 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, once you have layout*

Drain Sizing – Flow and Area



- Drainage Coefficient (DC)
  - *= inches/day*
- Flow = DC x Area (ac drained)
- Area = Spacing x Length
- Find no. of acres drained by pipe size of choice
  - *Given the grade, material, etc.*

- Example 1: (find pipe)
  - 80-ft spacing (above)
  - DC = 0.5 in/day
  - Grade = 0.1%
  - 4” pipe drains 2.5 ac (1361 ft)
  - 5” pipe drains 4.5 ac (2450 ft)

- Example 2: (find grade)
  - 80-ft spacing (above)
  - 1500-ft distance (2.2 ac)
  - DC = 0.5 in/day
  - What grade for 4” pipe? (.08%)
  - What grade for 3” pipe? (.36%)
  - Mixed pipe sizes??

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	-	-	-	-	-	-

Example: A 12-in pipe has the capacity of 5.5 6-in pipes

Design Tools

Design Tools

- Acres Drained
  - *DC*
  - *Grade*
  - *Material*
  - *Pipe size*

- Pipe Size
  - *DC*
  - *Grade*
  - *Material*
  - *Area Drained*

Pipe Size-Acres Drained Equation

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

- Manning's Equation
- Also used for flow in ditches

UNITS:

Area = acres

DC = in/day

D = ft

Grade = ft/ft

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

Solve for Acres Drained or Pipe Size

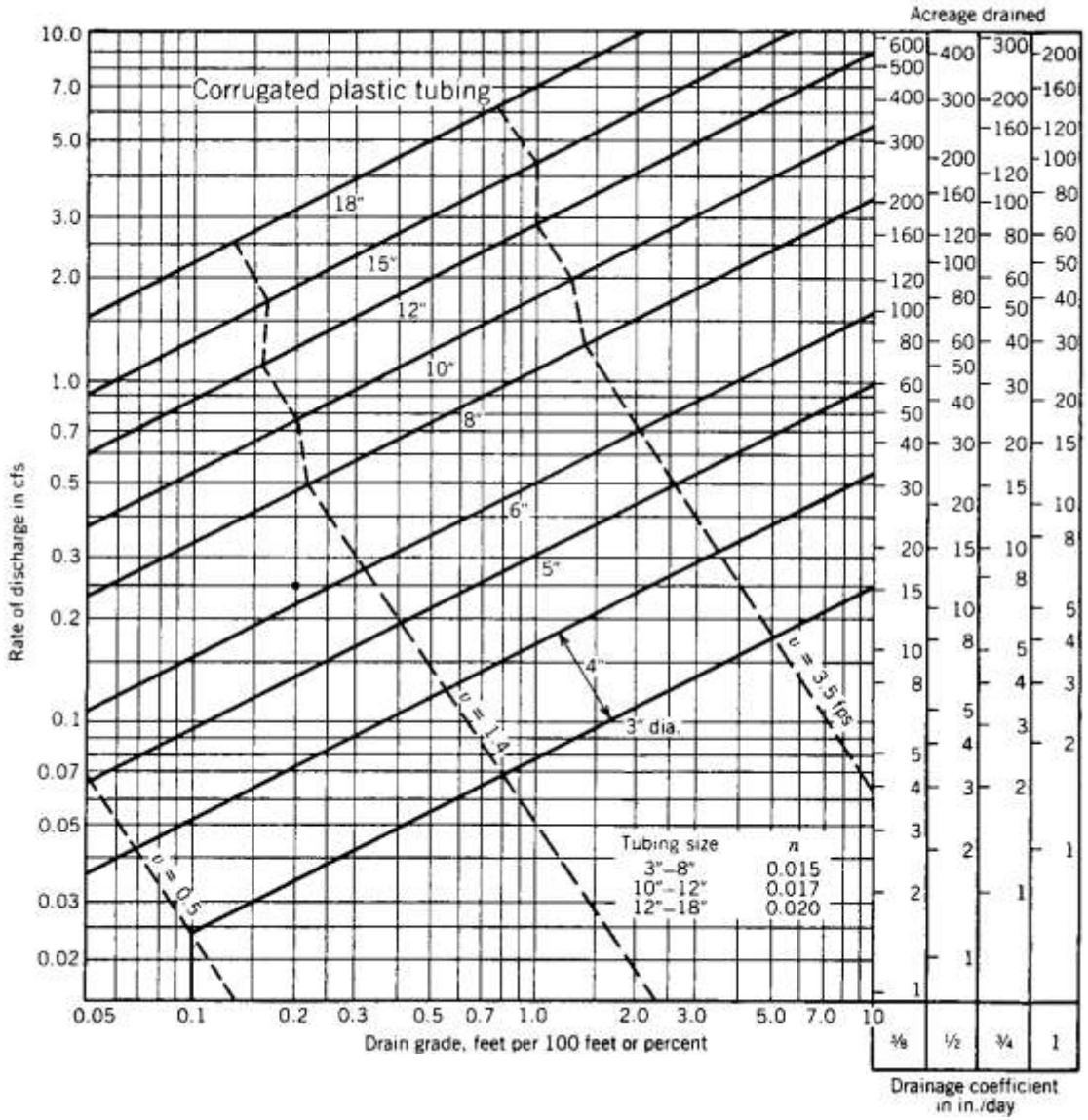
- Acres Drained

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

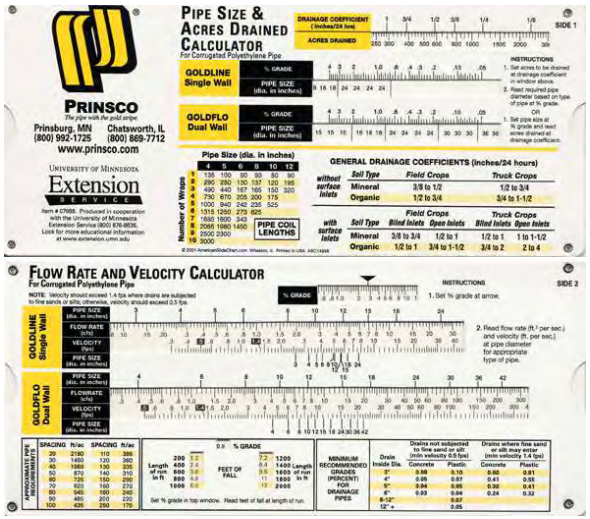
- Pipe Size (inches)

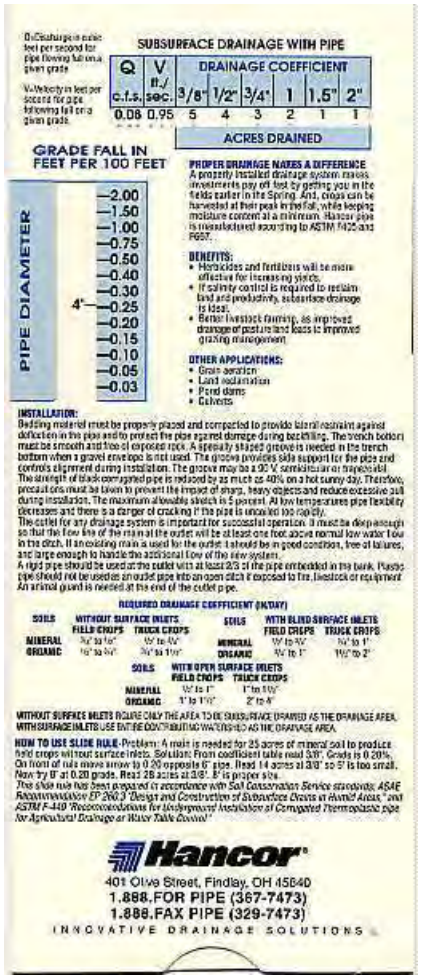
$$\text{Diameter}(D) = 12 \times \left[\frac{n \times DC \times \text{Area}}{11.05 \times \sqrt{\%\text{grade}/100}} \right]^{0.375}$$

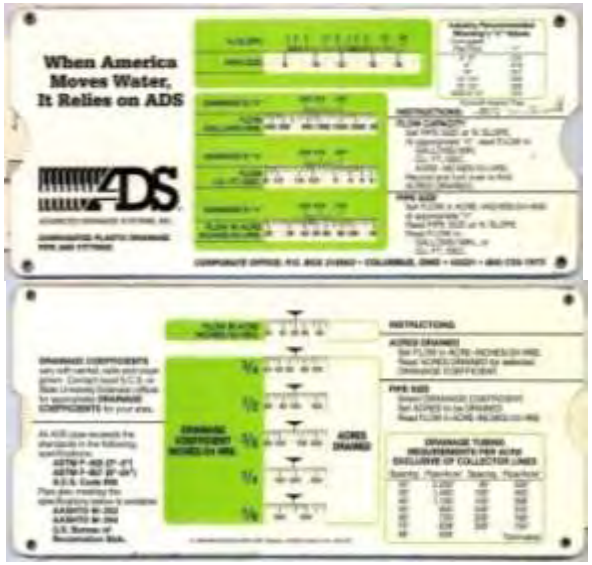
Nomograph


Acreage drained
Corrugated plastic tubing
18"
15"
12"
10"
8"
6"
5"
4"
3" dia.
v = 3.5 fps
v = 1.4
v = 0.5
Tubing size
n
3"–8" 0.015
10"–12" 0.017
12"–18" 0.020
Rate of discharge in cfs
Drain grade, feet per 100 feet or percent
Drainage coefficient in in./day

Calculators-Slide Charts



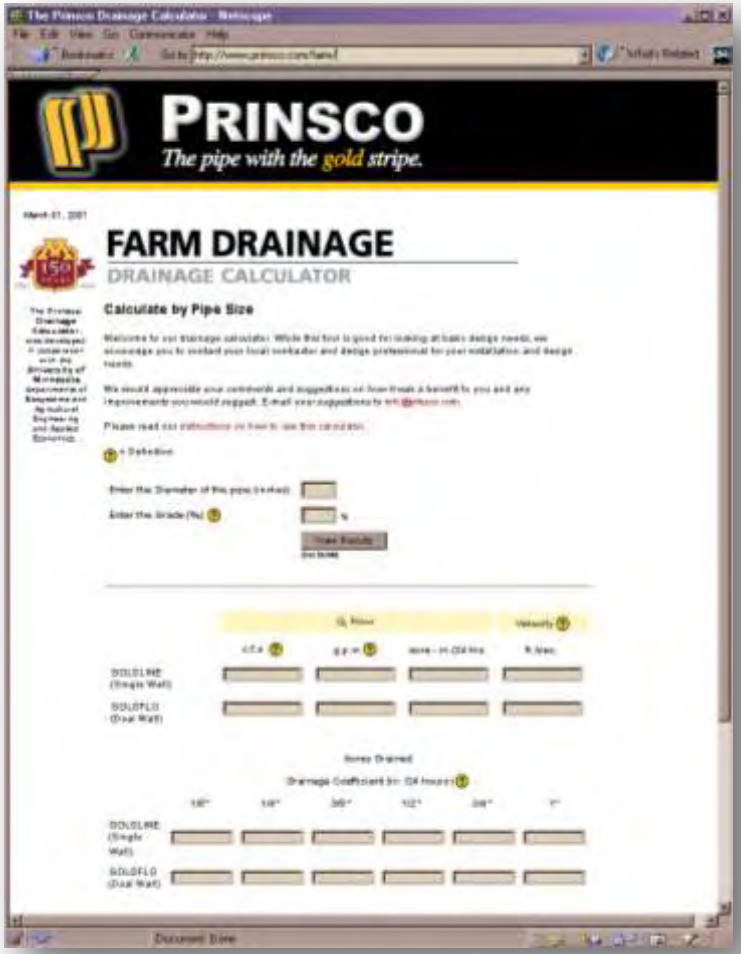




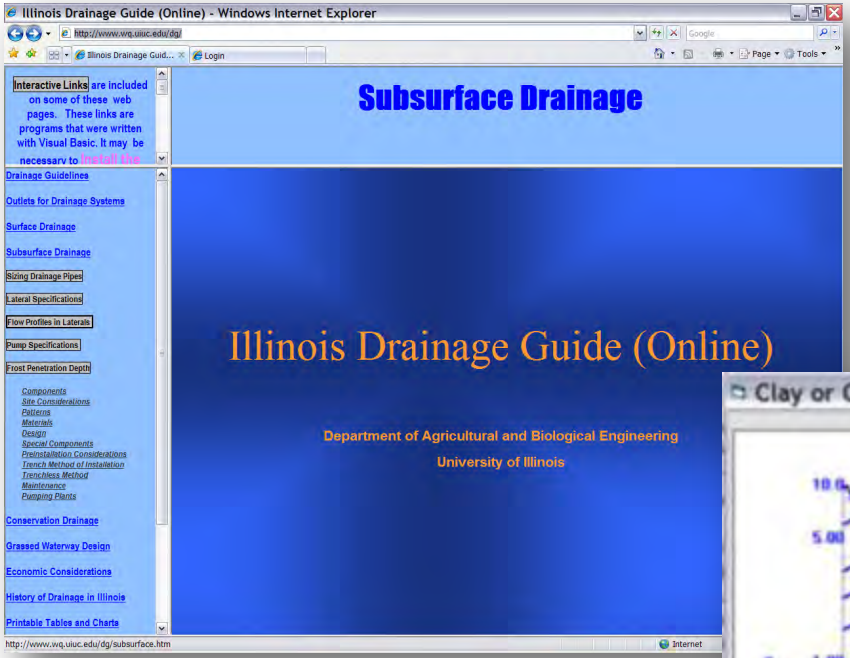
Design Charts & Tables

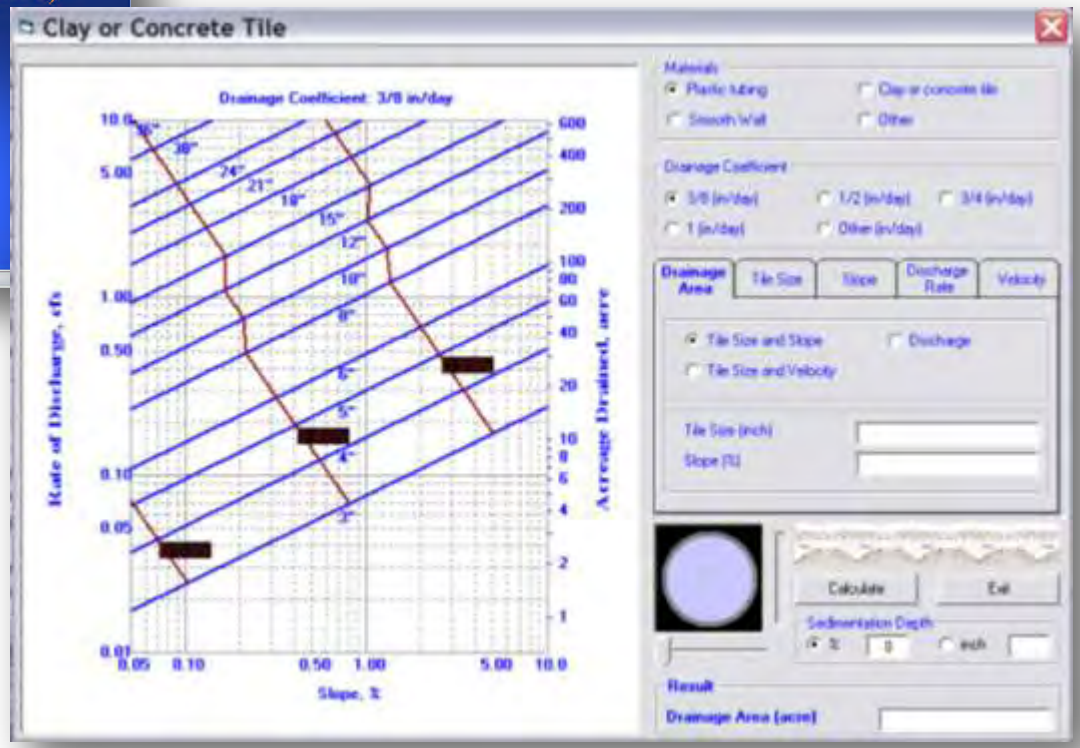
Grade (%)	Drain Size (inches)							
	4	5	6	8	10	12	15	18
0.1	2.5	4.5	7.3	16	25	41	63	103
0.2	3.5	6.4	10.4	22	36	58	89	145
0.3	4.3	7.8	12.7	27	44	71	110	178
0.4	5.0	9.0	14.6	32	50	82	126	206
0.6	6.1	11.0	17.9	39	62	101	155	252
0.8	7.0	12.7	20.7	45	71	116	179	291
1	7.9	14.2	23.2	50	80	130	200	325
1.5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

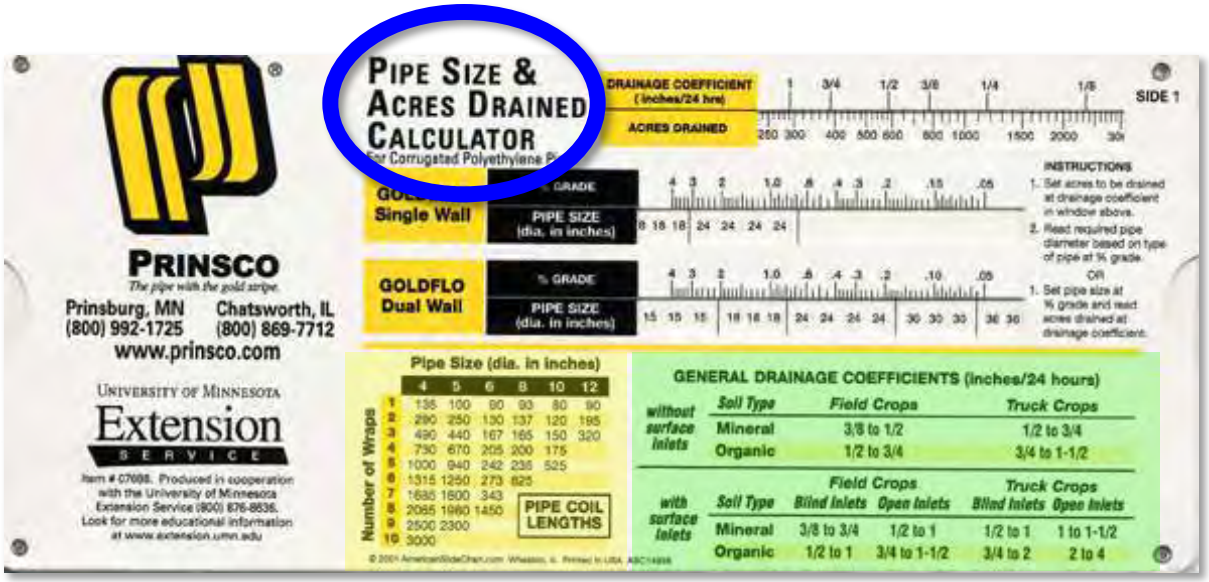


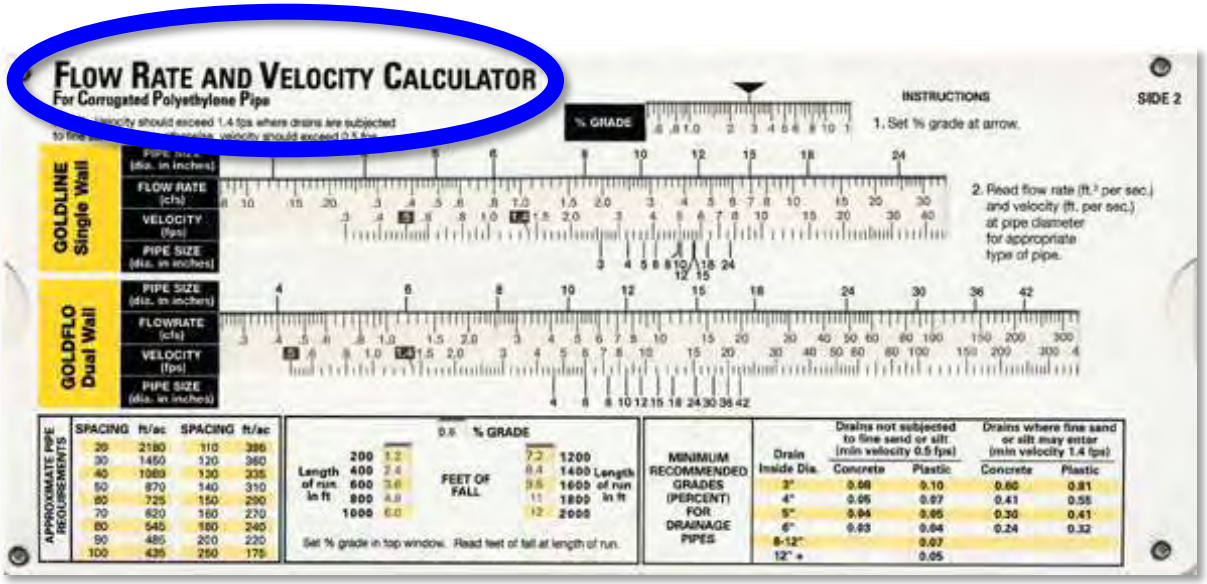
On-line Calculators (cont.)





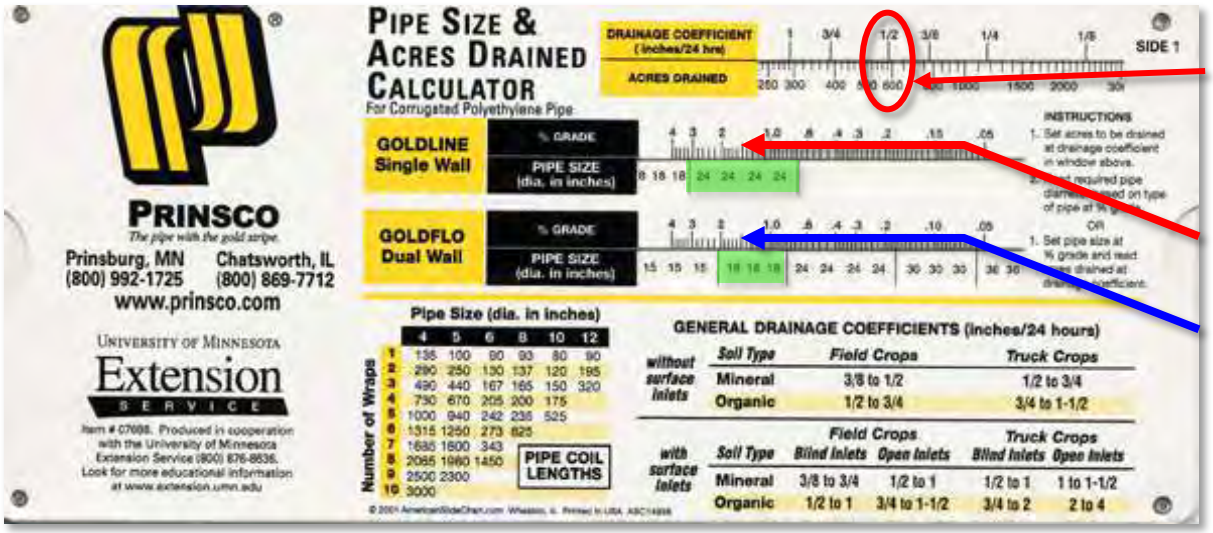
Prinsco-UofM Slide Rule





Prinsco-UofM Slide Rule

- acres drained ➔ pipe size



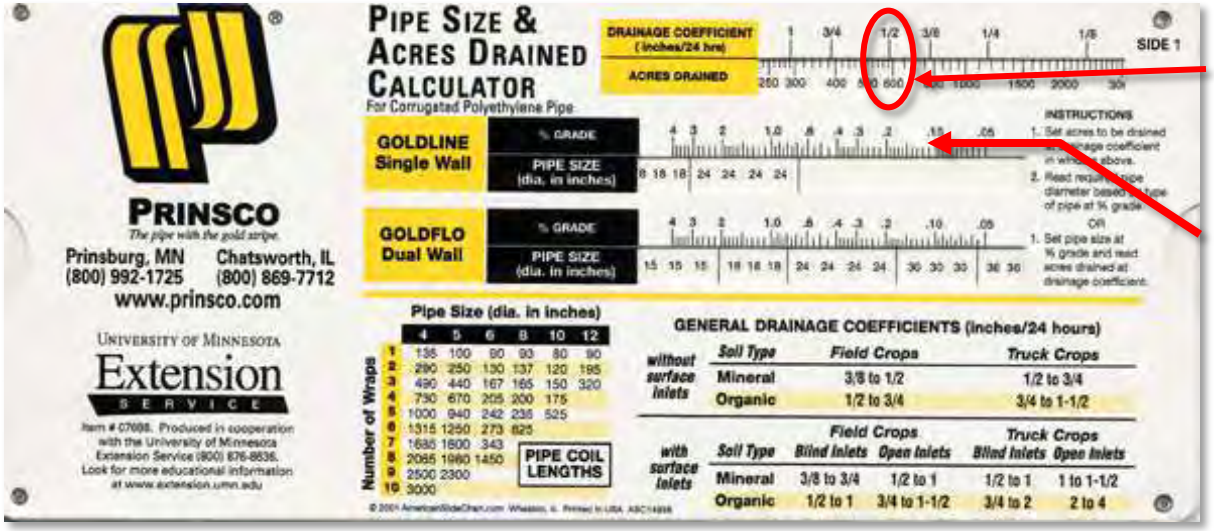
600 acres at ½"DC

1.5% grade – 24"

dual wall – 18"

Prinsco-UofM Slide Rule

- pipe size ➔ acres drained



25 acres at ½" DC

0.1% grade – 10"

Drain Sizing - Grade & Size

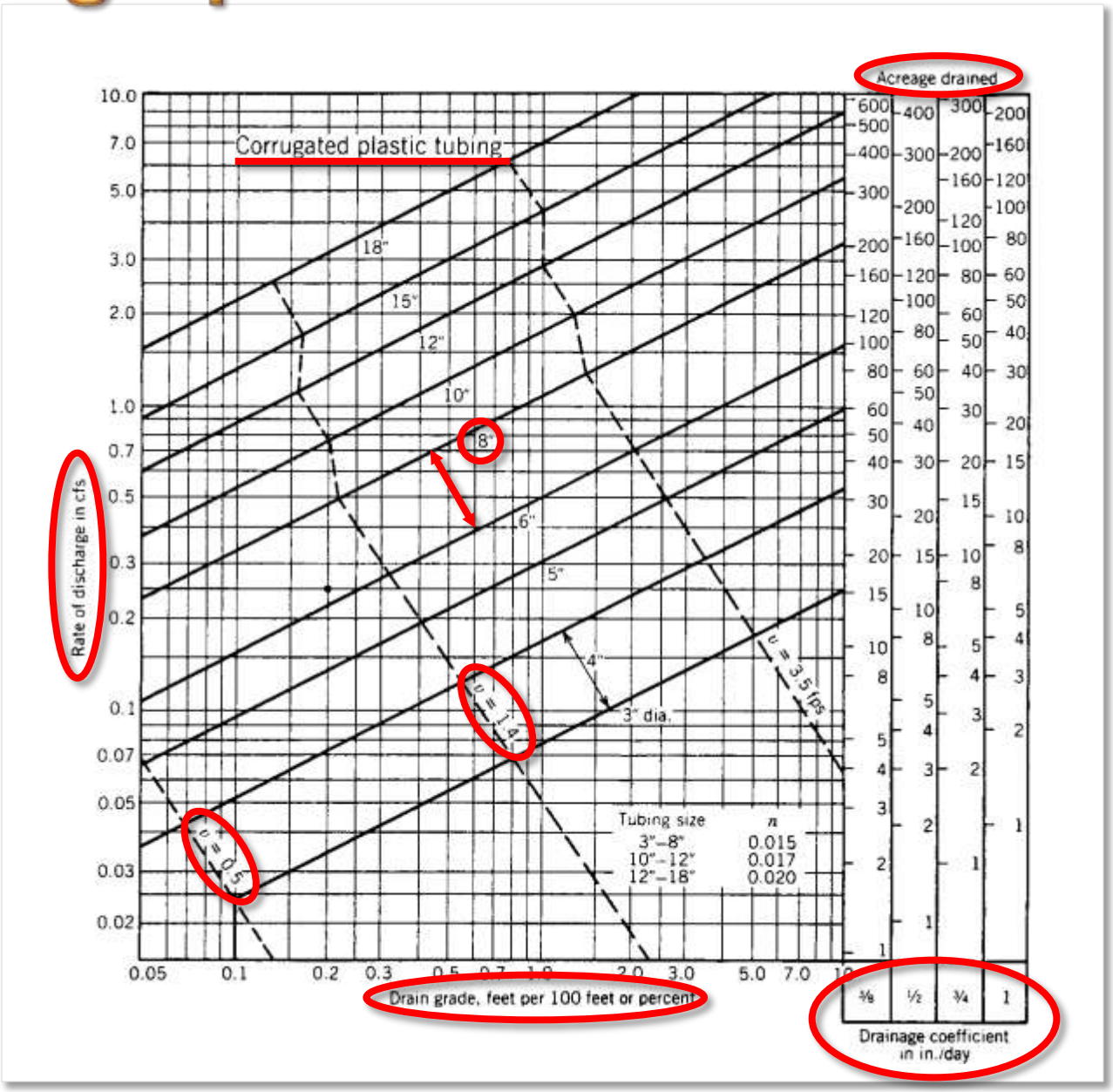
University of Minnesota EXTENSION

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

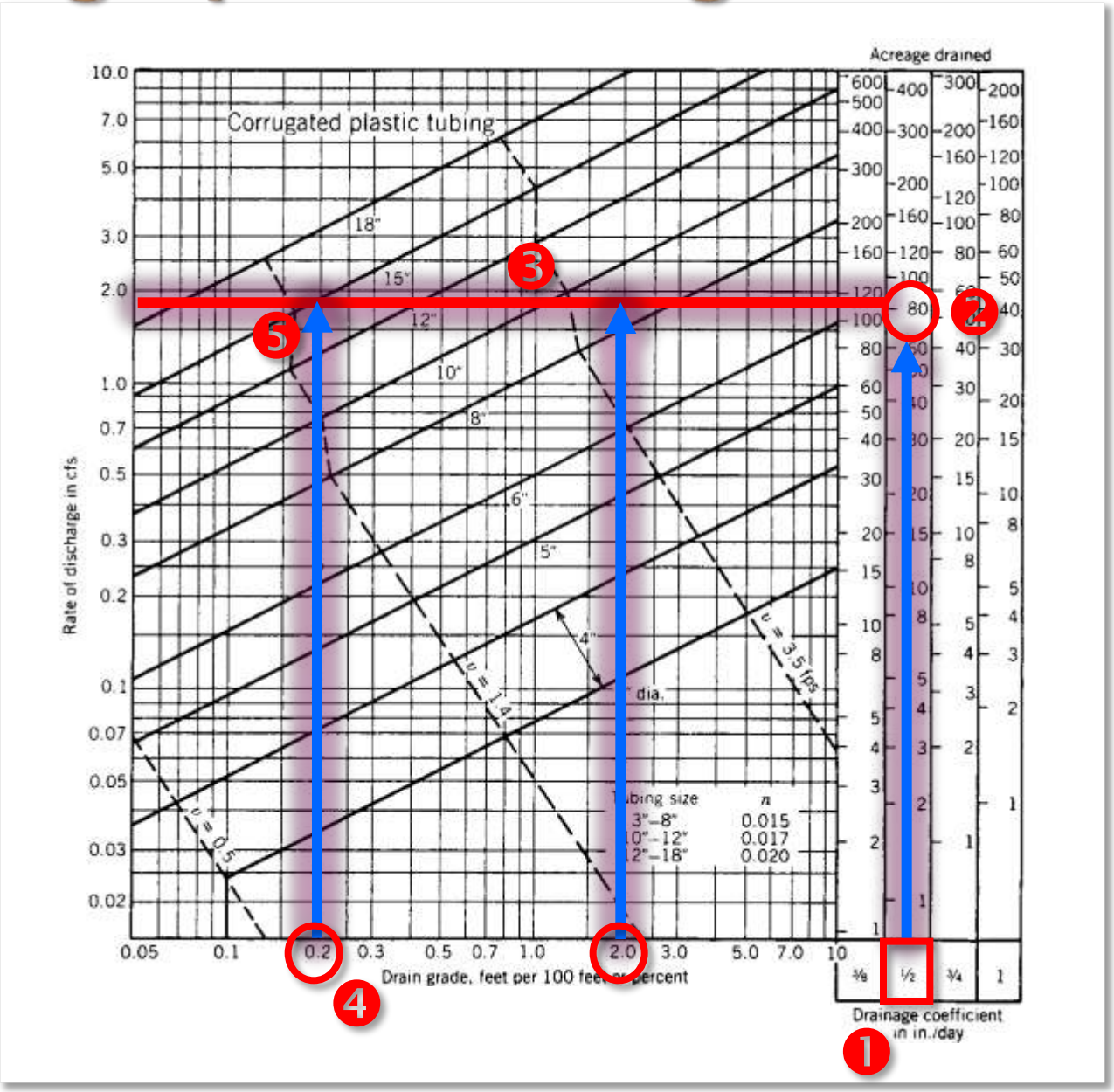
Potential Acres Drained by Selected Tile Sizes and Grades
Drainage Coefficient = ½-inch/day

% 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

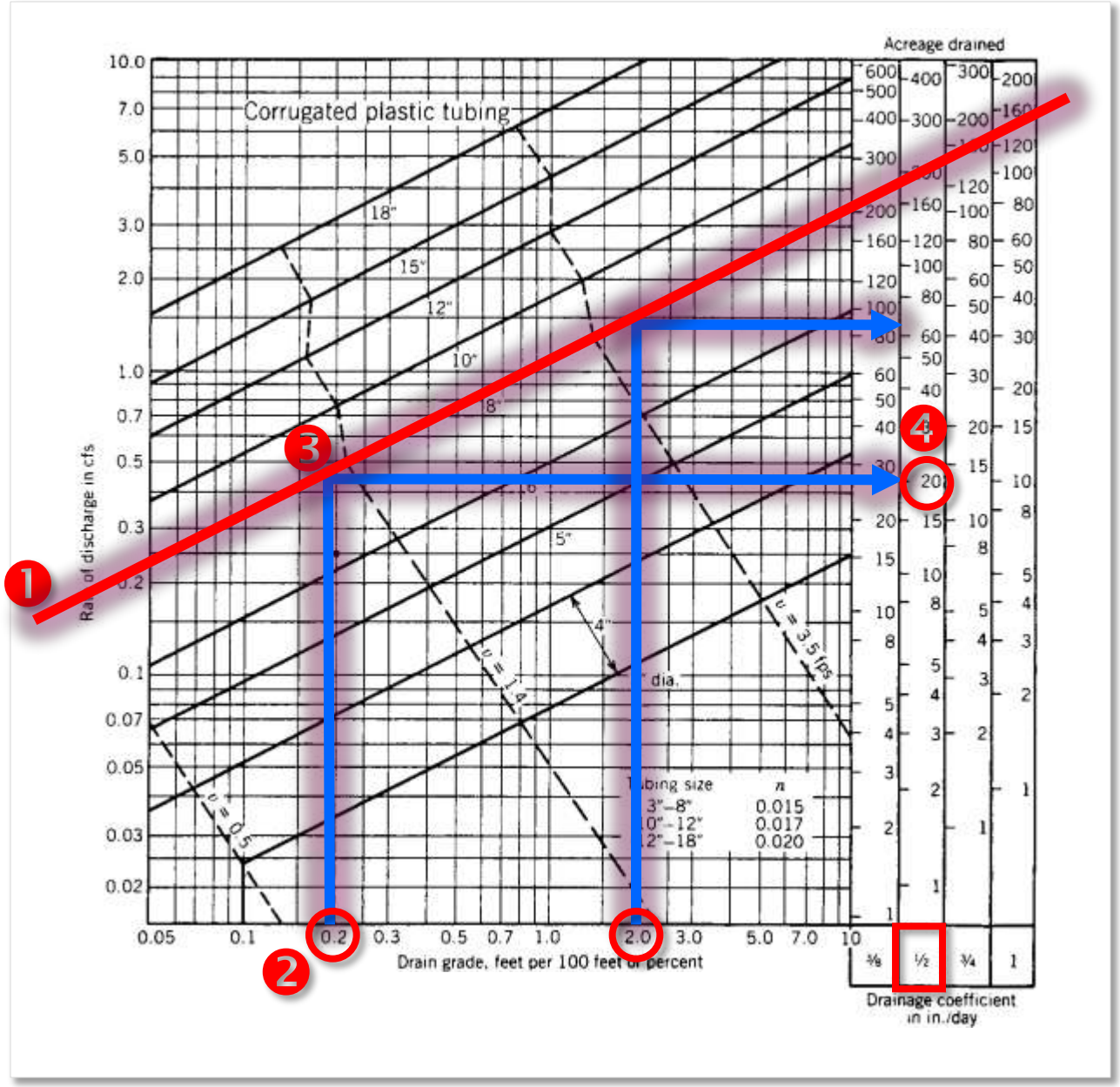
Nomograph - How to Use It



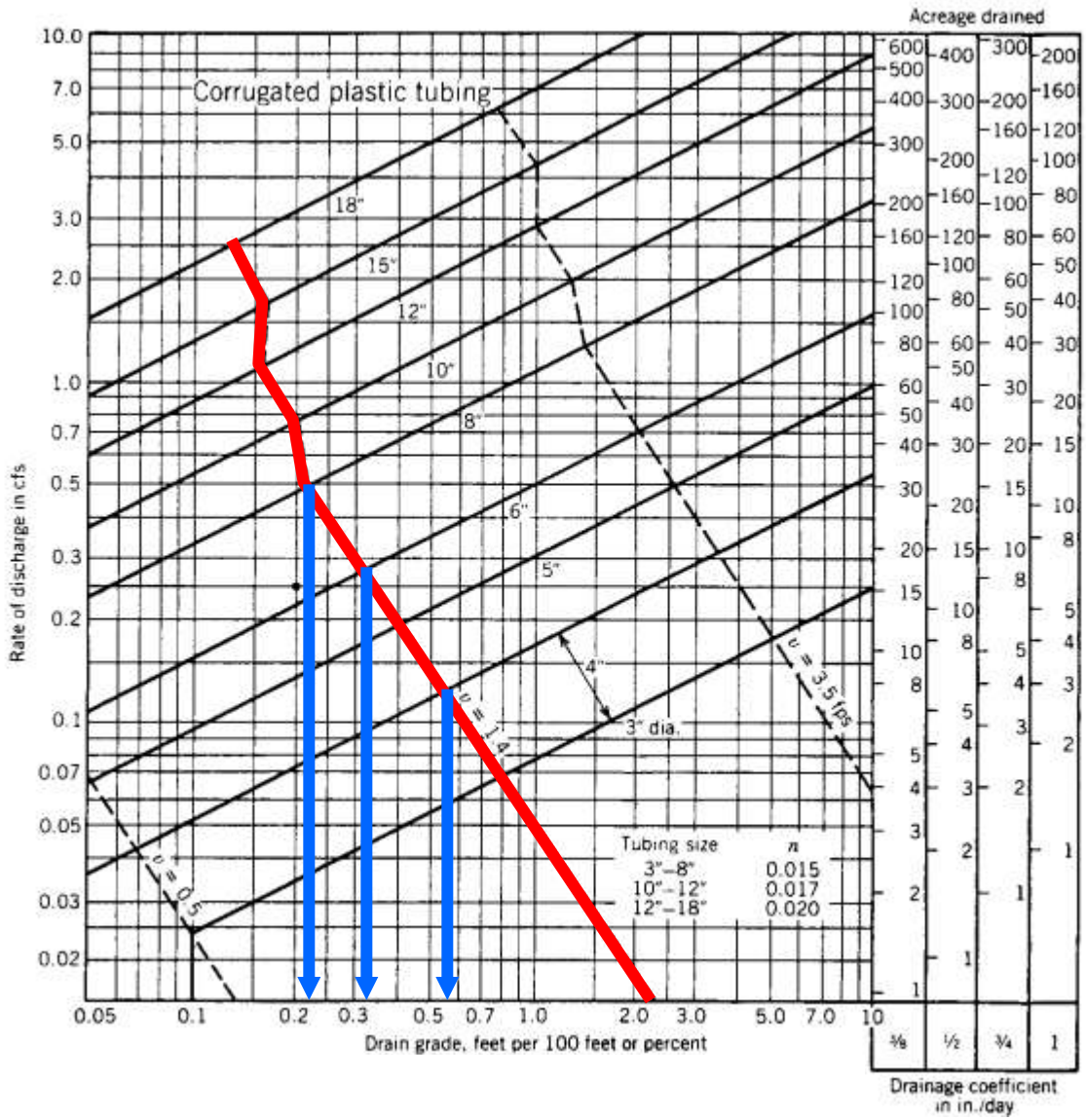
Nomograph - Finding Drain Size



Nomograph – Acres Drained



Nomograph - Minimum Grade



Illinois Drainage Guide (Online) - Windows Internet Explorer

http://www.wq.uiuc.edu/dg/

Illinois Drainage Guid... | Login

Interactive Links are included on some of these web pages. These links are programs that were written with Visual Basic. It may be necessary to install the

Subsurface Drainage

Drainage Guidelines

Outlets for Drainage Systems

Surface Drainage

Subsurface Drainage

Sizing Drainage Pipes

Lateral Specifications

Flow Profiles in Laterals

Pump Specifications

Frost Penetration Depth

- Components
- Site Considerations
- Patterns
- Materials
- Design
- Special Components
- Preinstallation Considerations
- Trench Method of Installation
- Trenchless Method
- Maintenance
- Pumping Plants

Conservation Drainage

Grassed Waterway Design

Economic Considerations

History of Drainage in Illinois

Printable Tables and Charts

Illinois Drainage Guide (Online)

Department of Agricultural and Biological Engineering

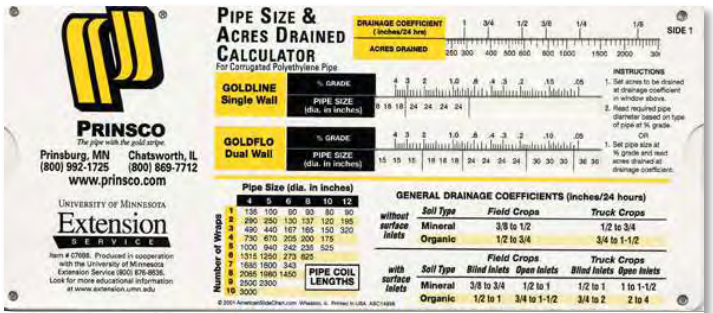
University of Illinois

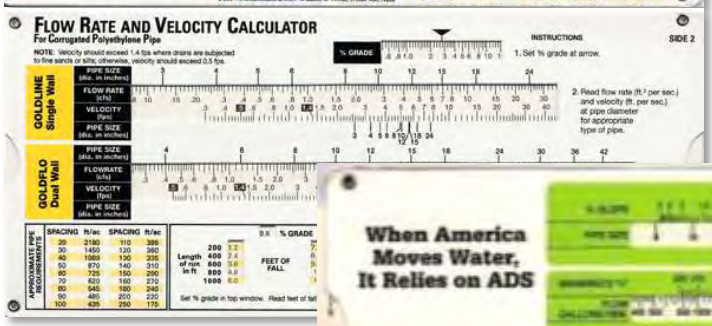
http://www.wq.uiuc.edu/dg/subsurface.htm

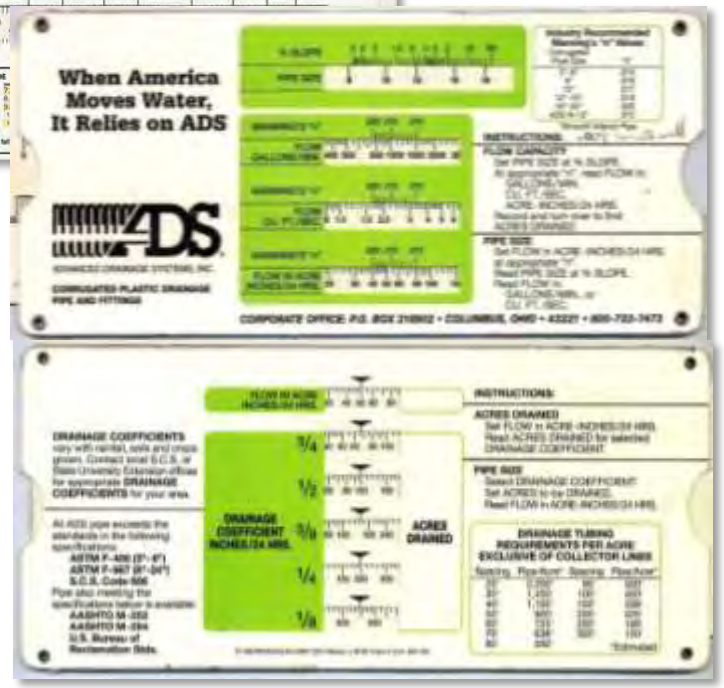
Internet 100%

HANDS-ON EXAMPLES

Slide Rules/Charts



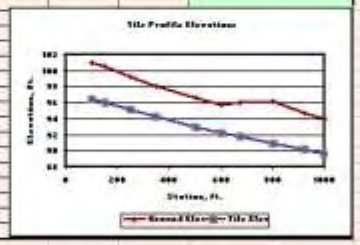




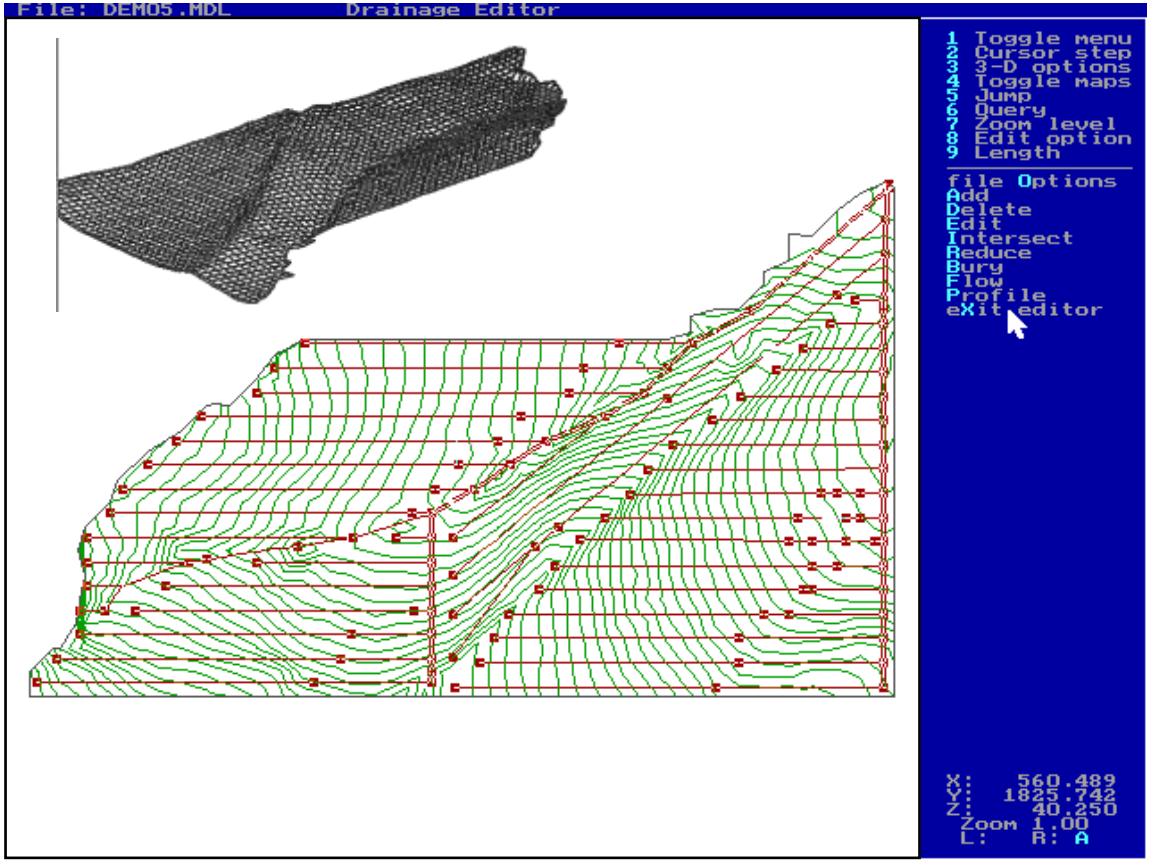
Spreadsheets

Microsoft Excel - Drain Cut Sheet Aid.xls

	Enter Drain Station	Enter Drain Hub Elevation	Ground Grade (%)	Enter Outlet Elev	Drain Elev	Enter Drain Grade (%)
Begin	CLEAR	CLEAR		CLEAR		CLEAR
Data Entry	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



Computer Aided Drainage



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

accessories
installation guide
delivery

farm drainage

about prinsco
industry news
trade shows
contact us
site map

home page

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

University of Minnesota Extension Drainage Outlet Website - Windows Internet Explorer

http://www.drainageoutlet.umn.edu/

File Edit View Favorites Tools Help

Google Des Moines, IA Go Bookmarks 10 blocked Check Settings

University of Minnesota Extension Drainage Outlet W...

U of M Home | U of M Directories | Search U of M

UNIVERSITY OF MINNESOTA
EXTENSION

What's Inside

Search our website

Go

- Home
- Educational Links
- Conservation Drainage
- Planning and Design
- Meetings/Events
- General Links
- Photo Archives

THE Drainage Outlet

The latest information on agricultural drainage water management

UPCOMING EVENTS

- Event

NEWS

- News Item

RESEARCH HIGHLIGHTS

- Program Highlight

Information presented here is for educational purposes only. The University of

Frequently Asked Questions

What is agricultural drainage water management?

Is drainage water management the same as subirrigation?

What fields are most suitable for drainage water management?

More FAQs....

Extension Publications

University of Minnesota Extension

www.extension.umn.edu

AGRICULTURAL DRAINAGE publication series

Soil Water Concep

The *Agricultural Drainage* series covers topics includin economics; environmental impacts; wetlands; and legal

The growing use of artificial subsurface or "tile" drainage in Minnesota has sparked much debate about its impact on local hydrology and water quantity and quality. Discussions are typically focused on the following questions that have important policy implications for local and state decision makers.

- Does subsurface drainage lessen or worsen localized flooding?
- Are catastrophic floods more frequent because of subsurface drainage?

This publication presents concepts that are fundament soil water and the water balance. It provides informati crop/soil system and their relationship to drainage. In drainage, soil water, and hydrology are addressed. Un broad issues and policy questions related to drainage

SUBSURFACE DRAINAGE

Artificial subsurface drainage continues to be a common practice in Minnesota, as well as in other states and countries around the world. Subsurface drainage is the practice of placing perforated pipe at a specified grade (slope) at some depth below the soil surface. Excess water from the crop root zone can enter the pipe through the perforations and flow away from the field to a ditch or other outlet. Subsurface drainage improves the productivity of poorly drained soils by lowering the water table, providing greater soil aeration, and enabling faster soil drying and warming in the spring. This may allow fields to be planted earlier and other field operations to take place in a timely fashion. It also provides a better environment for crop emergence and early growth, and can reduce soil compaction. Once a

AGRICULTURAL DRAINAGE publication series

Issues and Answ

The *Agricultural Drainage* series covers such topic economics; environmental impacts; wetlands; and le

WHAT IS AGRICULTURAL DRAINAGE?

Agricultural drainage is the use of surface ditches, subsurface permeable pipes, or both, to remove standing or excess water from poorly drained lands During the late 1800s, European settlers in the Upp Midwest began making drainage ditches and channelizing (straightening and reshaping) streams to carry water from the wet areas of their farms to nearby streams and rivers. Later, farmers increased drainage by installing subsurface drainage pipes generally at a depth of three to six feet. Until the 1970s, most subsurface drainage pipes were made from short, cylindrical sections of concrete or tile called "tile." That is why terms like tile, tile drainage and tiling are still used, even though most drainage pipe today is perforated polyethylene tubing. When installing a subsurface drainage system, pipes are either strategically placed in a field to remove water from isolated wet areas or installed in a pattern to drain an entire field. In some areas, surface inlets or inlakes (risers extended from underground pipes to the surface) remove excess surface water from low spots in fields.

Poorly drained agricultural land

AGRICULTURAL DRAINAGE publication series

Planning an Agricul
Subsurface Drainage S

The *Agricultural Drainage* series covers such topics a economics; environmental impacts; wetlands; and legal

GENERAL CONSIDERATIONS

Many soils in Minnesota and throughout the world would remain wet for several days after a rain without adequate drainage, preventing timely fieldwork, and causing stress on growing crops. Saturated soils do not provide sufficient aeration for crop root development, and can be an important source of plant stress. That's why artificial drainage of poorly draining soils has become integral to maintaining a profitable crop production system. Some of the world's most productive soils are drained, including 25 percent of the farmland in the United States and Canada.

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

- Local, state, and federal regulations
- Soil information
- Wetland impact
- Adequacy of system outlet
- Field elevation, slope (grade), and topography assessment
- Economic feasibility
- Present and future cropping strategies
- Environmental impacts associated with drainage discharge
- Easements and right-of-ways
- Quality of the installation

The U.S. Department of Agriculture (USDA) Food Security Act and the farm bills of 1985, 1990, and 1996 created many special wetlands restrictions and mandates that all drainage projects, including upgrades, must follow. It's also very important that the landowner, system designer, and contractor understand other applicable federal laws, as well as the local watershed and state laws dealing with

WD-44

DRAINAGE WATER MANAGEMENT
for the Midwest

Questions and Answers About Drainage Water Management for the Midwest

Jane Frankenberger, Eileen Kladivko, Gary Sands, Dan Jaynes, Norm Fausey, Matt Helmers, Richard Cooke, Jeff Strock, Kelly Nelson, Larry Brown

Purdue University
University of Minnesota
Iowa State University
University of Missouri
University of Illinois
The Ohio State University
USDA-Agricultural Research Service

Introduction

Subsurface tile drainage is an essential water management practice on many highly productive fields in the Midwest. However, nitrate carried in drainage water can lead to local water quality problems and contribute to hypoxia in the Gulf of Mexico, so strategies are needed to reduce the nitrate loads while maintaining adequate drainage for crop production. Practices that can reduce nitrate loads on tile-drained soils include growing winter forage or cover crops, fine-tuning fertilizer application rates and timing, bioreactors, treatment wetlands, and modifying drainage system design and operation. Drainage water management is one of these practices and is described in this fact sheet. Answers given here apply specifically to Midwest corn and soybean cropping systems, and not to perennial or winter annual crops.

1. What is drainage water management?

Drainage water management is the practice of using a water control structure in a main, submain, or lateral drain to vary the depth of the drainage outlet. The water table must rise above the outlet depth for drainage to occur, as illustrated at right. The outlet depth, as determined by the control structure, is

- Raised after harvest to limit drainage outflow and reduce the delivery of nitrate to ditches and streams during the off-season. (Figure 1)
- Lowered in early spring and again in the fall so the drain can flow freely before field operations such as planting or harvest. (Figure 2)
- Raised again after planting and spring field operations to create a potential to store water for the crop to use in midsummer. (Figure 3)

Outlet

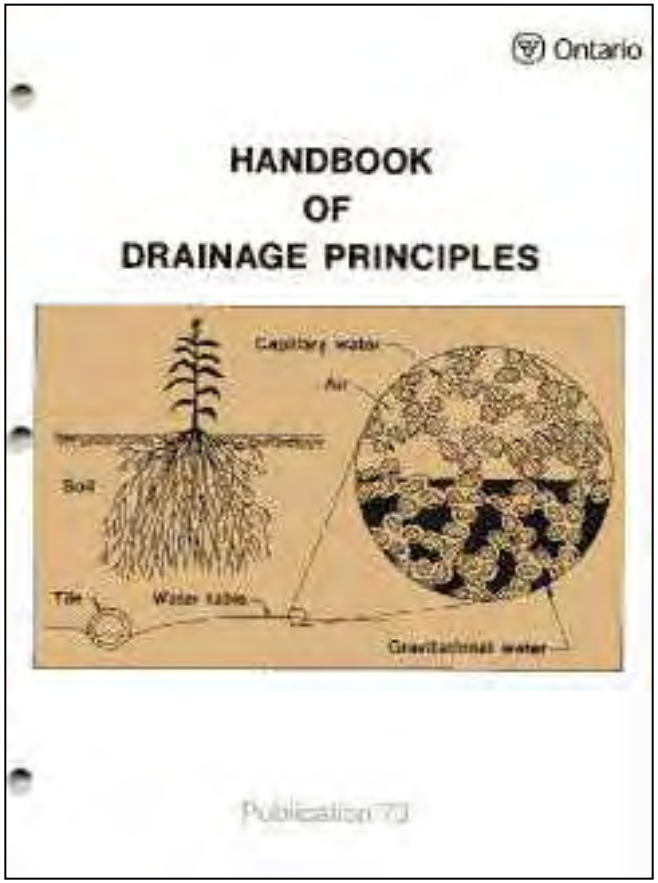
Figure 1. The outlet is raised after harvest to reduce nitrate delivery.

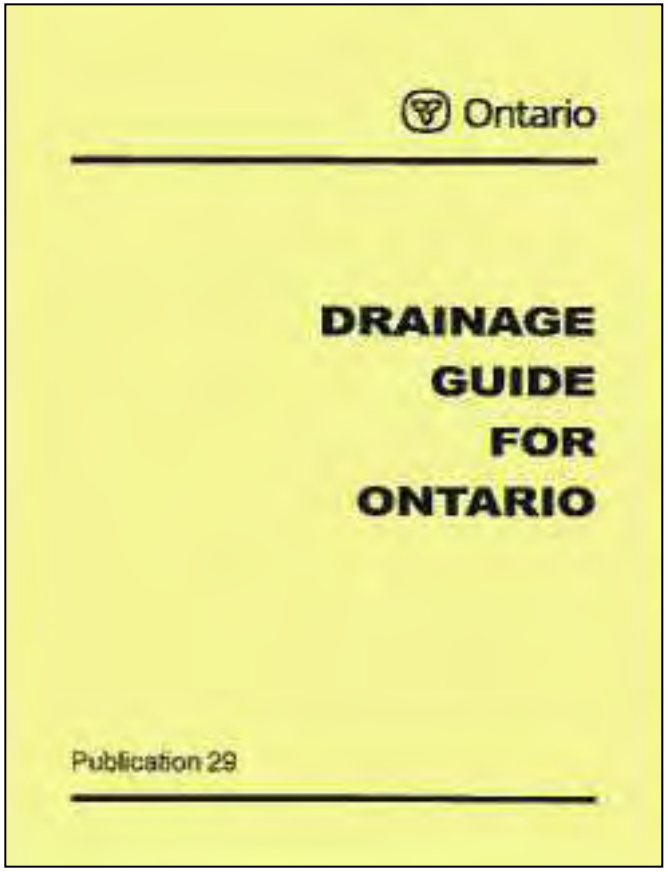
Figure 2. The outlet is lowered a few weeks before planting and harvest to allow the field to drain more fully.

Figure 3. The outlet is raised after planting to potentially store water for crops.

Purdue Extension
Knowledge to Go
1-888-EXT-INFO

Important Planning Publications





Ontario Ministry of Agriculture, Food and Rural Affairs

www.gov.on.ca/omafra

Questions?

Gary R. Sands, Ph.D.
Associate Professor
Bioproducts & Biosystems Engineering
University of Minnesota
St. Paul, MN 55112
(612) 625-4756
grsands@umn.edu
http://www.DrainageOutlet.umn.edu