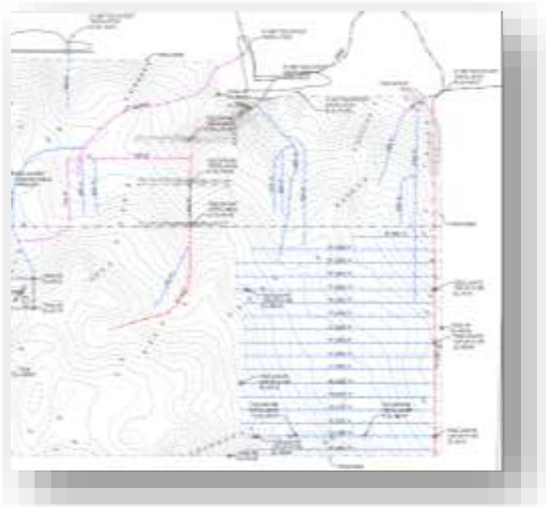
Understanding Agricultural Drainage



Gary R. Sands
Professor & Extension Engineer
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@UoMExtWater

Department of
BIOPRODUCTS AND
BIOSYSTEMS ENGINEERING
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U of M Extension Drainage Design Workshop

2011 – 2014 Participants

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WORKSHOP GOALS

- Expand knowledge
- Nail the concepts
- Build on fundamentals
- Learn new tools
- Learn new practices
- Learn from others

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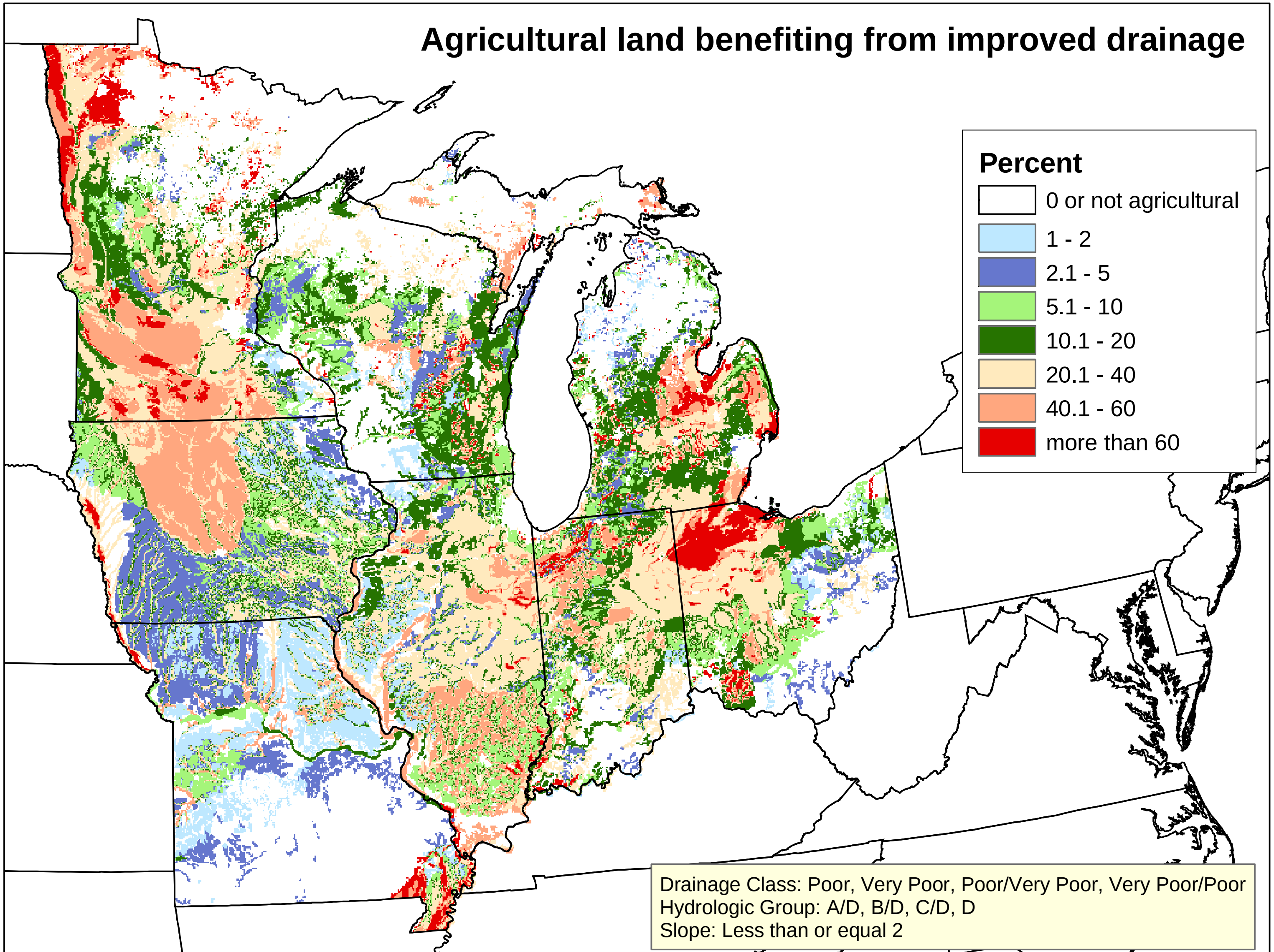
Learning Units for Workshop

- Safety
- Design 1: Soils & principles and tools
- Design 2: Intro to drainage design
- Design 3: Whole-class design project
- Design 4: Managed drainage design
- Design 6: Team design project
- Design 7: Lift station design
- Design 8: Subirrigation design
- Conservation drainage practices
- Legal updates and perspectives
- Drainage Software

Take Home Points

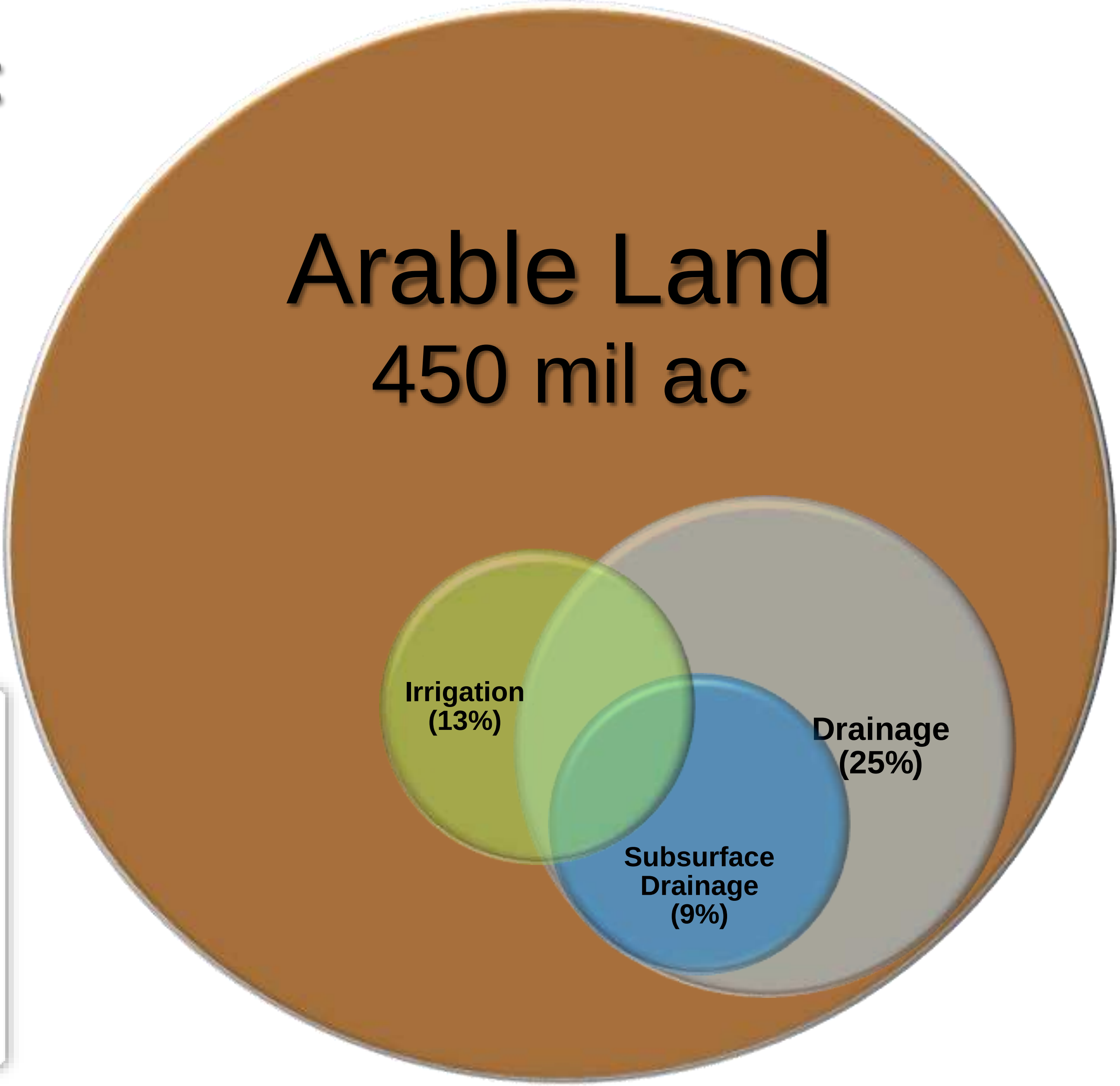
- Be safe in the field (esp. trench safety)!
- Be kind to your neighbors
- Generally, state laws support drainage, but there are limits
- Drainage spacing may be the hardest and the most important decision; layout comes next
- Make your drainage systems function as uniformly as possible
- Design with conservation drainage in mind
- Drainage isn't rocket science, but there is plenty of room for excellence!
- If going to self-install, walk before you run!

Poorly Drained Soils in the Upper Midwest



Courtesy of Dan Jaynes, ARS – Ames, IA

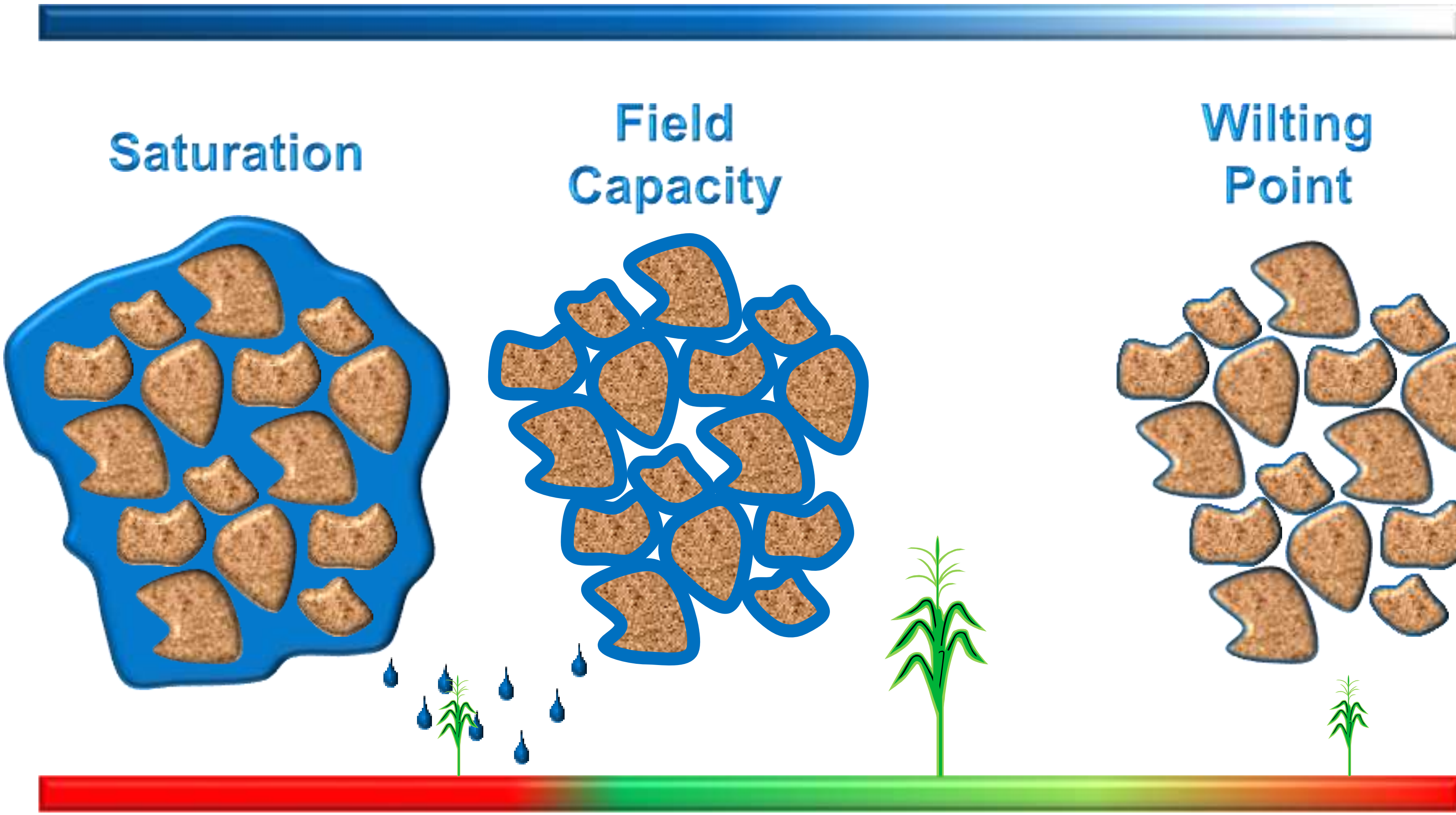
U.S. Water Management



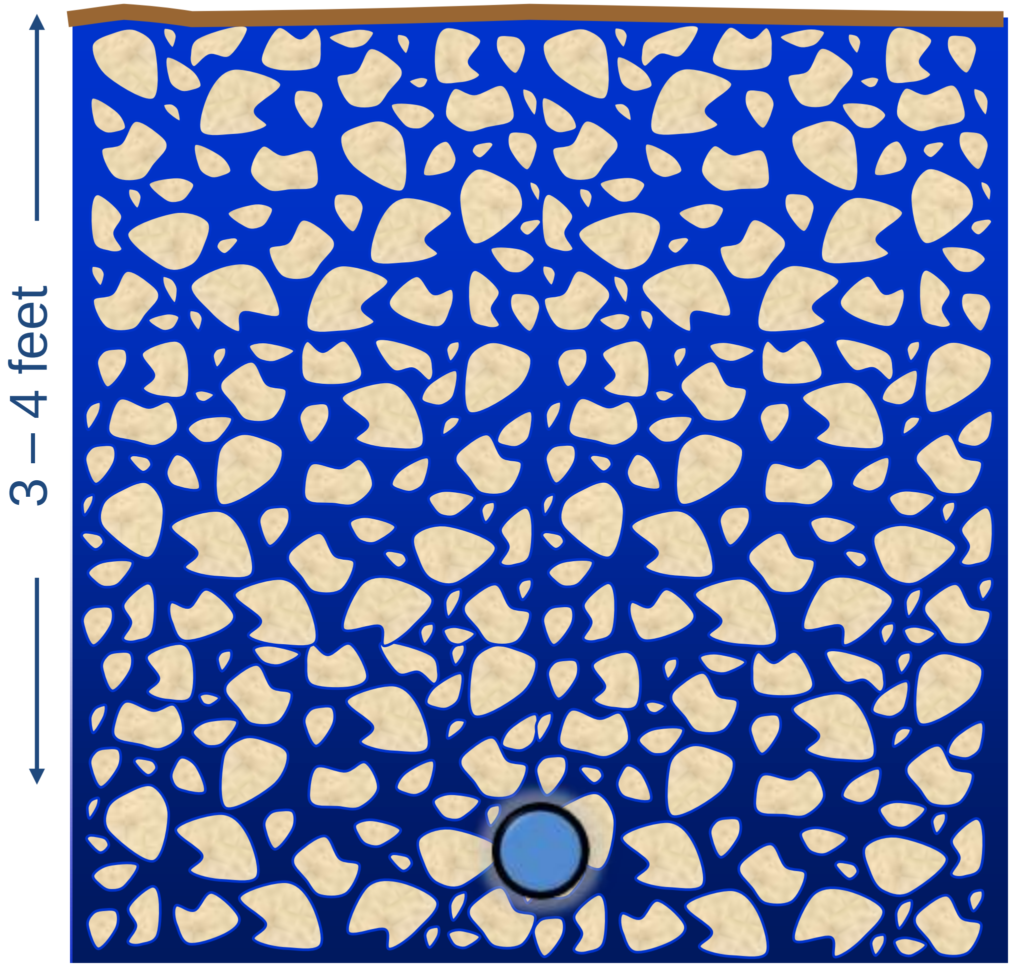
World (30% land)

- 11% arable
- 18% irrigated
- ~25% drained

Soil Water and Drainage

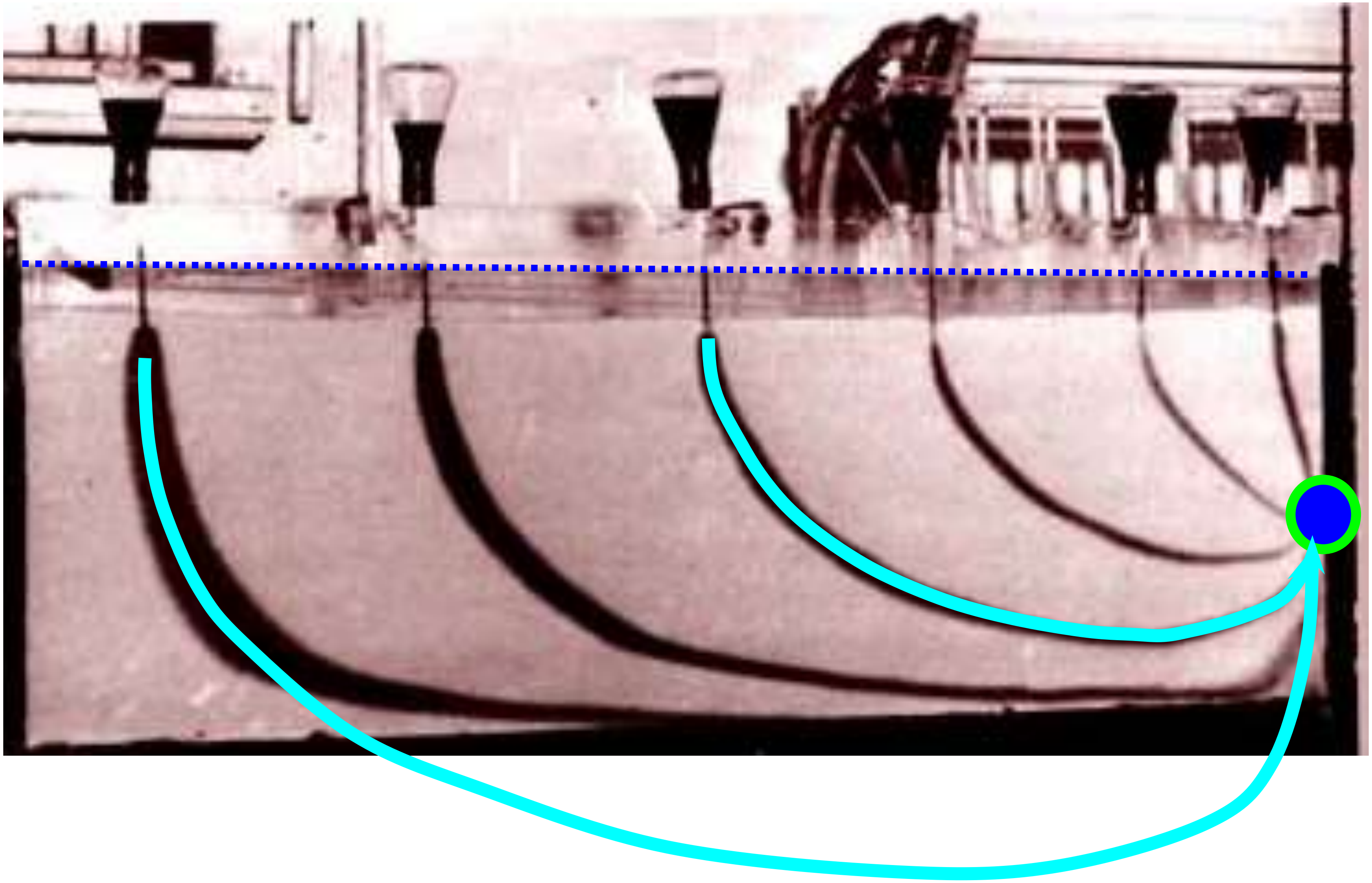


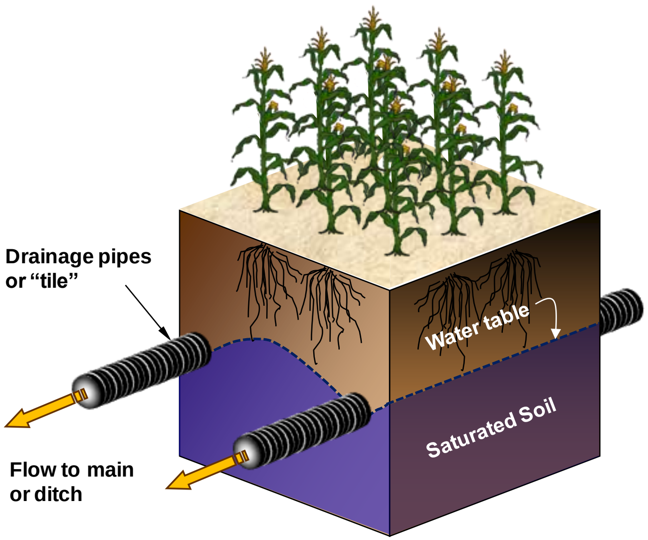
What is a Water Table?



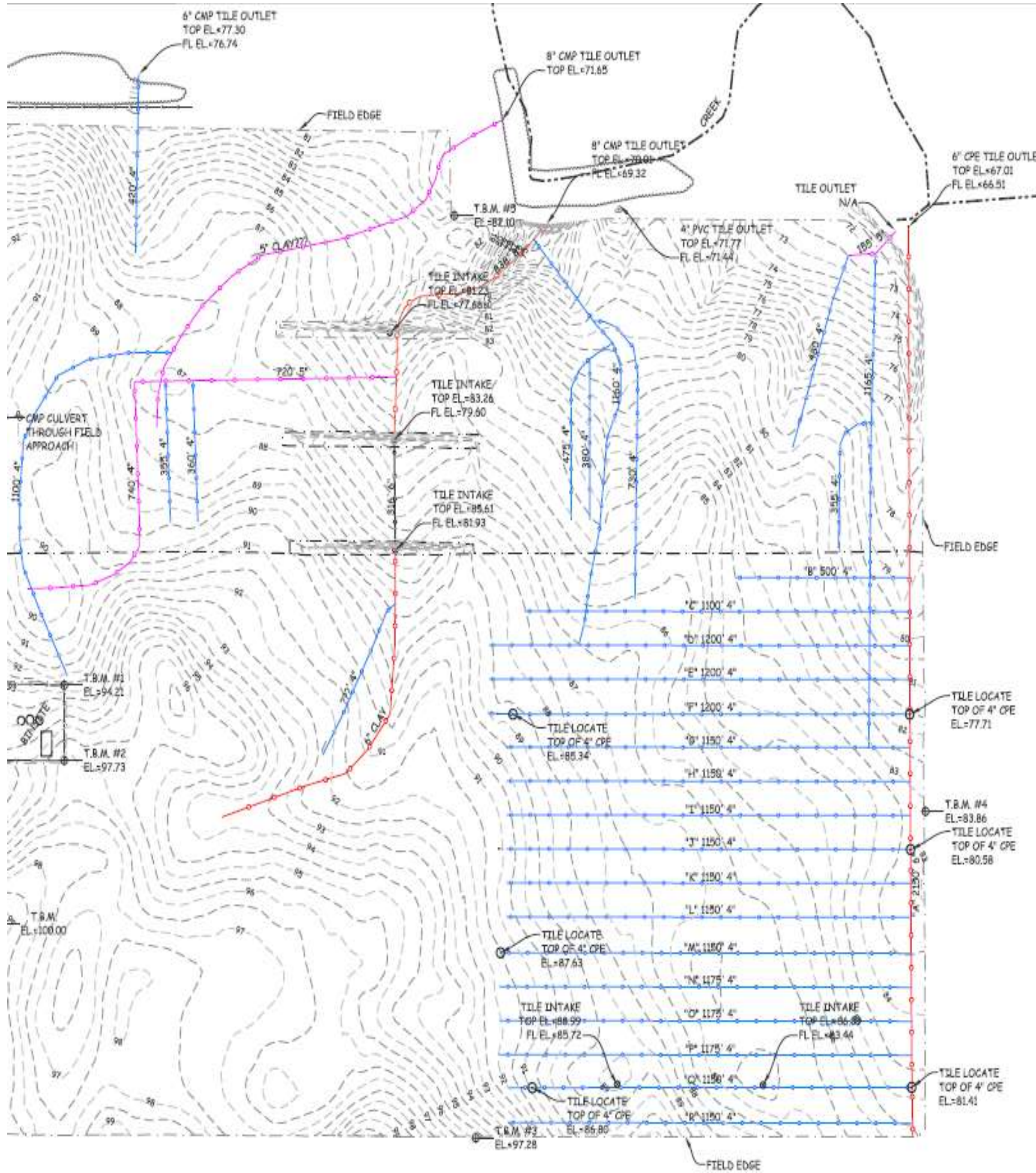
- "Gravitational" water drains from larger pores
- Water remains in smaller pores
- Water table drops over hours to days
  - *Faster at first, then more slowly*

Drainage Flow: Water Flows "Up"



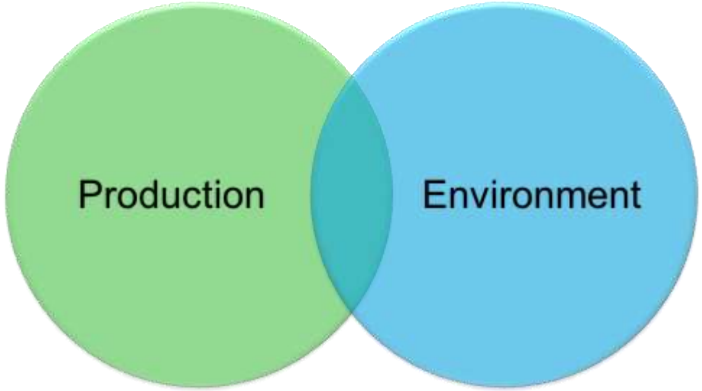


Introduction to Drainage Design



A New Age of Drainage

- Water still flows downhill, but …..
- Today's issues call for new approach
- **Golden Rule of Drainage**



How do you know when you've done a good job with drainage design?

- Maximizes net returns?
- Reduced annual variability? Reduced Stress?
- Maintenance free?
- Reduces risk of crop loss?
- Improves field operations?
- Environmental effects minimized?
- Ability to manage the system?

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?***

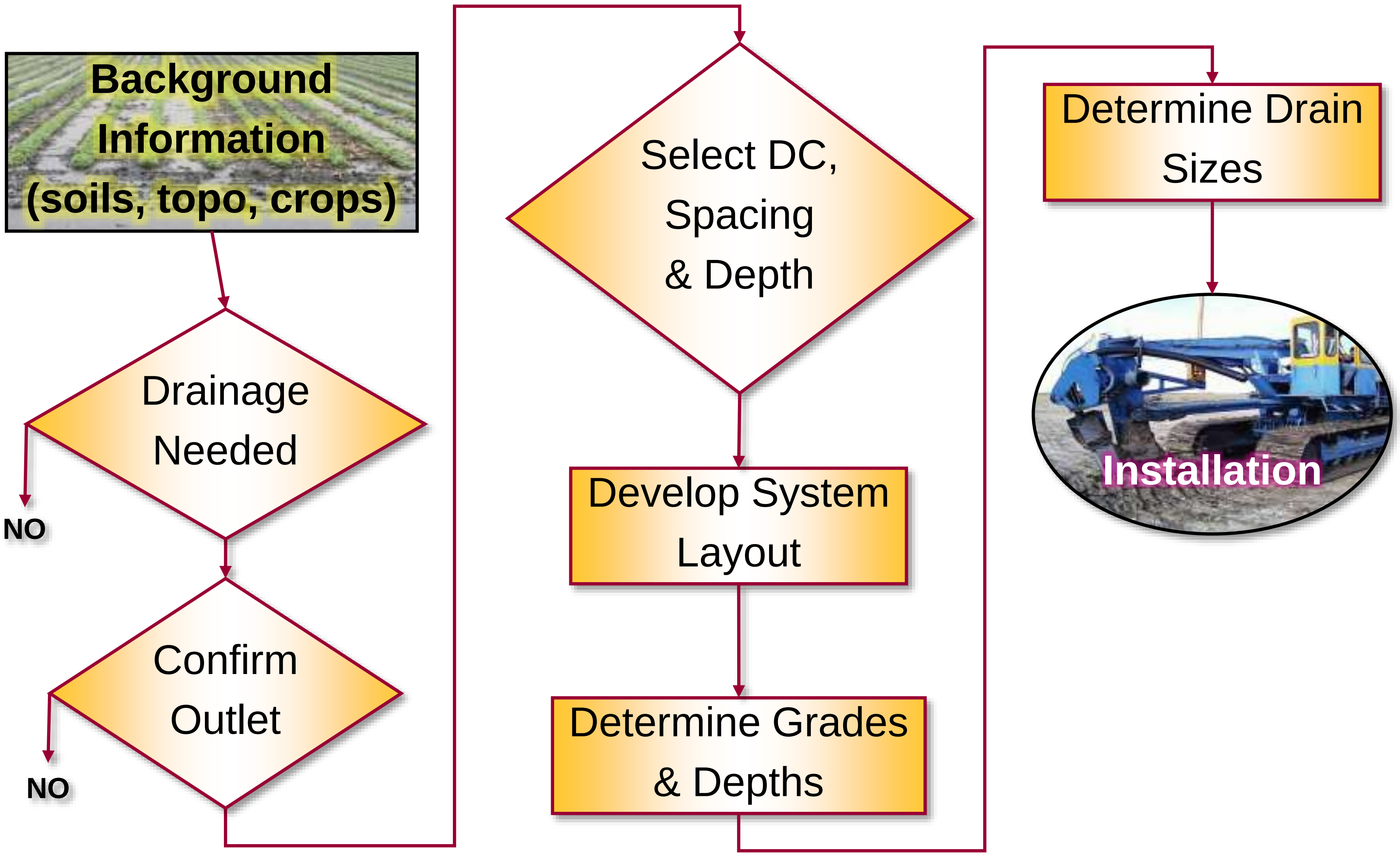
Design Choices (cont.)

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

Drainage Design Conditions

- Rainfall/climate factors
- Soils
- Topography
- Outlet condition
- Legal & regulatory framework
- Client's risk aversion?
- Landowner's priorities?

Design Process Flowchart



Selection of Drain Depth & Spacing …

- Determines drainage rate/coefficient
- Influences cost of system
- Influences performance and impact

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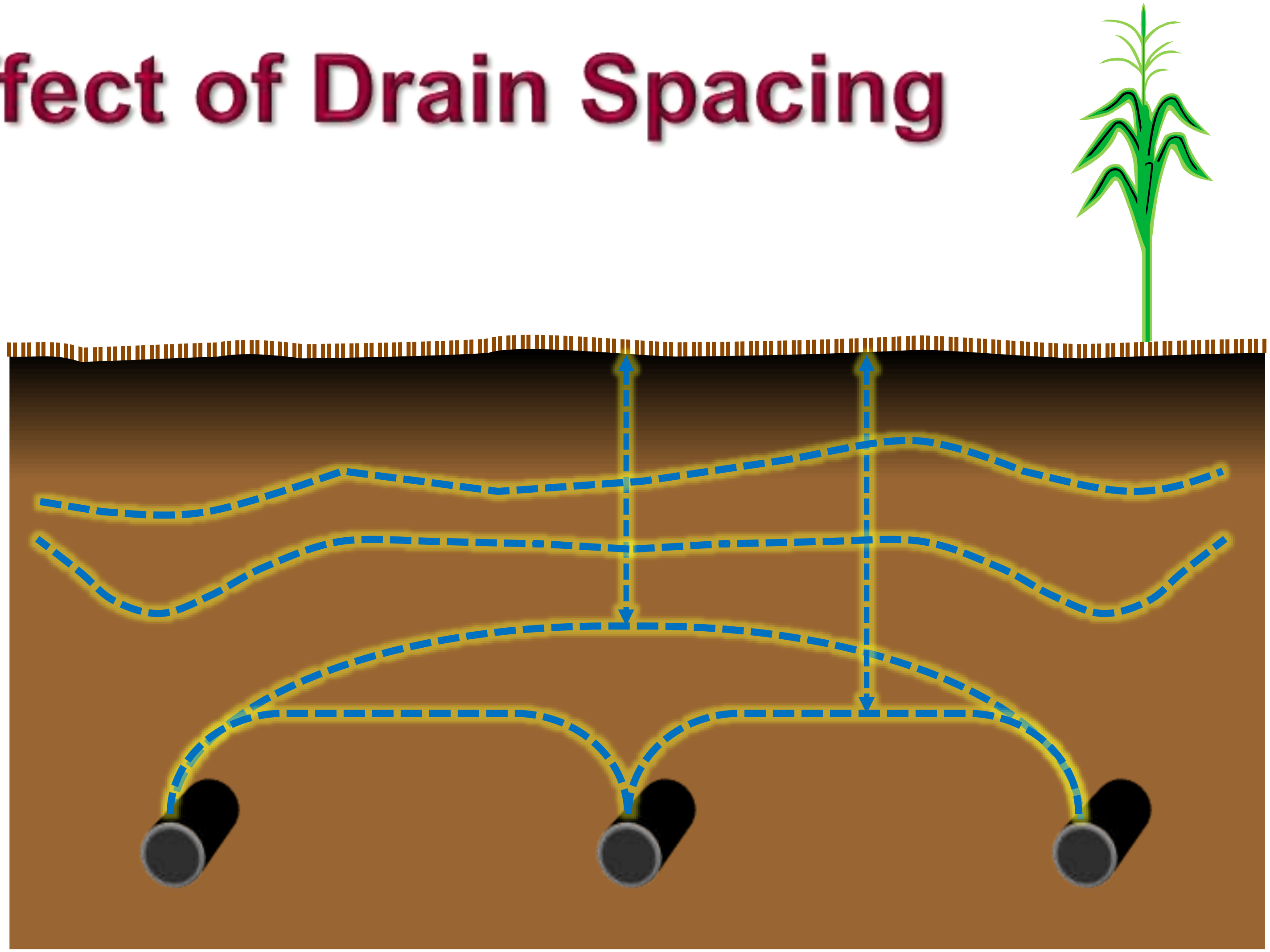
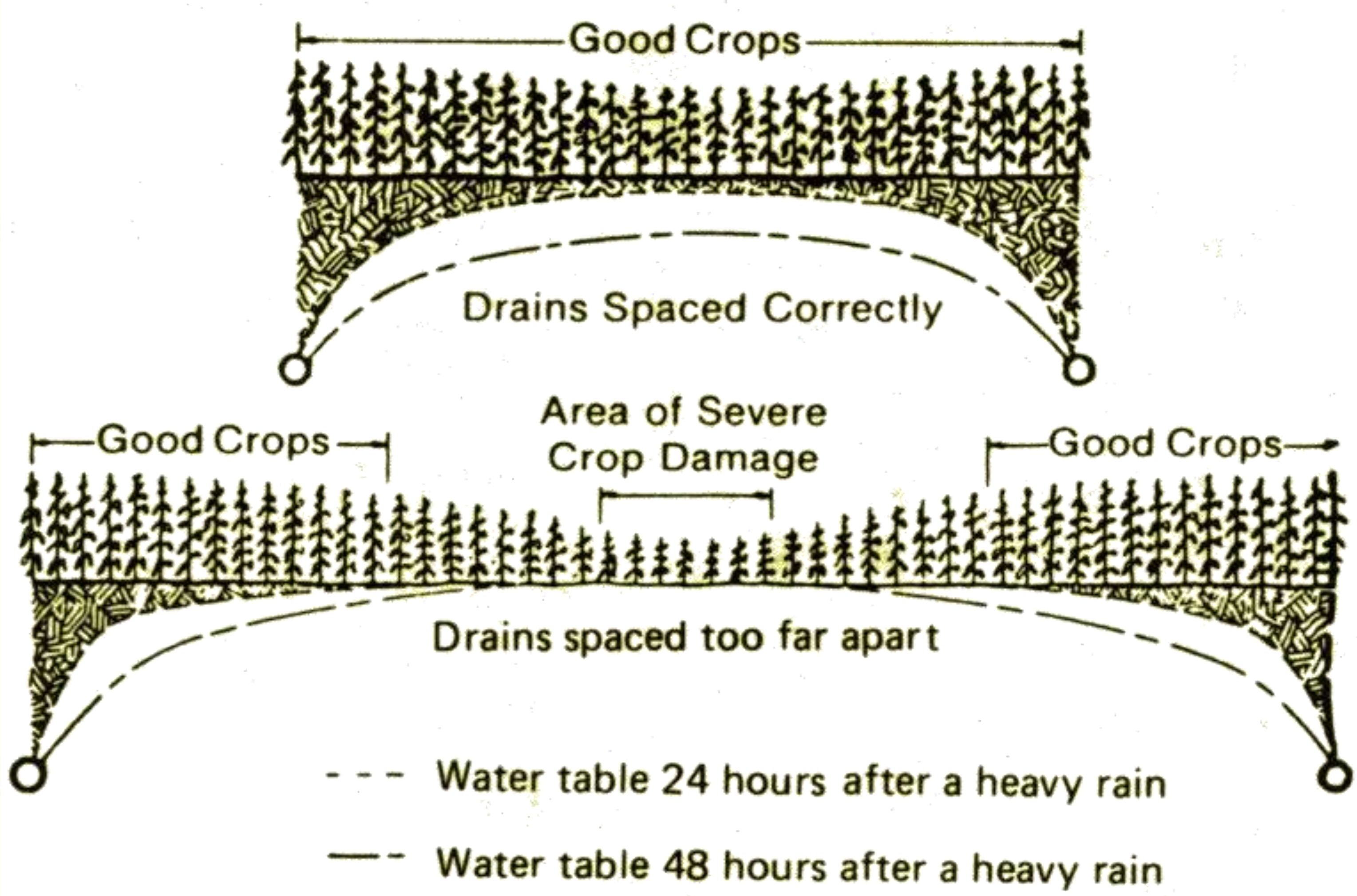
Effect of Drain Spacing

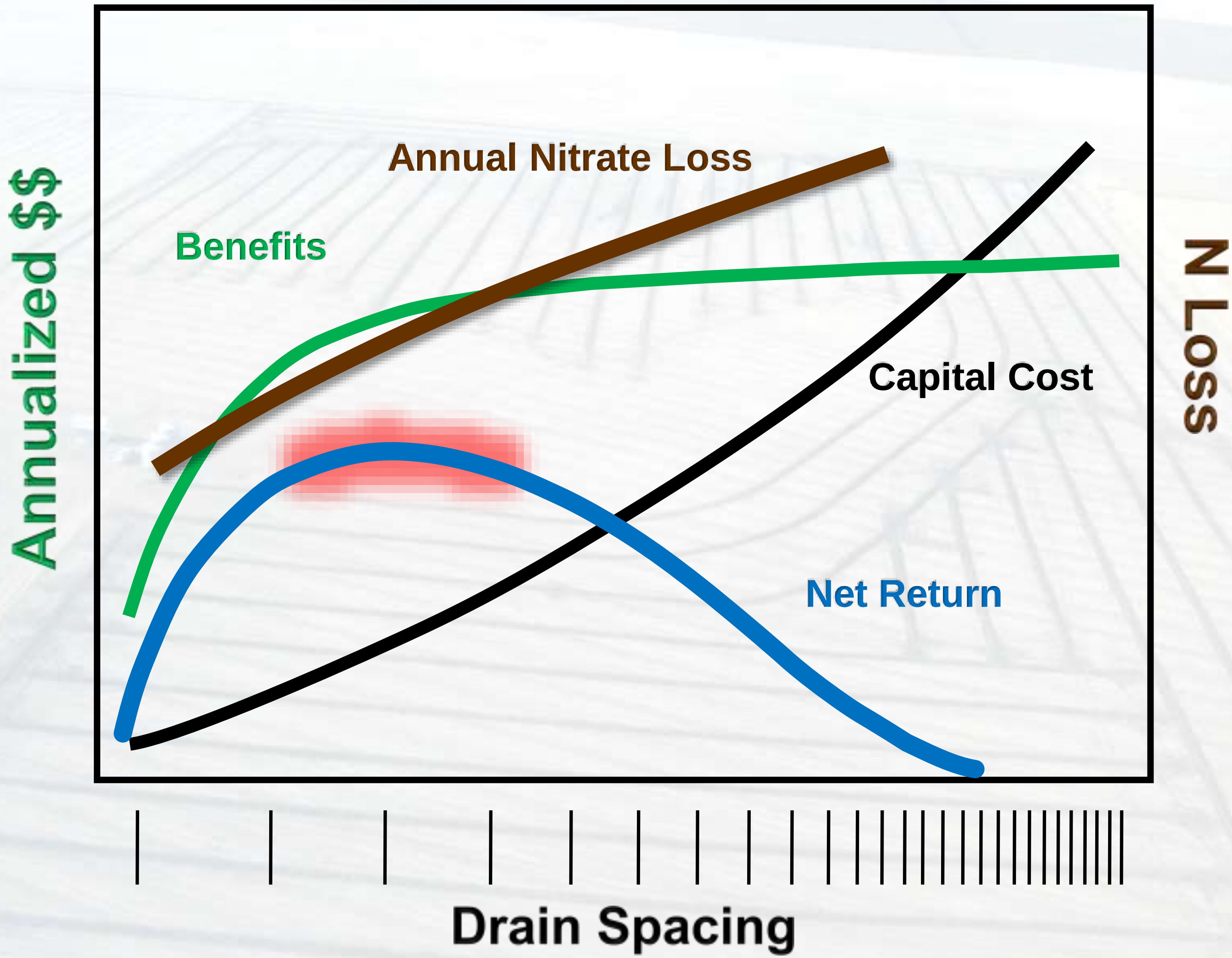


- Profitability
- Downstream or unwanted effects?

Drain Spacing: *How close is close enough? How close is too close?*

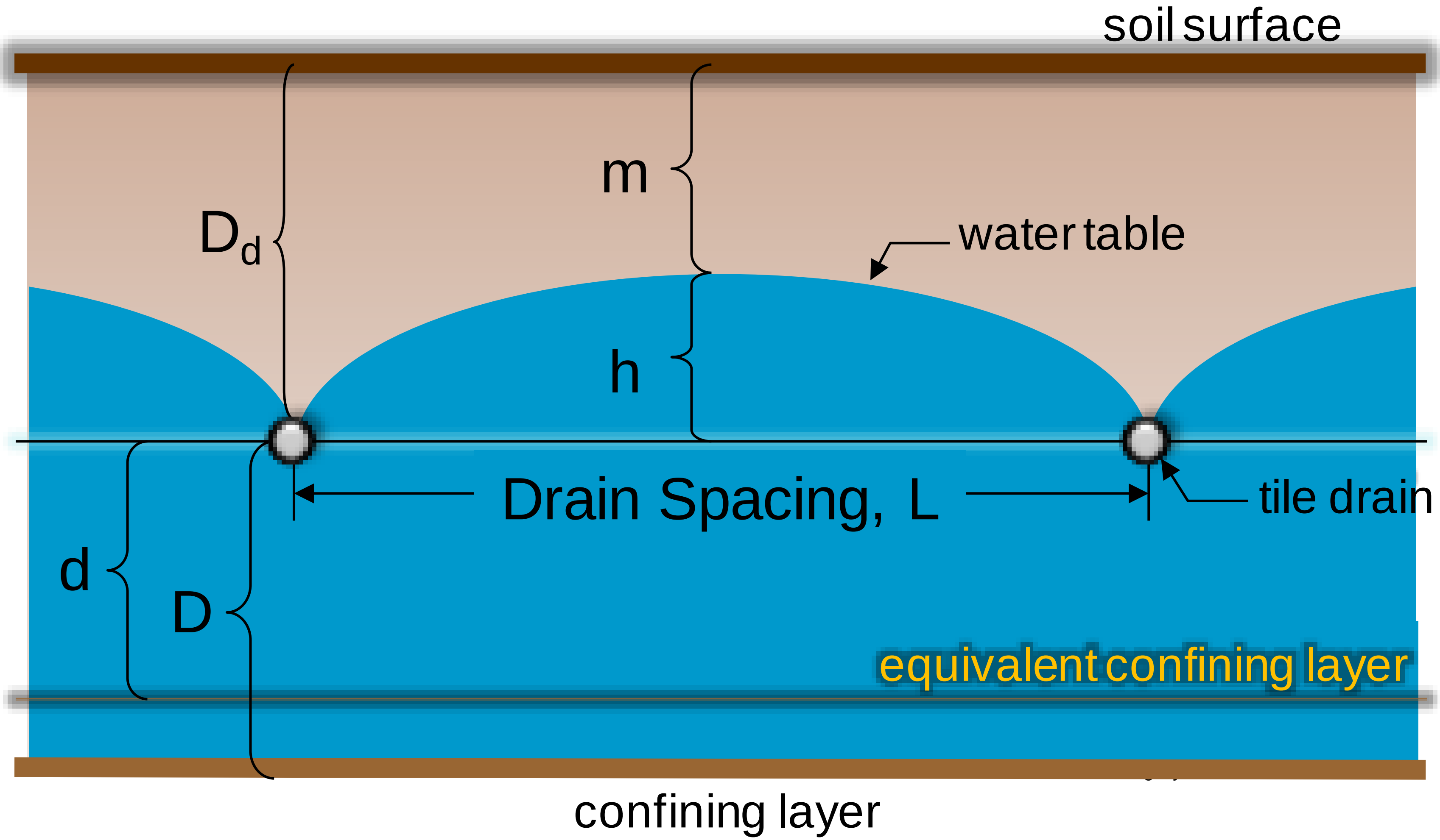


“Optimized” Drainage Design



How do you come up with drain spacing?

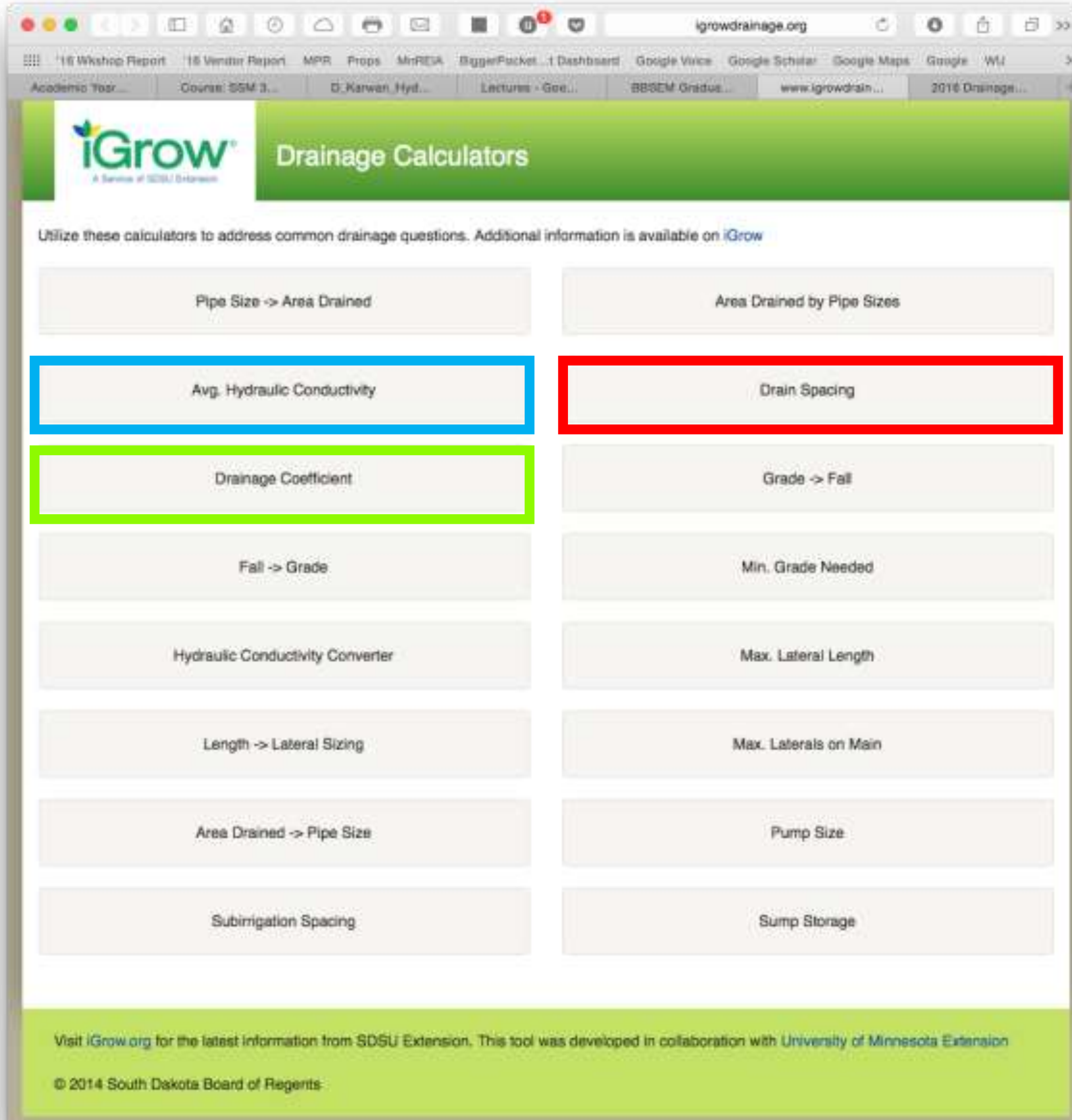
Drain Spacing Equation

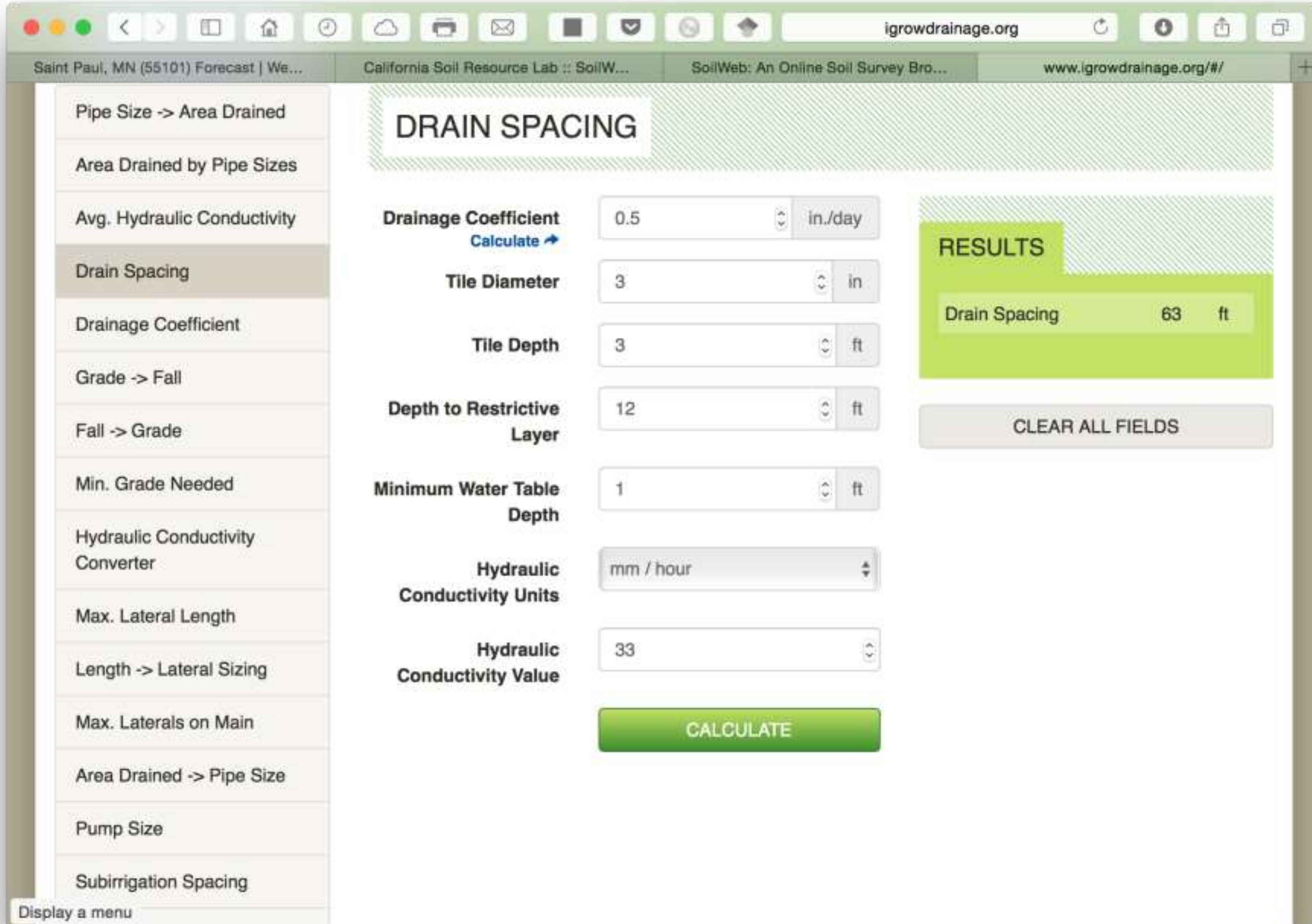


Estimating Drain Spacing: SDSU/U of M

Drainage Calculators

igrowdrainage.org



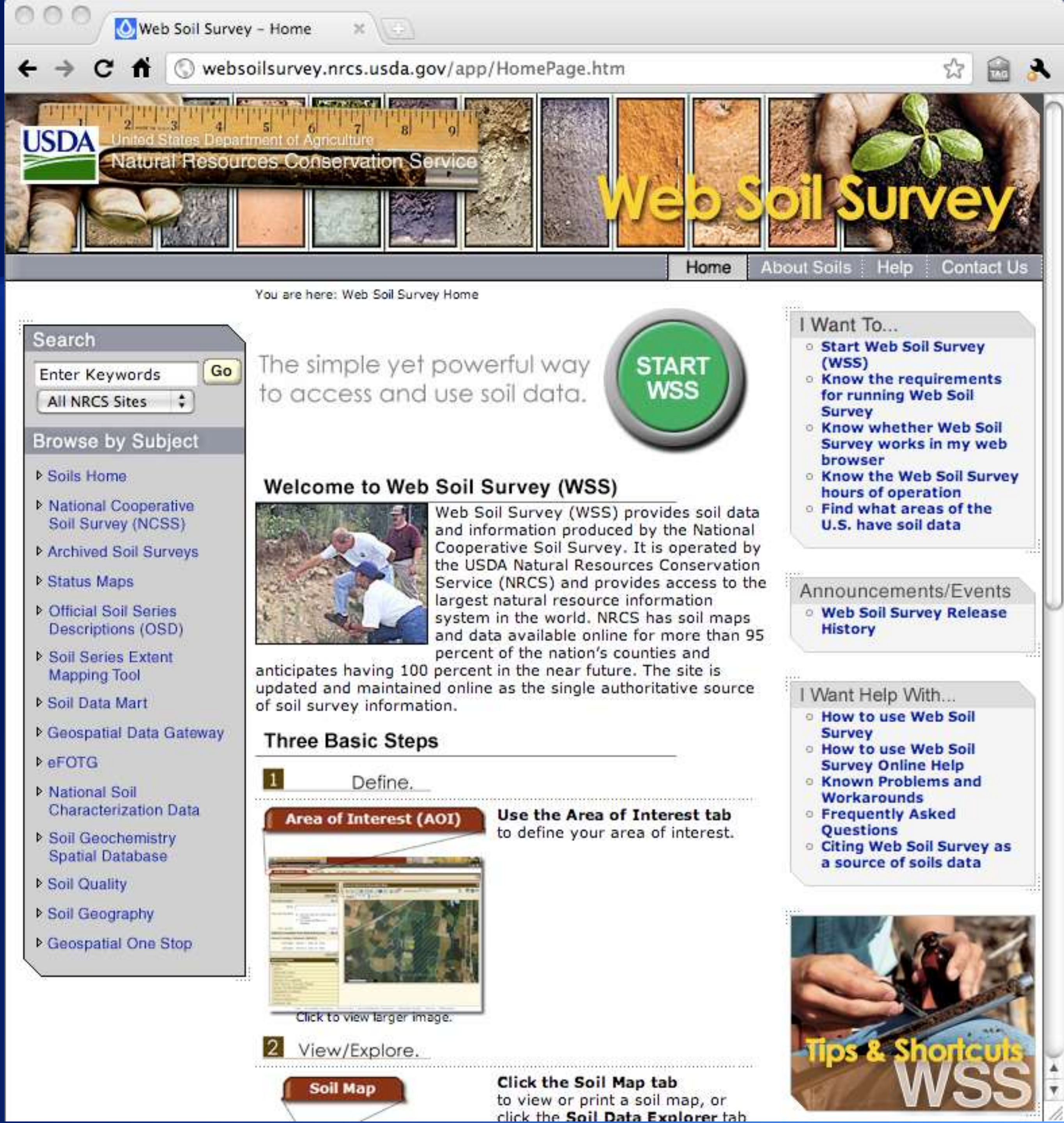

igrowdrainage.org
Saint Paul, MN (55101) Forecast | We...
California Soil Resource Lab :: SoilW...
SoilWeb: An Online Soil Survey Bro...
www.igrowdrainage.org/#/
Pipe Size -> Area Drained
Area Drained by Pipe Sizes
Avg. Hydraulic Conductivity
Drain Spacing
Drainage Coefficient
Grade -> Fall
Fall -> Grade
Min. Grade Needed
Hydraulic Conductivity Converter
Max. Lateral Length
Length -> Lateral Sizing
Max. Laterals on Main
Area Drained -> Pipe Size
Pump Size
Subirrigation Spacing
Display a menu
DRAIN SPACING
Drainage Coefficient
Calculate
0.5
in./day
Tile Diameter
3
in
Tile Depth
3
ft
Depth to Restrictive Layer
12
ft
Minimum Water Table Depth
1
ft
Hydraulic Conductivity Units
mm / hour
Hydraulic Conductivity Value
33
CALCULATE
RESULTS
Drain Spacing
63
ft
CLEAR ALL FIELDS

Resources for Soils Data

- NRCS Web Soil Survey
- Soilweb (ARS) (www, Google Earth, smartphone)
- Illinois Online Drainage Guide (U of IL)

Web Soil Survey

Home Page



USDA United States Department of Agriculture

NRCS Natural Resources Conservation Service

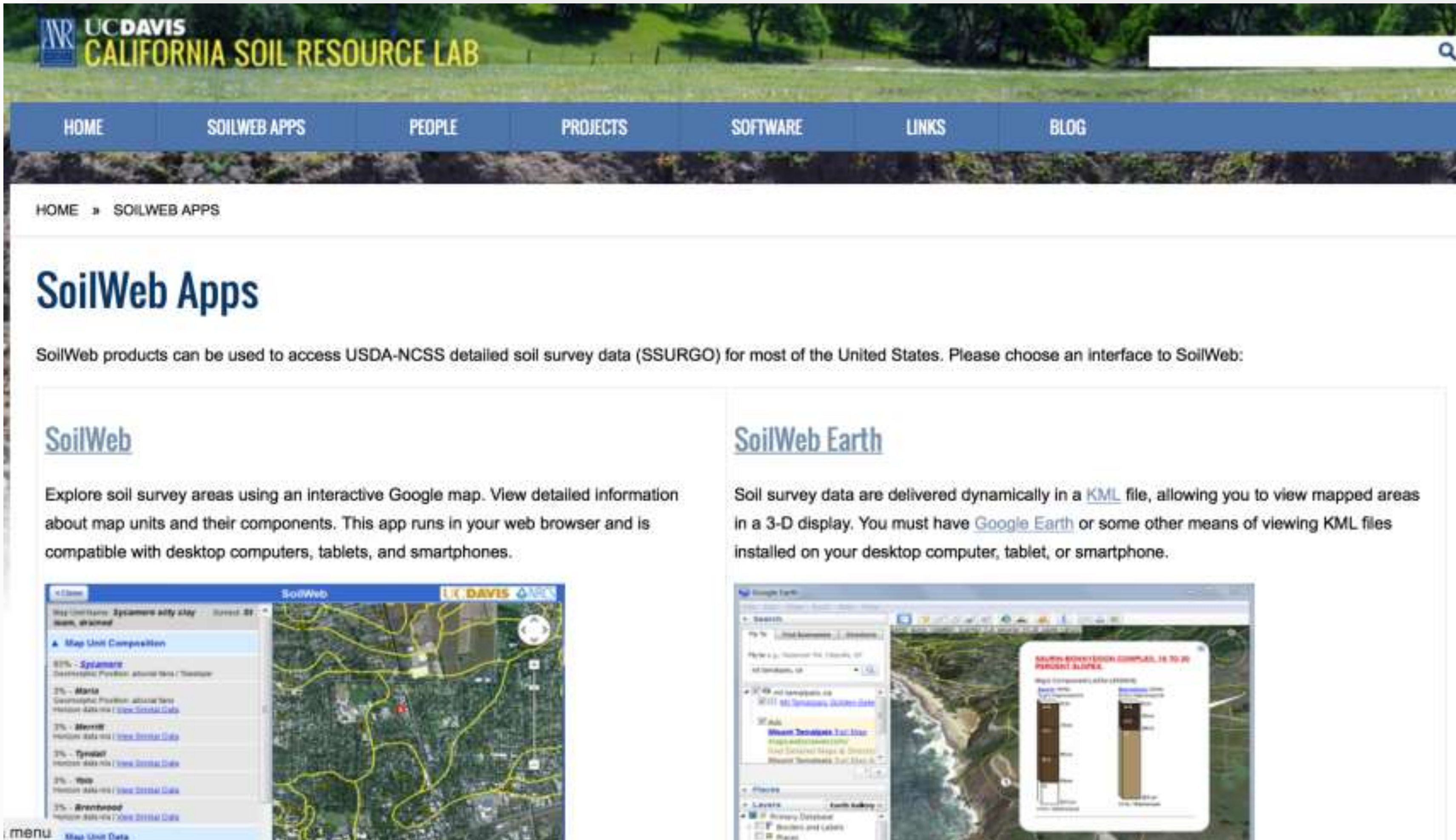
A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants

Custom Soil Resource Report for
Waseca County, Minnesota

March 25, 2013

Soilweb:

http://casoilresource.lawr.ucdavis.edu/soilweb-apps



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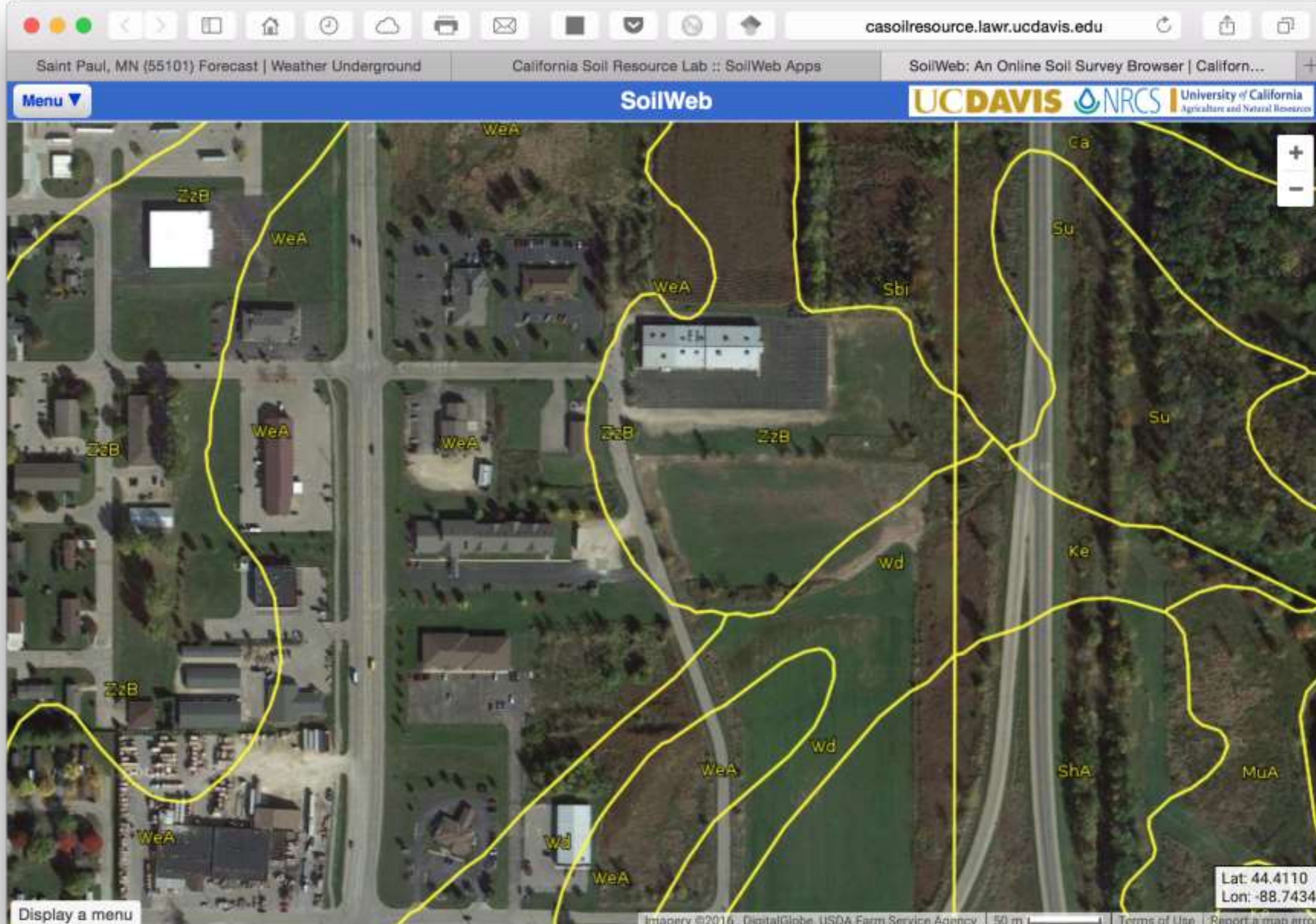

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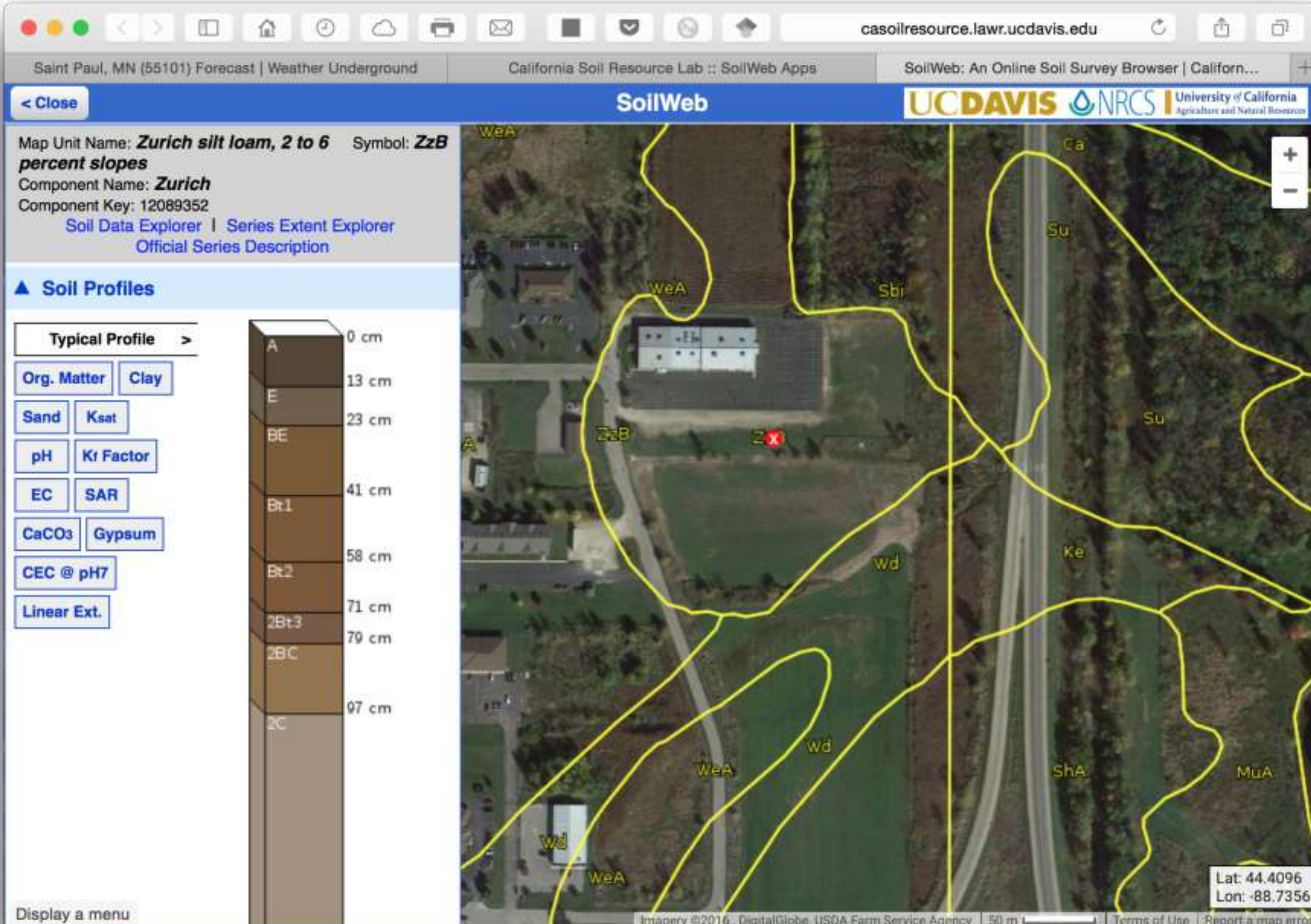

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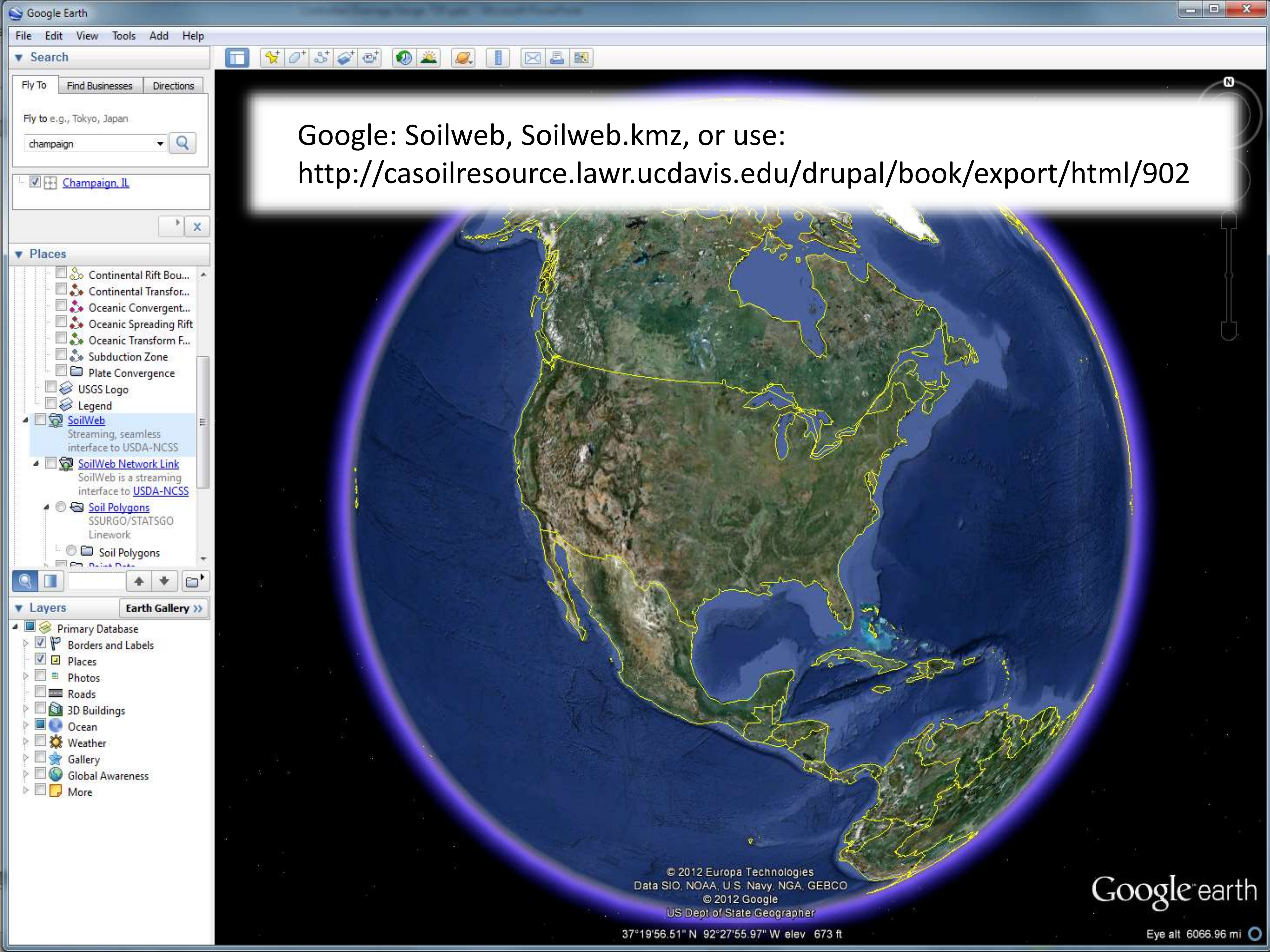
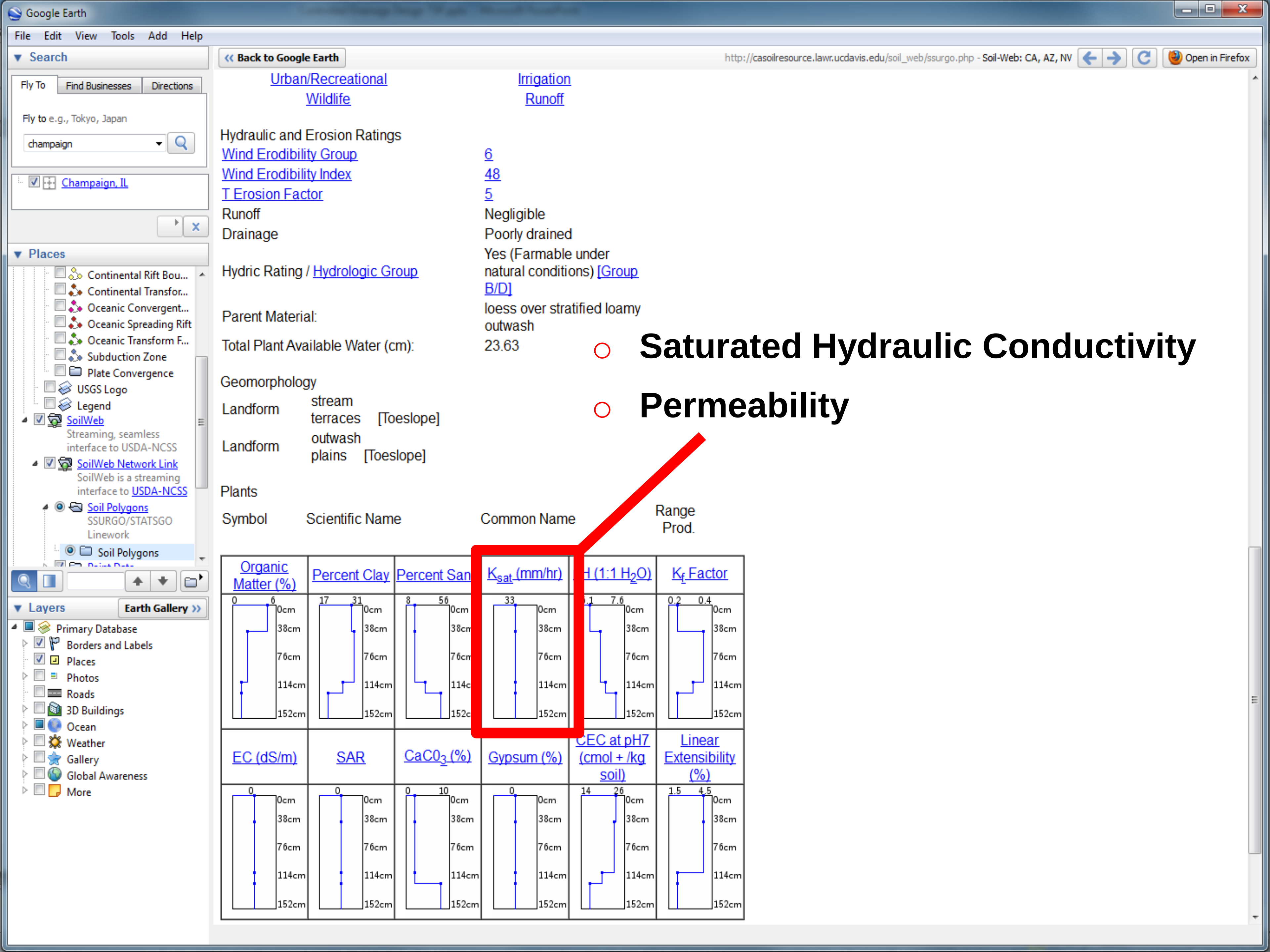
Google: Soilweb, Soilweb.kmz, or use:
http://casoilresource.lawr.ucdavis.edu/drupal/book/export/html/902

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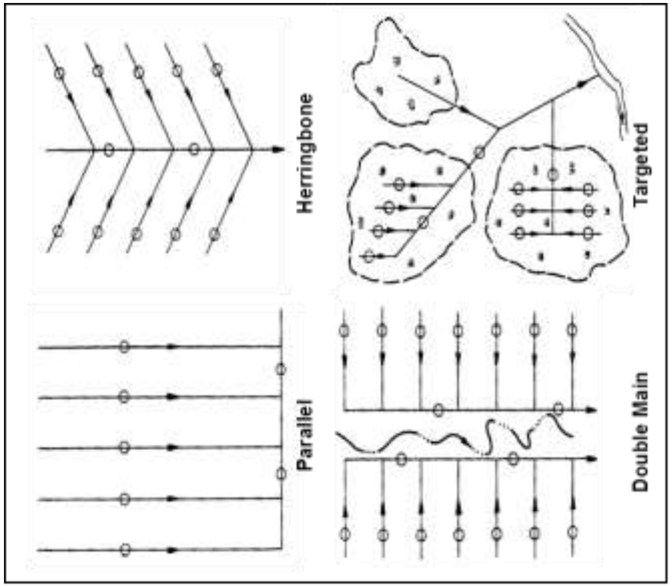
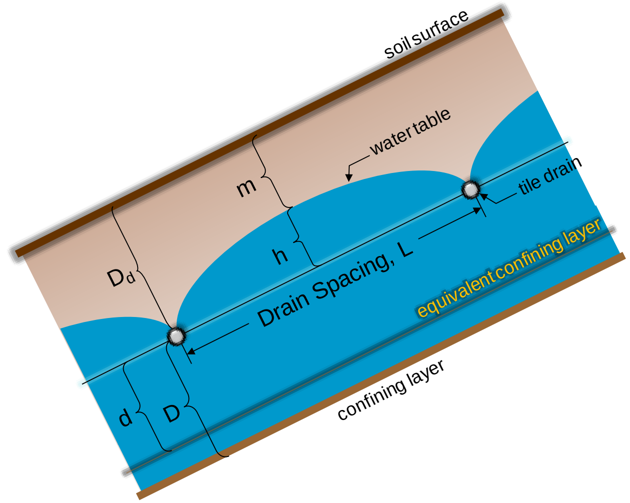
Directions
Fly to e.g., Tokyo, Japan
champaign
Champaign, IL
Places
Continental Rift Bou...
Continental Transfor...
Oceanic Convergent...
Oceanic Spreading Rift
Oceanic Transform F...
Subduction Zone
Plate Convergence
USGS Logo
Legend
SoilWeb
Streaming, seamless interface to USDA-NCSS
SoilWeb Network Link
SoilWeb is a streaming interface to USDA-NCSS
Soil Polygons
SSURGO/STATSGO Linework
Soil Polygons
Layers
Earth Gallery
Primary Database
Borders and Labels
Places
Photos
Roads
3D Buildings
Ocean
Weather
Gallery
Global Awareness
More
Back to Google Earth
http://casoilresource.lawr.ucdavis.edu/soil_web/ssurgo.php - Soil-Web: CA, AZ, NV
Open in Firefox
Urban/Recreational
Irrigation
Wildlife
Runoff
Hydraulic and Erosion Ratings
Wind Erodibility Group 6
Wind Erodibility Index 48
T Erosion Factor 5
Runoff Negligible
Drainage Poorly drained
Hydric Rating / Hydrologic Group Yes (Farmable under natural conditions) [Group B/D]
Parent Material: loess over stratified loamy outwash
Total Plant Available Water (cm): 23.63
Geomorphology
Landform stream terraces [Toeslope]
Landform outwash plains [Toeslope]
Plants
Symbol
Scientific Name
Common Name
Range Prod.
Organic Matter (%)
Percent Clay
Percent San
Ksat (mm/hr)
H (1:1 H2O)
Kf Factor
EC (dS/m)
SAR
CaC03 (%)
Gypsum (%)
CEC at pH7 (cmol + /kg soil)
Linear Extensibility (%)
Saturated Hydraulic Conductivity
Permeability



Drainage system layout & design is about matching field topo with desired drain grades and depths so system works well and is economical!

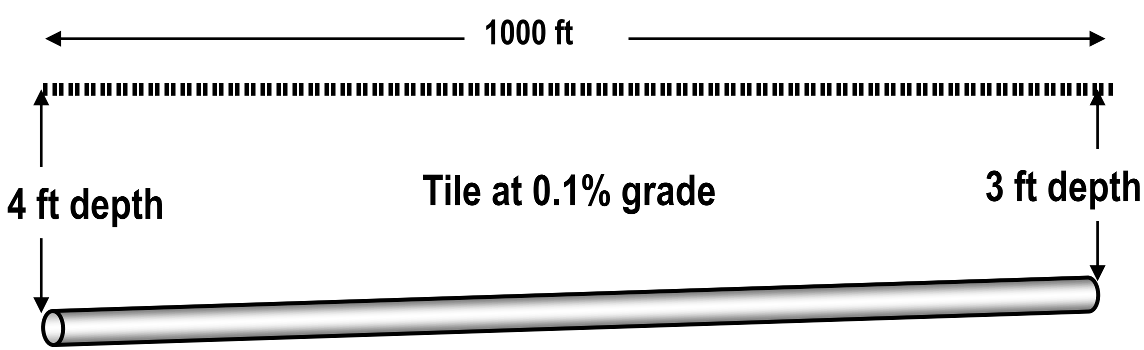
Drain Layout, Grades & Depths



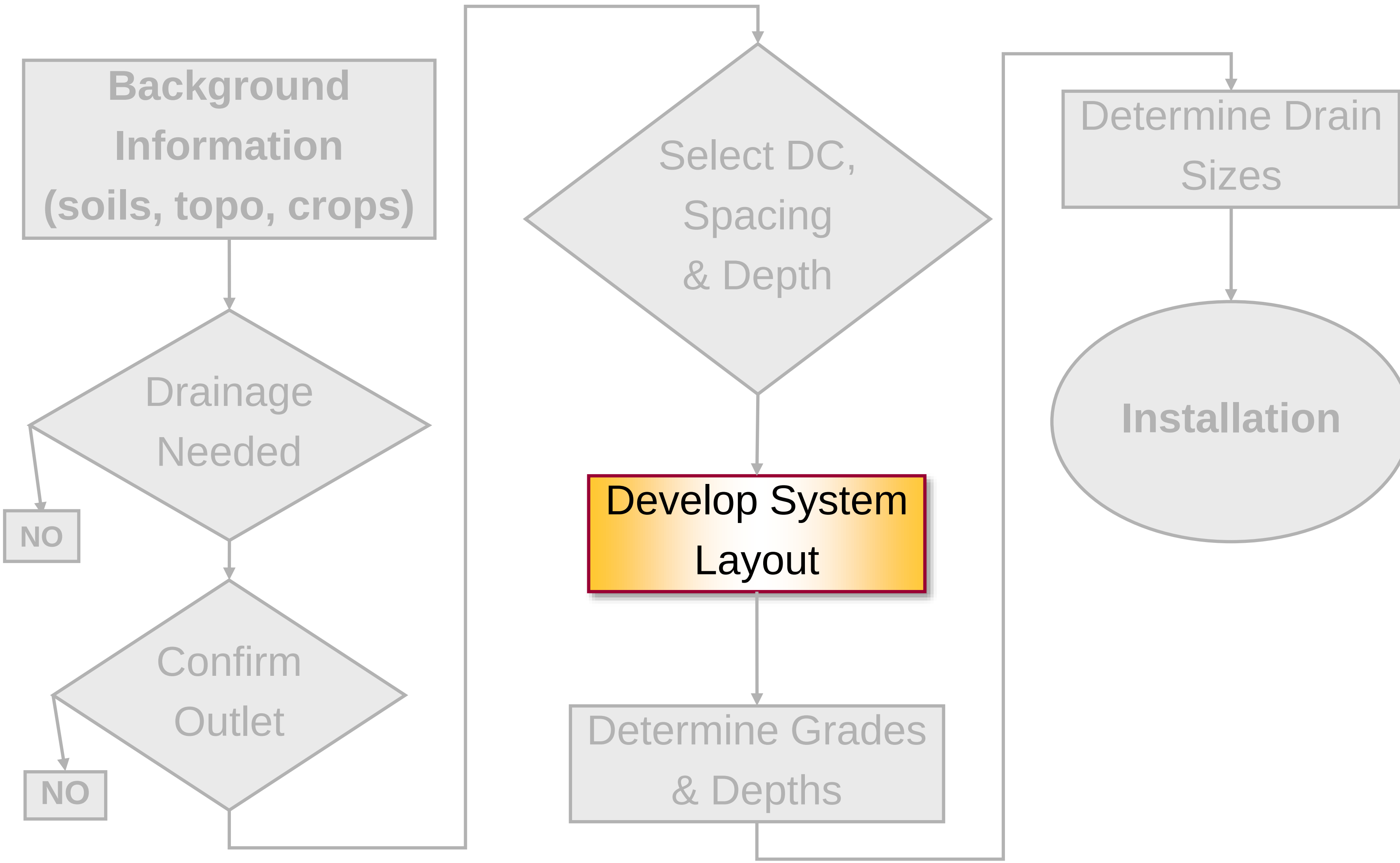
DRAINAGE DEPTH:
GOING FOR UNIFORMITY

Drain Depth

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

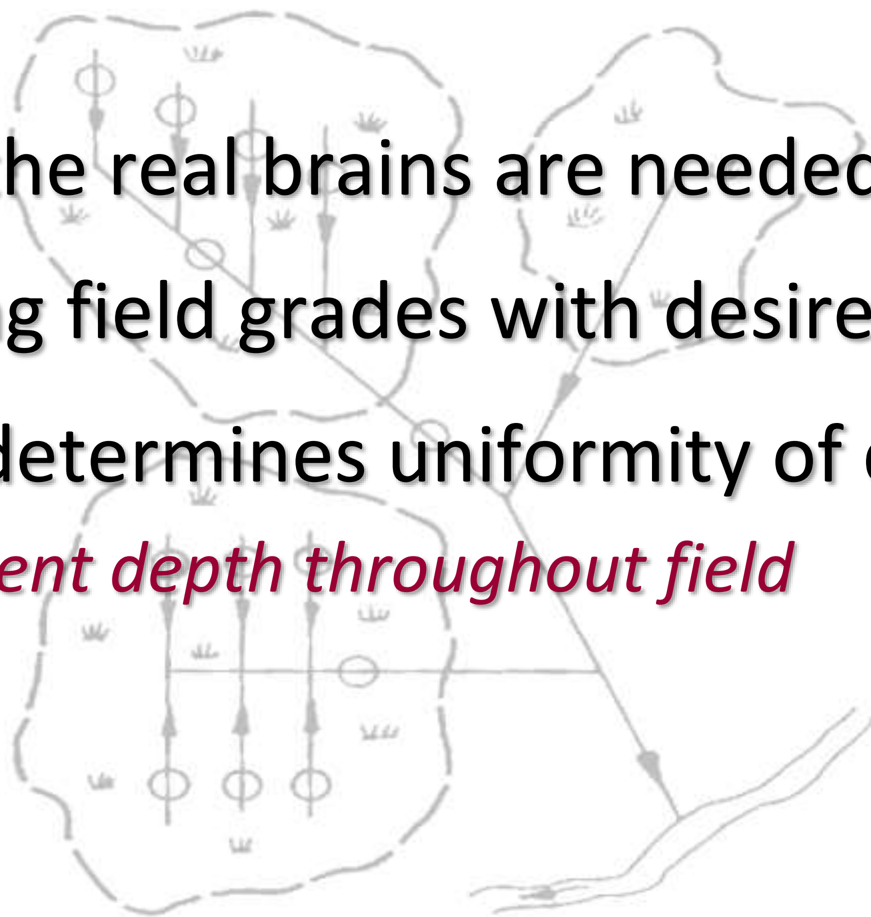


Design Process Flowchart

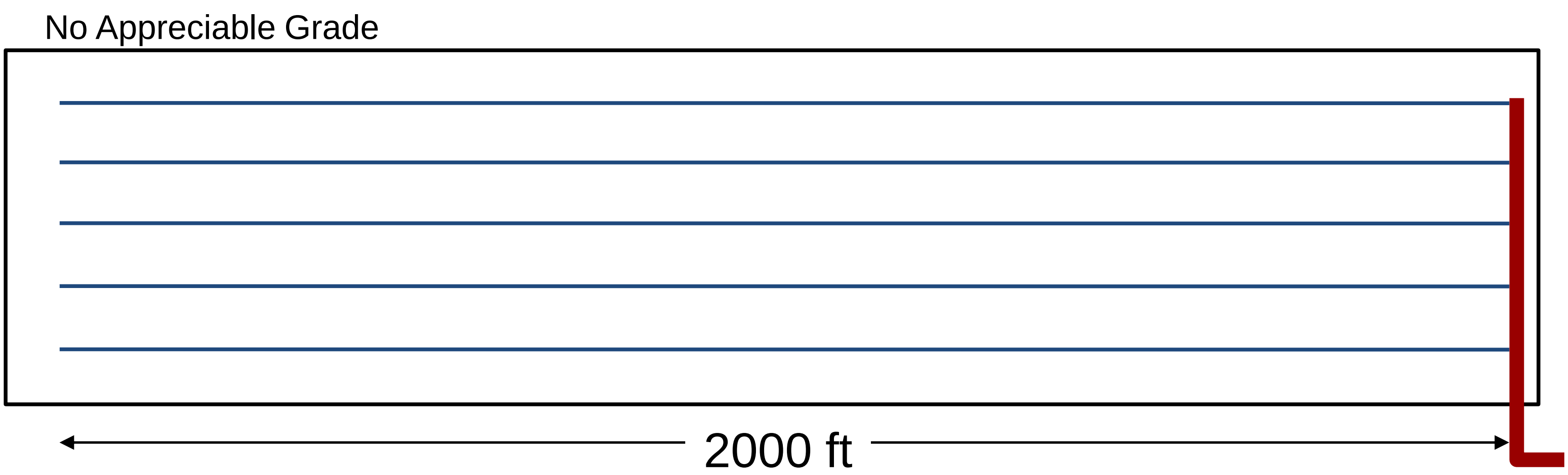


Layout

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

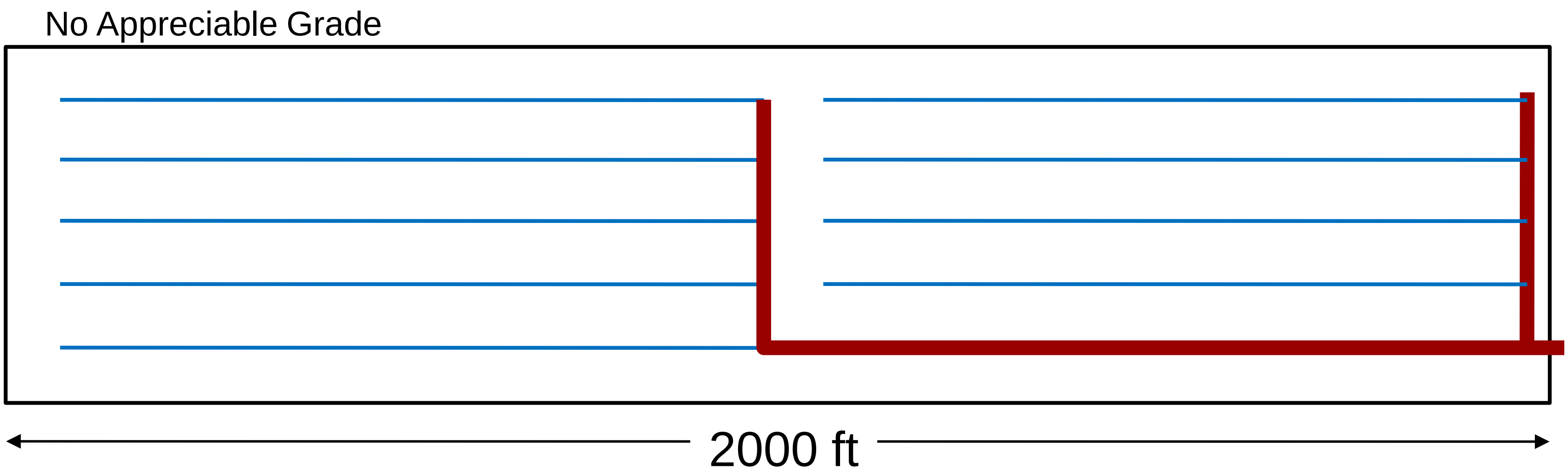


Uniform Drainage Example: Long Fields



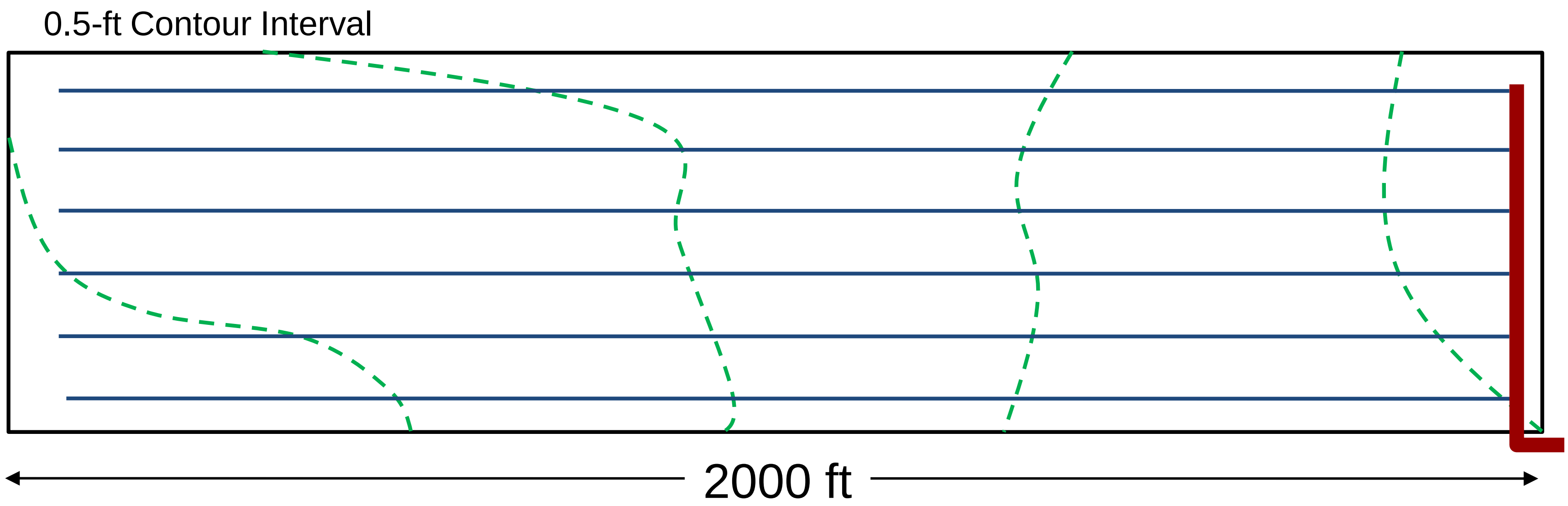
- 2000-ft laterals:
  - *@ 0.08%   = 1.6 ft of fall*
  - *@ 0.1 %   = 2.0 ft of fall*

Possible Solution for Long Fields



- Split the feet of fall in half
- More uniform drainage coefficient
- Yes, more connections and feet of collector (but collectors are smaller)

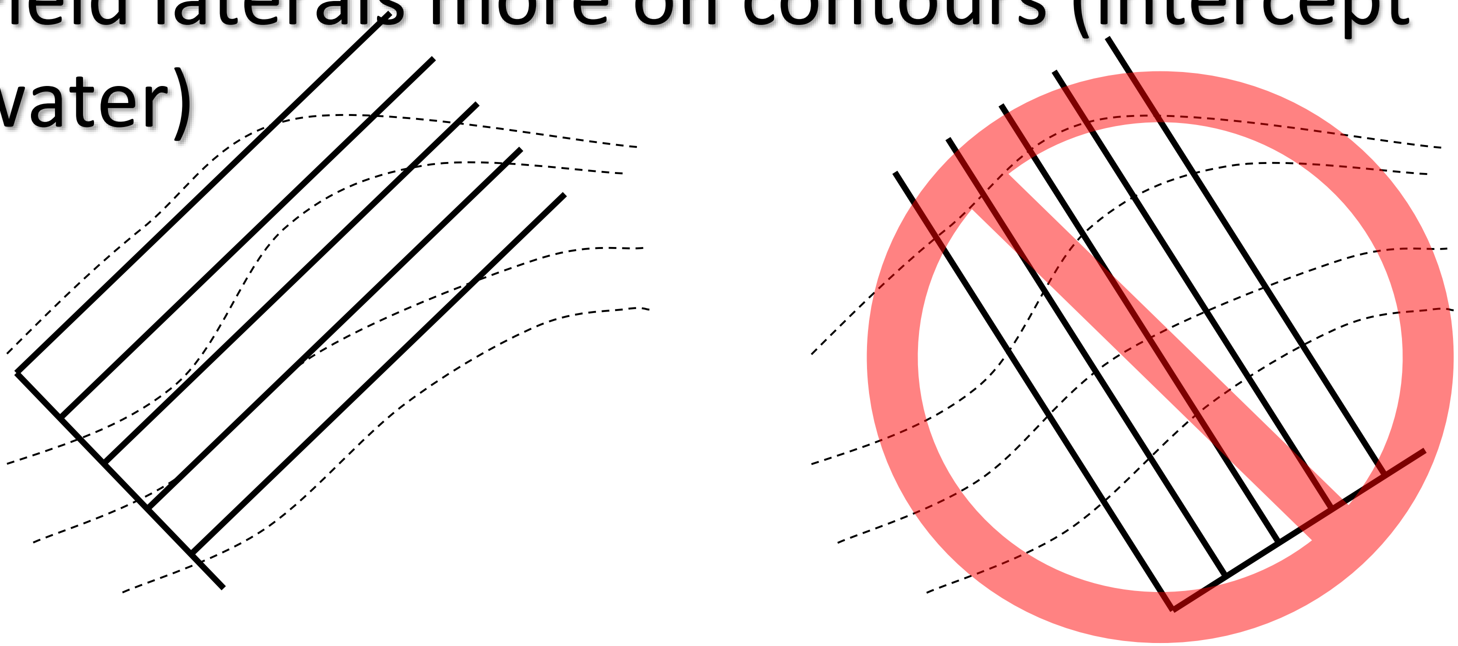
Another Example: Long Fields



- Natural field grade is 2.0 ÷ 2000 × 100% = 0.1%
- Easy to keep laterals at uniform depth and maintain plenty of grade

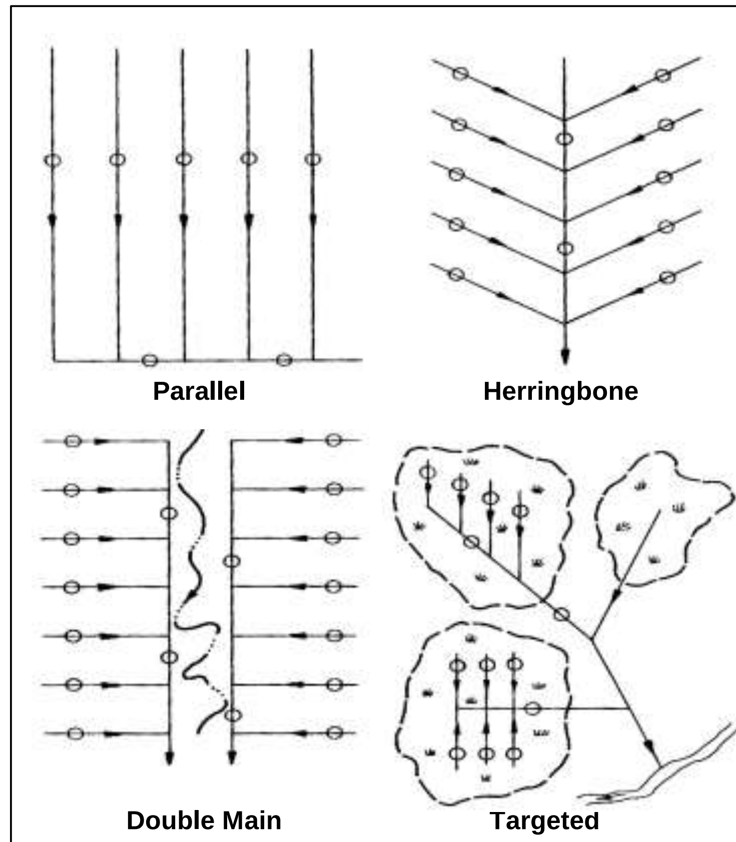
Layout

- 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)

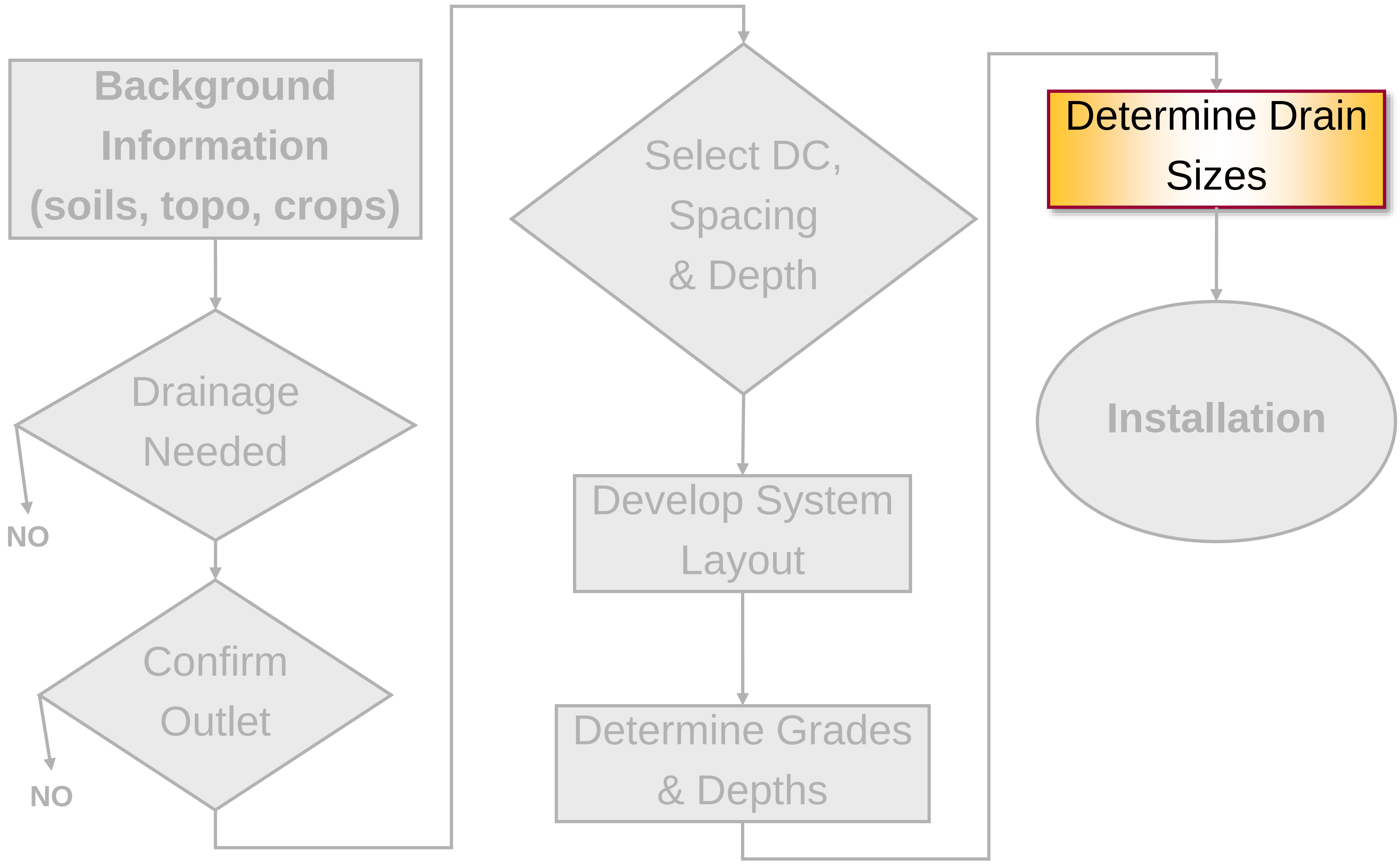


Layout

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



Design Process Flowchart



Drain Sizing

To determine tile capacity, we need:

- ❑ Grade (get from layout)
- ❑ Material (we choose)
- ❑ Pipe Size (what we're after)

Design Tools

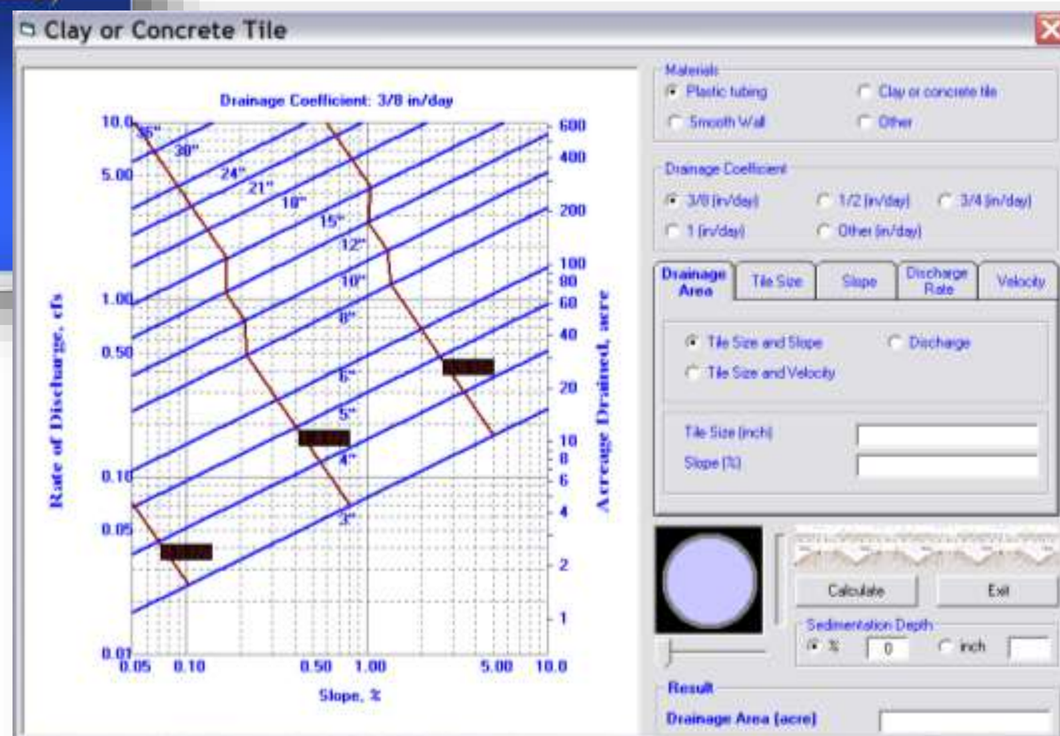
Design Tools

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

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

Design Tools

Design Tools (cont.)



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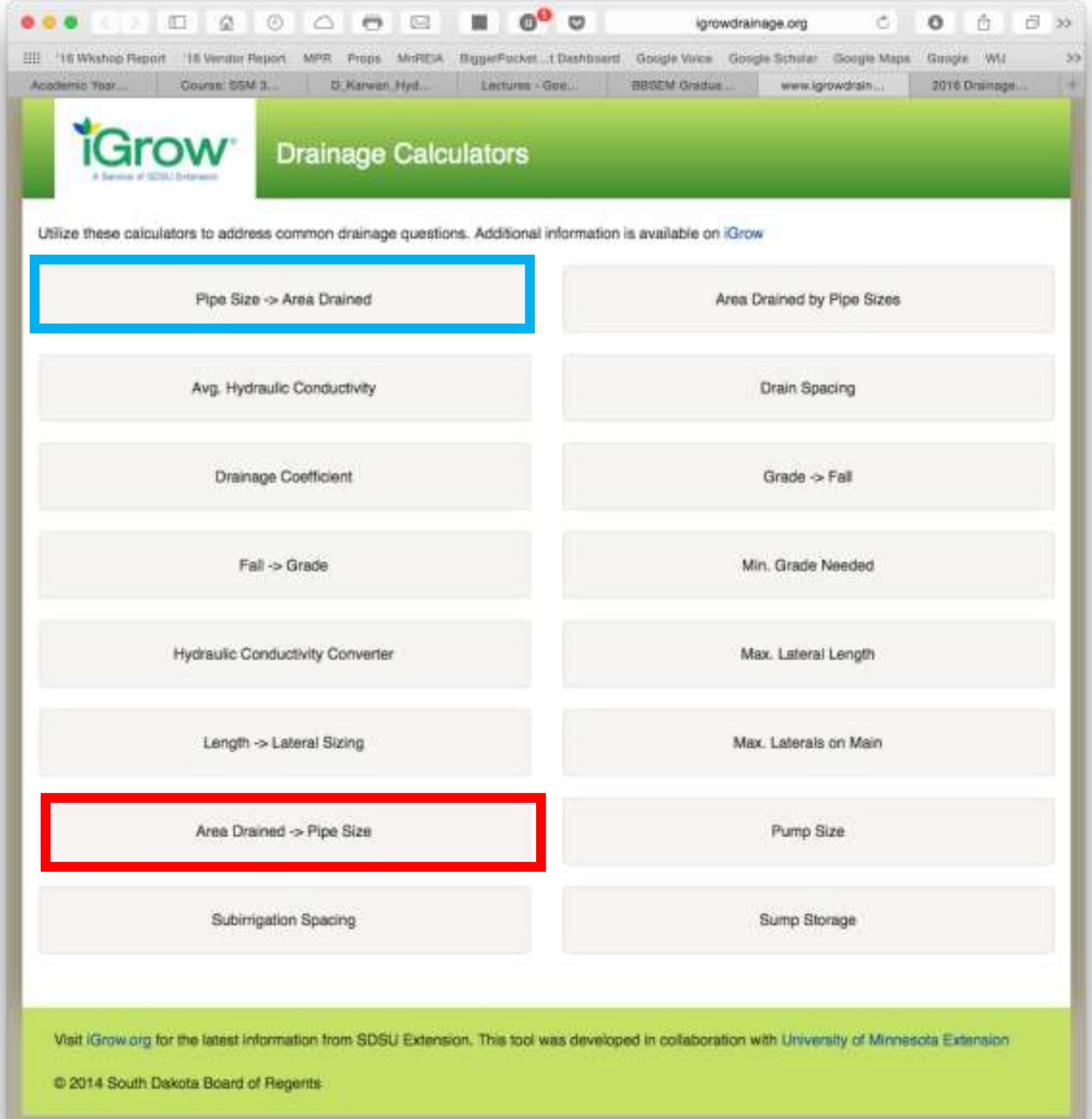
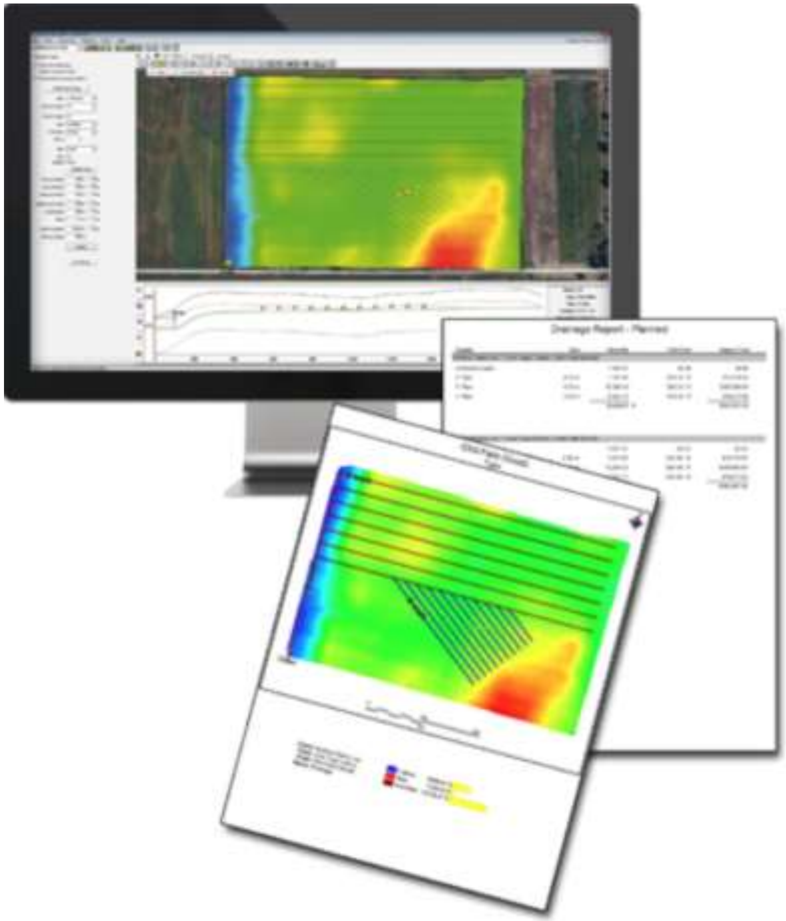
igrowdrainage.org

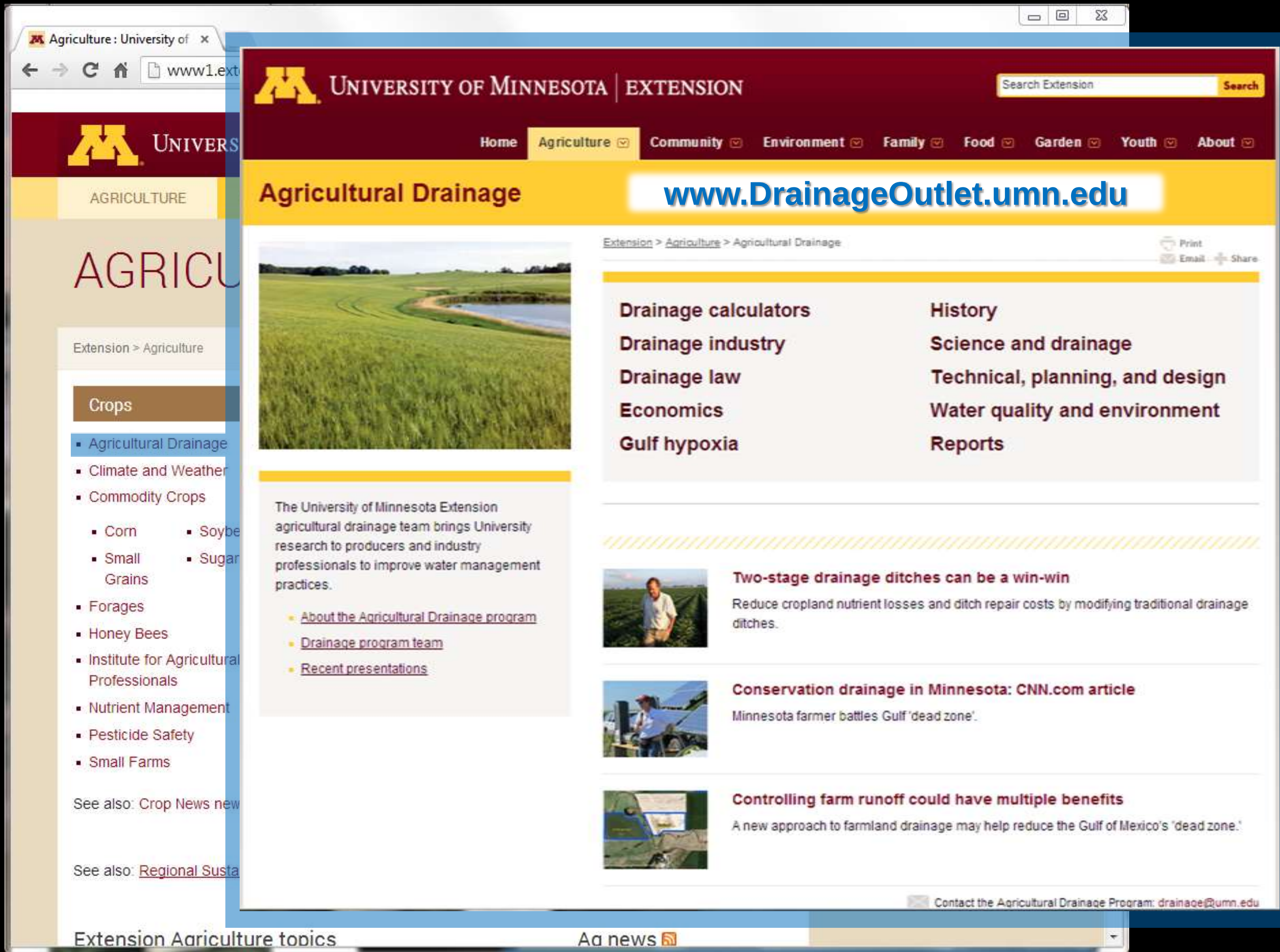


Computer-aided Design



Extension Drainage Publications

University of Minnesota Extension
www.extension.umn.edu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The University of Minnesota Extension agricultural drainage team brings University research to producers and industry professionals to improve water management practices.
About the Agricultural Drainage program
Drainage program team
Recent presentations
Two-stage drainage ditches can be a win-win
Reduce cropland nutrient losses and ditch repair costs by modifying traditional drainage ditches.
Conservation drainage in Minnesota: CNN.com article
Minnesota farmer battles Gulf 'dead zone'.
Controlling farm runoff could have multiple benefits
A new approach to farmland drainage may help reduce the Gulf of Mexico's 'dead zone.'
Contact the Agricultural Drainage Program: drainage@umn.edu

Take Home Points

- Be safe in the field (esp. trench safety)!
- Be kind to your neighbors
- Generally, state laws support drainage, but there are limits
- Drainage spacing may be the hardest and the most important decision; layout comes next
- Make your drainage systems function as uniformly as possible
- Design with conservation drainage in mind
- Drainage isn't rocket science, but there is plenty of room for excellence!
- If going to self-install, walk before you run!


Questions?