Design II

Comprehensive Drainage Design Problem

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“Concern for man himself and his fate must form the chief interest for all technical endeavors. Never forget this in the midst of your diagrams and equations.”

- *Albert Einstein*

Drainage Design Problem

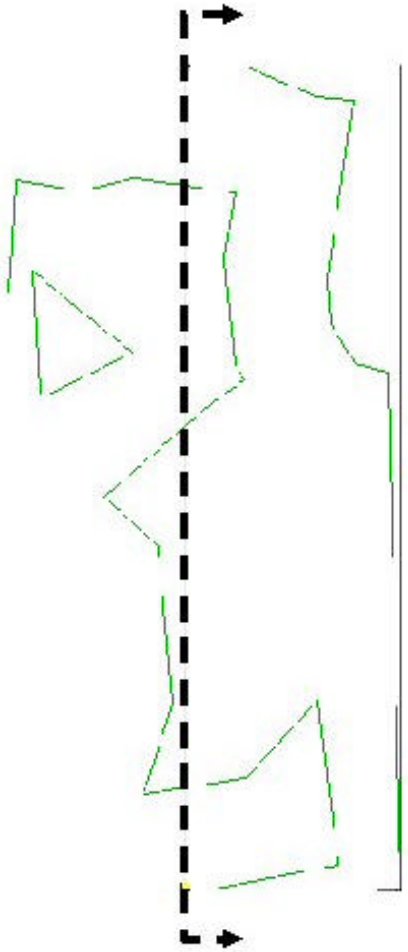
- Introduction
- Drainage System Layout
- Drainage Coefficient & Spacing
- Grade of main and laterals
- Pipe sizing – main
- Pipe sizing – laterals

Drainage Design Problem

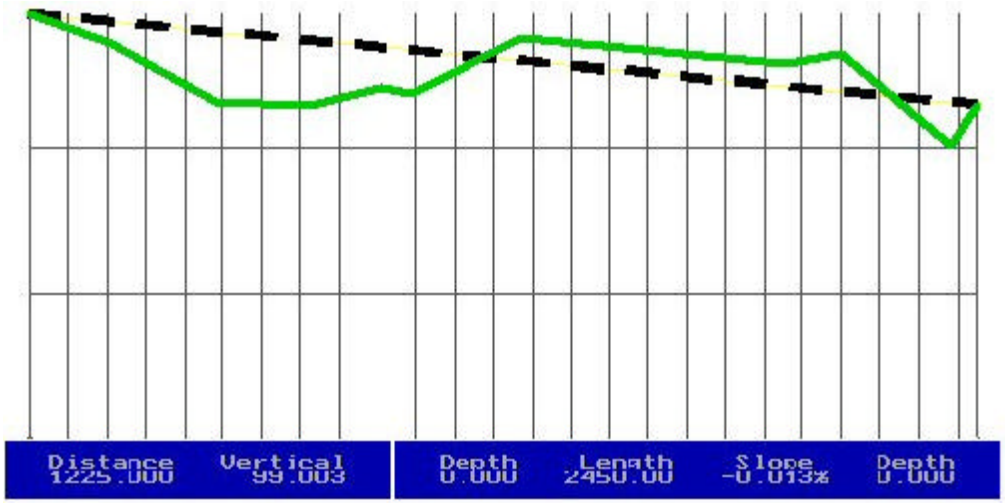
- Introduction ➔ overheads
  - Field, topo and site characteristics
  - Outlet considerations
  - Value of a topo map
- Layout Options
  - What are the layout options for this field? Advantages/disadvantages?
  - What if there were other obstacles in field (farm-place)?
  - What if the outlet had to be in a different location?

System Layout

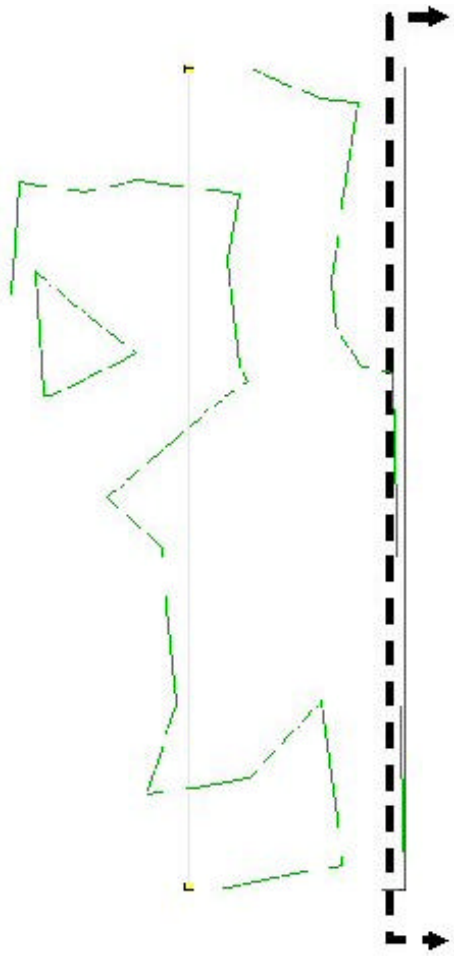
Evaluate Overall Field Grade



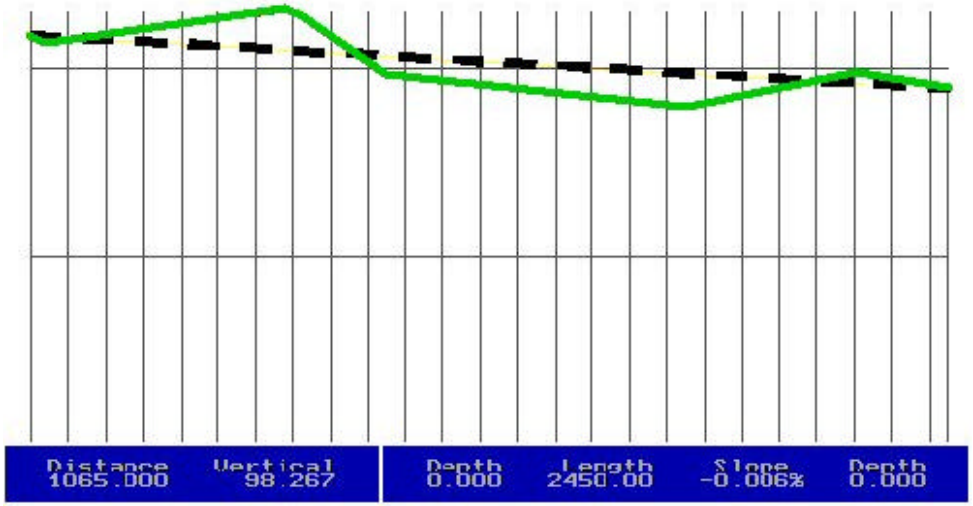
.013% GRADE



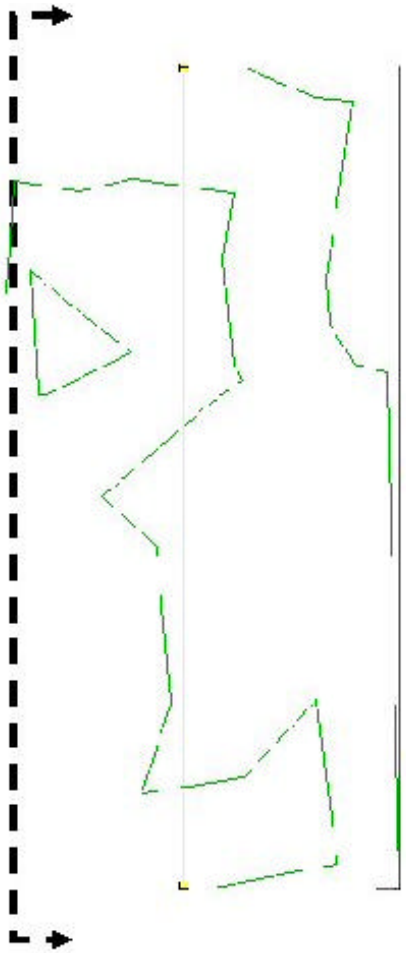
Field Grade (cont.)



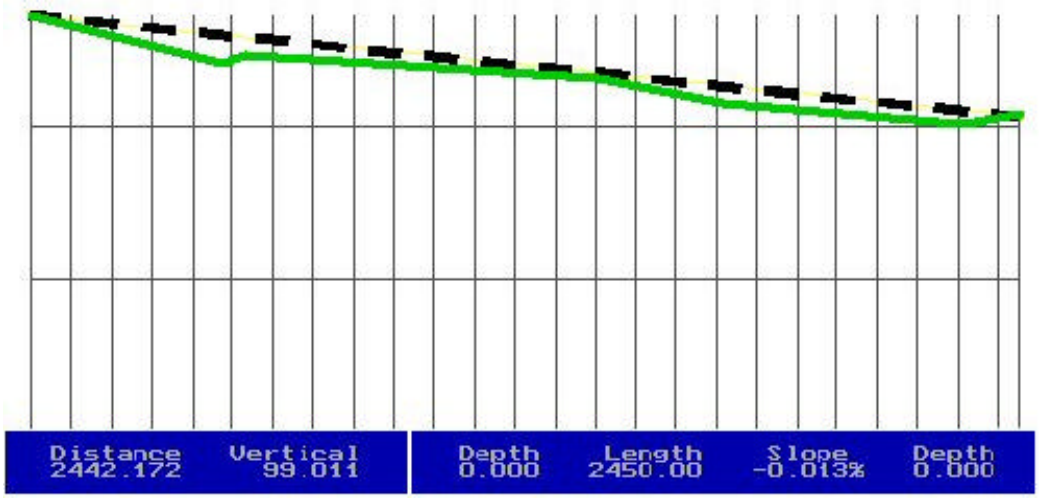
.006% GRADE



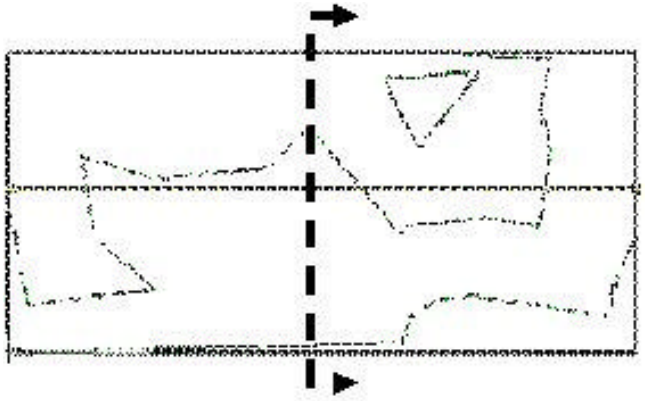
Field Grade (cont.)



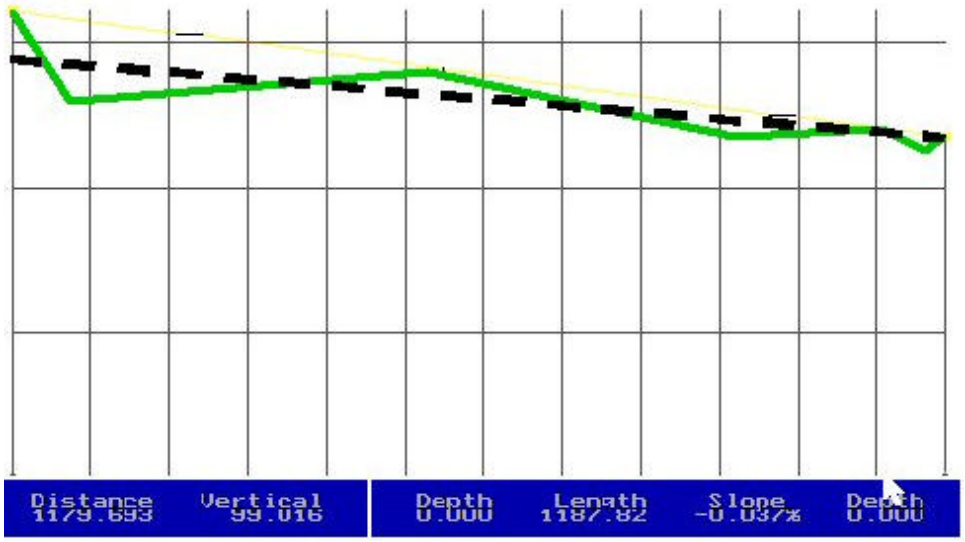
.013% GRADE



Field Grade (cont.)



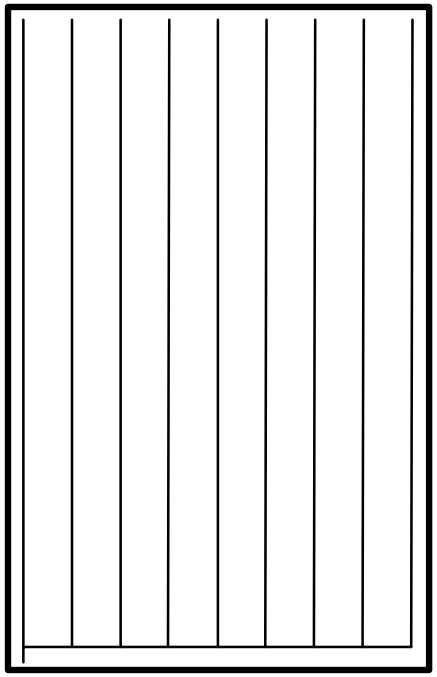
.021% GRADE



Layout Options

1. What are the layout options?
   - Sketch ideas on your field drawing
2. N-S laterals running full length of field, with E-W main
3. N-S laterals, split at mid-field, with 2 E-W mains
4. E-W laterals with N-S main

Field-length Lateral Design



- Advantages
  - fewest junctions (hookups)
  - Longer runs (less installation time)
- Disadvantages
  - more (too much) depth variation per lateral (next slide)

How much fall in a 2500-ft. lateral?

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

or;

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

- Calculate the answer for .05%, .06%, .07%, .08% and 0.1%

% Grade	.05%	.06%	.07%	.08%	0.1%
Ft. of Fall					

How much fall in a 2500-ft. lateral?

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

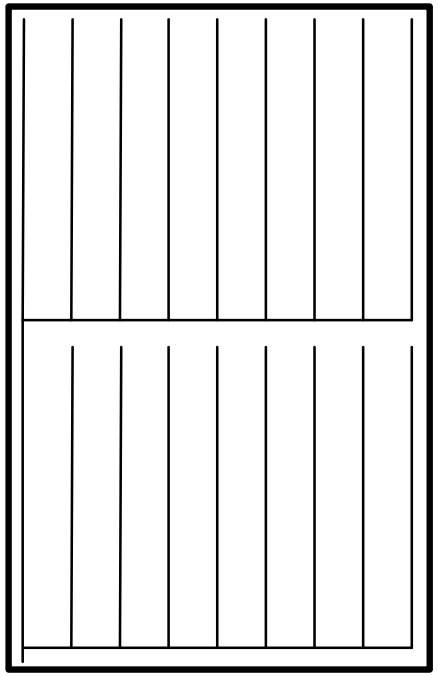
- Calculate the answer for .05%, .06%, .07%

or;

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

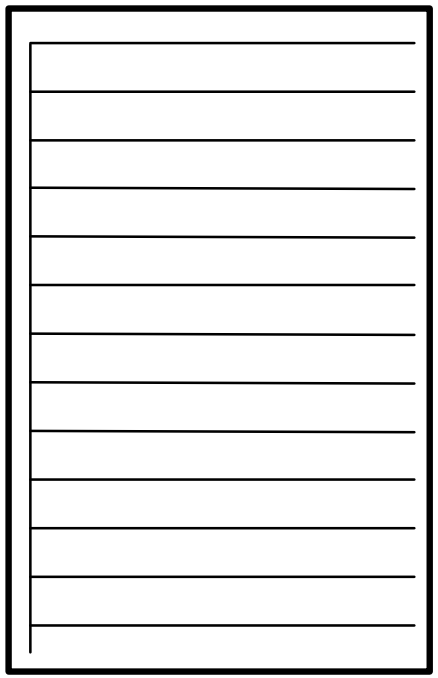
% Grade	.05%	.06%	.07%	.08%	0.1%
Ft. of Fall	$\frac{.05 \times 2500}{100} = 1.25$	1.5 ft	1.75 ft	2 ft	2.5 ft

Split-field Design



- Advantages
  - 1 foot or less of depth variation per lateral
  - this plan becomes even more advantageous on a longer field
- Disadvantages
  - More hookups (junctions)

E-W Laterals



- Advantages
  - More field grade to work with
  - 1 foot or less of depth variation per lateral
  - About same number of hookups as split-field
- Disadvantages
  - More hookups (junctions)
  - Less attractive than split field if field were longer

Drainage Coefficient & Spacing

Selection of Drainage Coefficient

- What would you use?
- I recommend a ? in/day DC
- Know what the implications of your choice are:
  - Higher DC:
    - More capacity
    - Closer-spaced laterals
    - Higher cost
  - Make sure cost is justified

Determine Drain Spacing

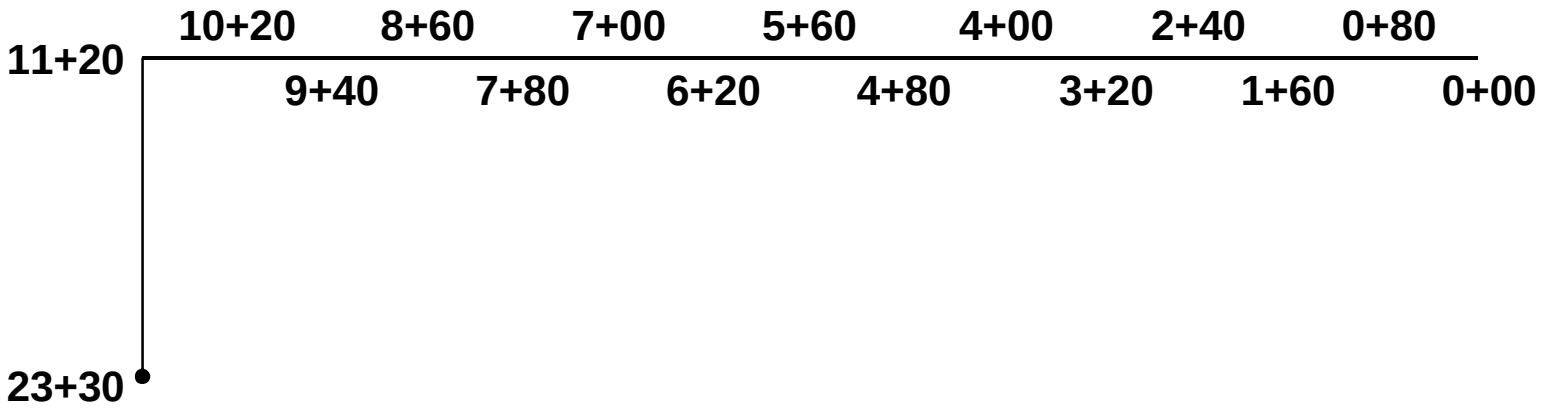
- Lookup Bearden soil in Mn Drainage Guide – handout

Drain Depth	Drainage Coefficient		
	¼ *in/24hrs*	? *in/24hrs*	½ *in/24hrs*
3 ft	**86**	**67**	**56**
4 ft	**112**	**88**	**75**

- Some do 3’ depth, some do 4’depth

Layout of Main

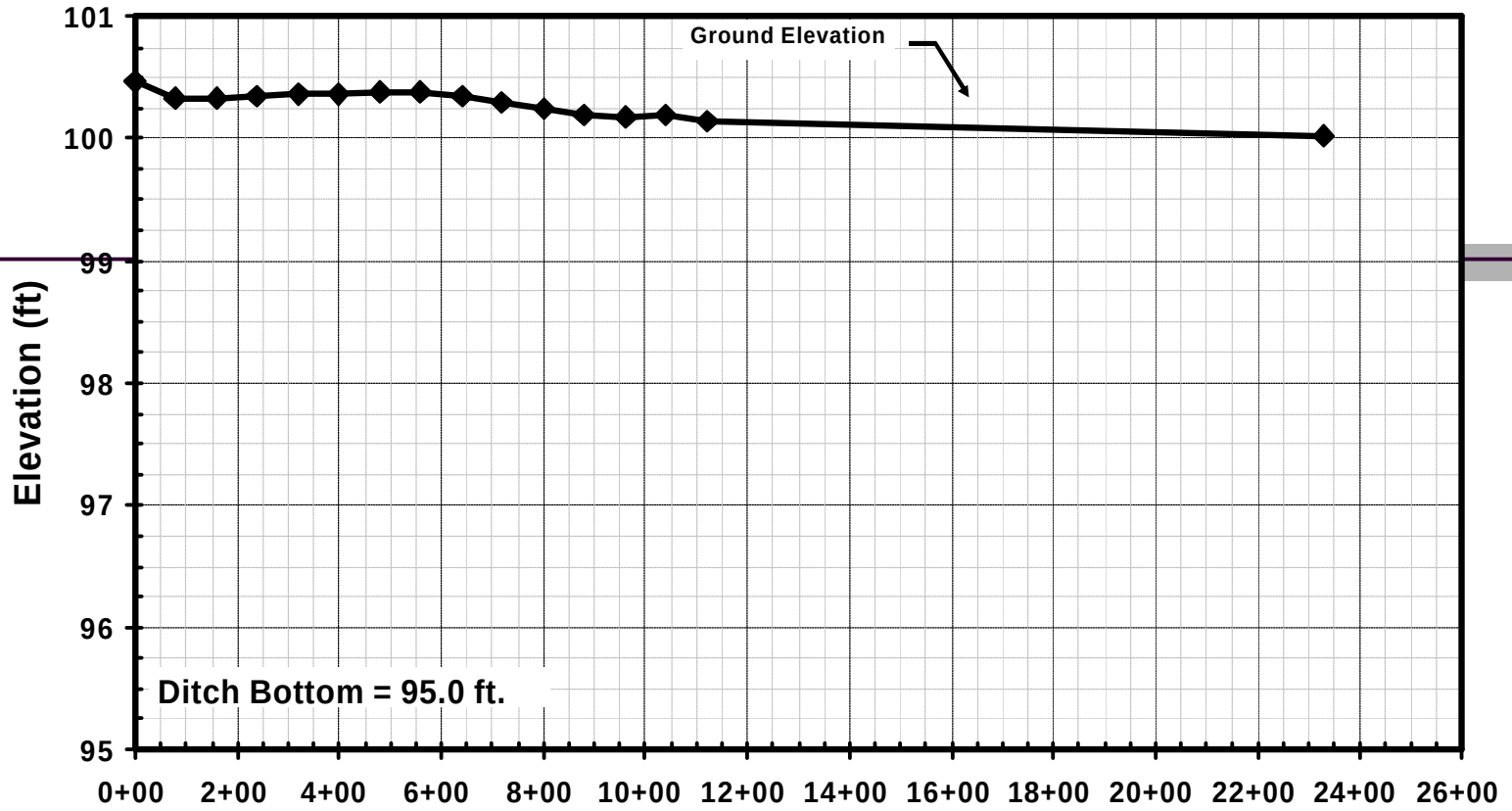
- Choose split field option
- Use the following numbering system for main
- Total length of main is 2330 ft.



Grade

Main Grade

- Goals: Uniform depth, achieve min grades, minimize deep cuts & shallow depths
- Determination of Grade
  - Find acceptable grade on main from surface profile (survey pts.)
  - See profile of shots on main



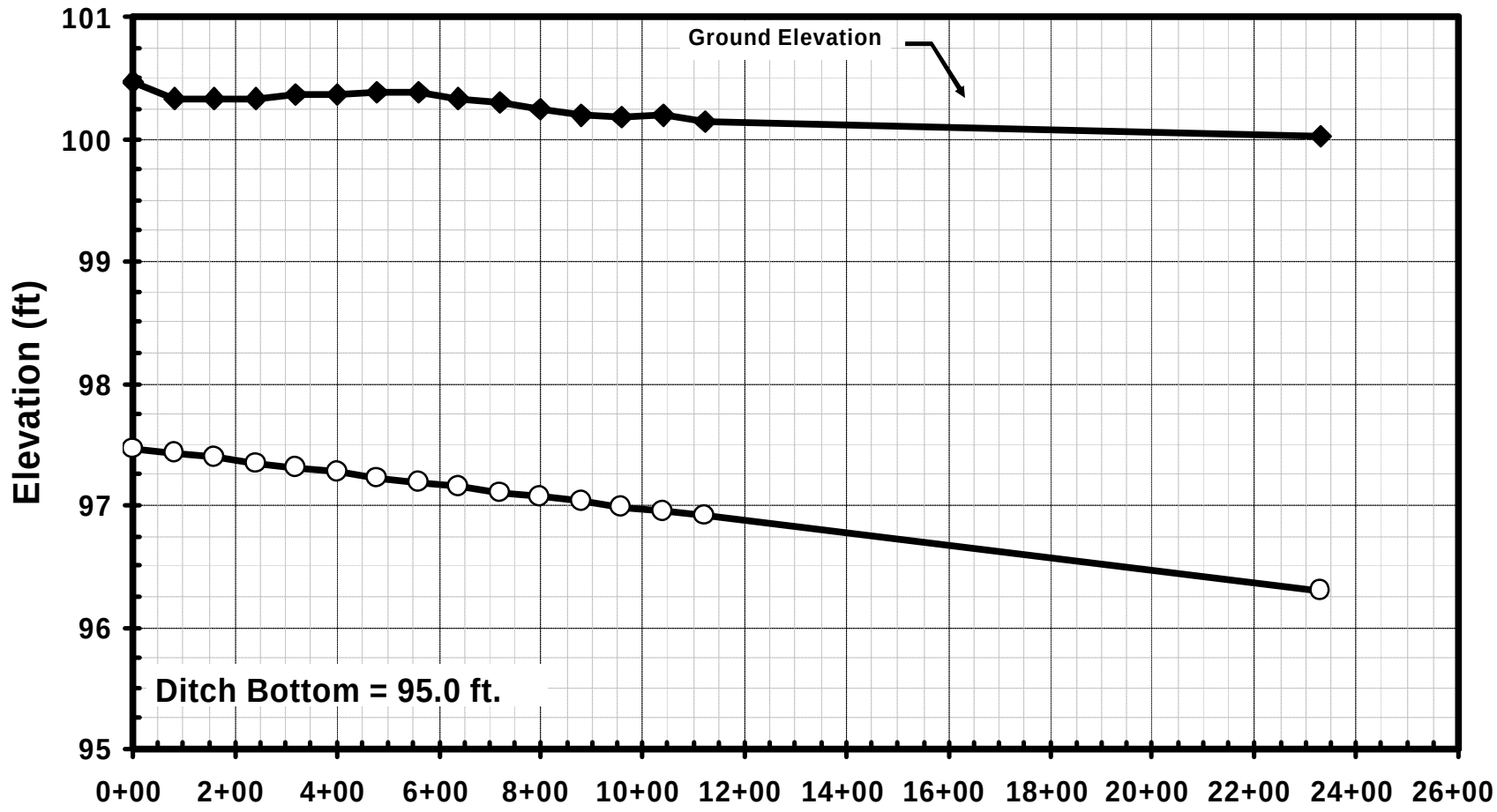
- Ground surface has minimal grade (.02%)
- What should we use for grade of main?
- Establish minimum grade from start to finish

  → select .05% grade for main

Layout of Main (cont.)

- Total length of main = 2330 ft.
- Calc. feet of fall on main:
  - Fall = Length x Slope ÷ 100%
  - 2,330 x .05 100% = 1.17ft. or 1’-2”
  - Need to establish cuts along main and depth at outlet
- Do cut sheet for main (where do you want to start/stop for depth?
- ➔ OH, Excel

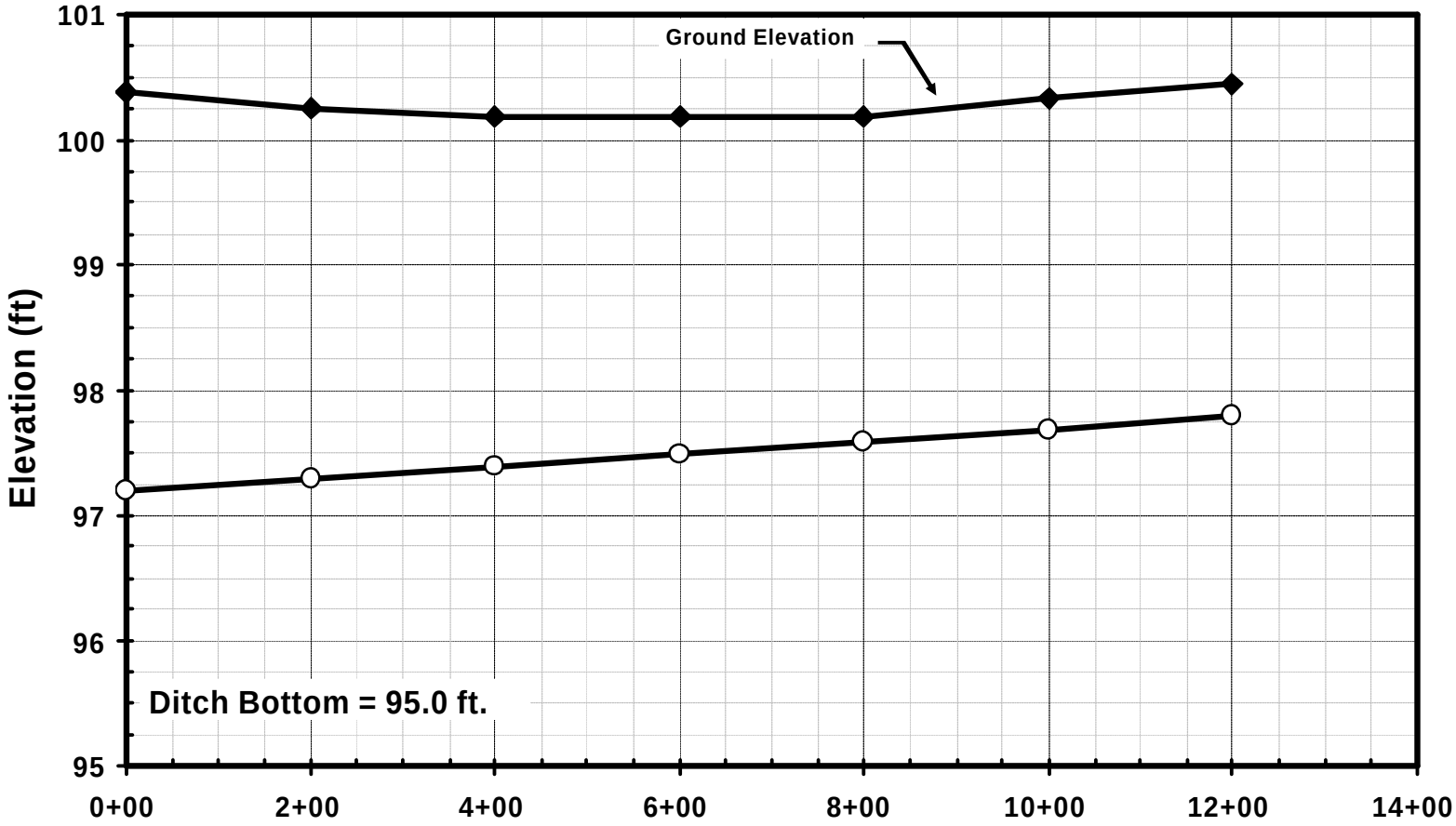
Layout of Main (cont.)



Grade (cont.)

- Are we finished with main?
- Must check all laterals to make sure they drain too.
- Check lateral 5+60 for grade
- Do cut sheet for lateral 5+60 on screen
  ➔ Excel

Lateral 5+60


Ground Elevation
Ditch Bottom = 95.0 ft.
Elevation (ft)
101
100
99
98
97
96
95
0+00
2+00
4+00
6+00
8+00
10+00
12+00
14+00

Pipe Sizing

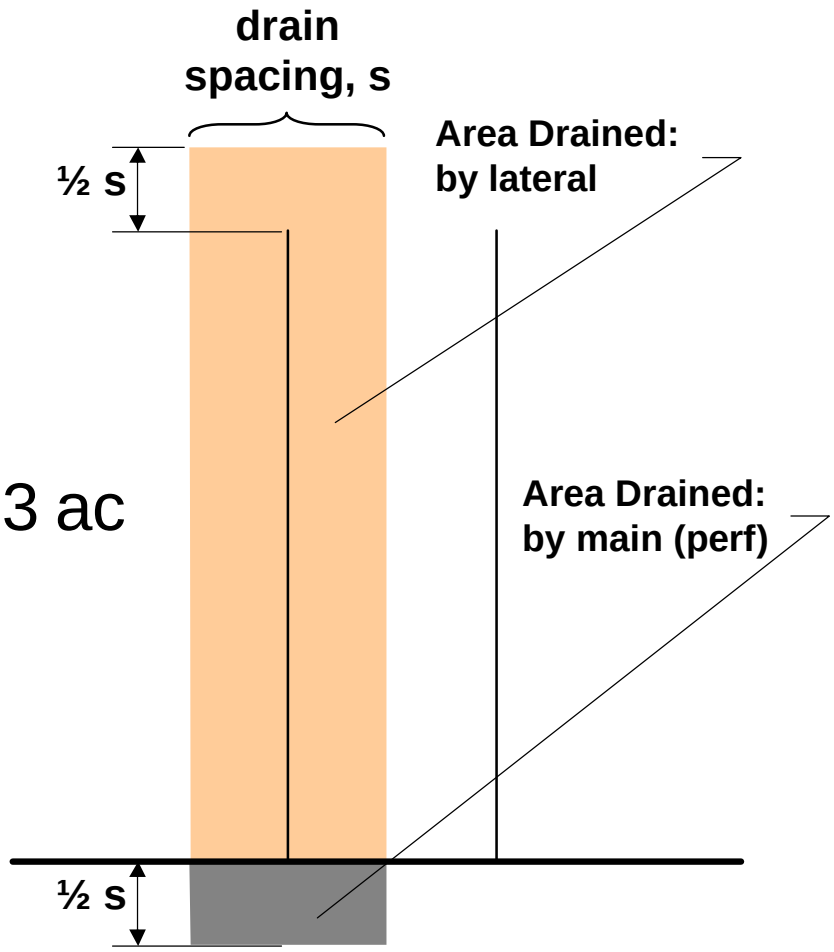
Lateral Pipe Sizing

- We know:
  - Grade (from layout)
  - Pipe material (standard CPE)
- We need to find acres drained for each pipe
- Then determine pipe size

Lateral Pipe Sizing

- Determine area drained by each lateral
  - Length = pipe + s/2
  - 1,210+40 (end) = 1,250 ft
  - Area drained =

$$\frac{1{,}250\text{ft} \times 80\text{ft spacing}}{43{,}560\ \text{ft}^2/\text{ac}} = 2.3\ \text{ac}$$



Lateral Pipe Sizing

- Acres drained per lateral = 2.3
- Find pipe size from Slide Chart for 2.3 ac and ? in/day DC
- For what grades does 4” pipe work? 3”?
  - If grade is greater than 0.05%, 4” pipe works
  - If grade is greater than 0.22%, 3” pipe works
- Choose 4-inch pipe for all laterals
  - As long as greater than .05%

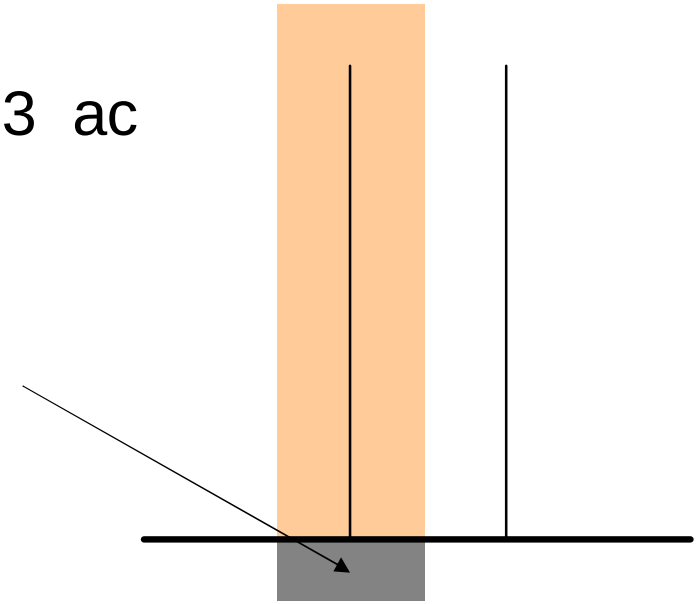
Main Pipe Sizing

- 4-inch will probably work for a portion of the upper end, for several junctions
- Determine size at the outlet
- Calculate total area drained by system by adding acres contributed by all laterals, plus the area drained by the main itself.
  - Main drains on one side only (side away from laterals) because laterals assumed to drain up to the main on their side.

Main Sizing (cont.)

- Main drains on one side only
- Each 80-ft section of main drains (1 side only):

$$\frac{80\text{ft length} \times 40\text{ft spacing}}{43{,}560\ \text{ft}^2/\text{ac}} = 0.073\ \text{ac}$$



Main Sizing (cont.)

- Find the acres drained per section:
  - **Main** acres/section = 0.07 ac
  - **Lateral** acres = 2.3 ac
  - **Total** acres/section = 2.37 ~ 2.4 ac
- Each section drains 2.4 acres

Main Sizing (cont.)

- Find the total acres drained by 15 laterals and mainline is:

main:	*15 sections x 0.073 ac/section*	=	1.1 ac
	1,210-ft. section to corner of field (both sides)	=	4.4 ac
laterals:	*15 laterals x 2.3 ac/lateral*	=	34.5 ac
Total area drained		**=**	**40.0 ac**

Main Sizing (cont.)

- Grade of the main is 0.05%
  - Check slide chart or nomograph for 40 ac, 0.05% grade, and ? in/day DC
- Tile size at outlet = 12 inches (slightly undersized)
  - What grade needed for 10”?
  - What about dual wall pipe?
- What’s left is to determine where the size changes occur along the main
  - start on upstream end and work down

Main Sizing (cont.)

- Check slide chart or nomograph to find the max number of acres that can be handled by 4”, 6”, 8”, 10” and 12” at .05% grade and ? in/day DC:

	4”	6”	8”	10”	12”
.05%					

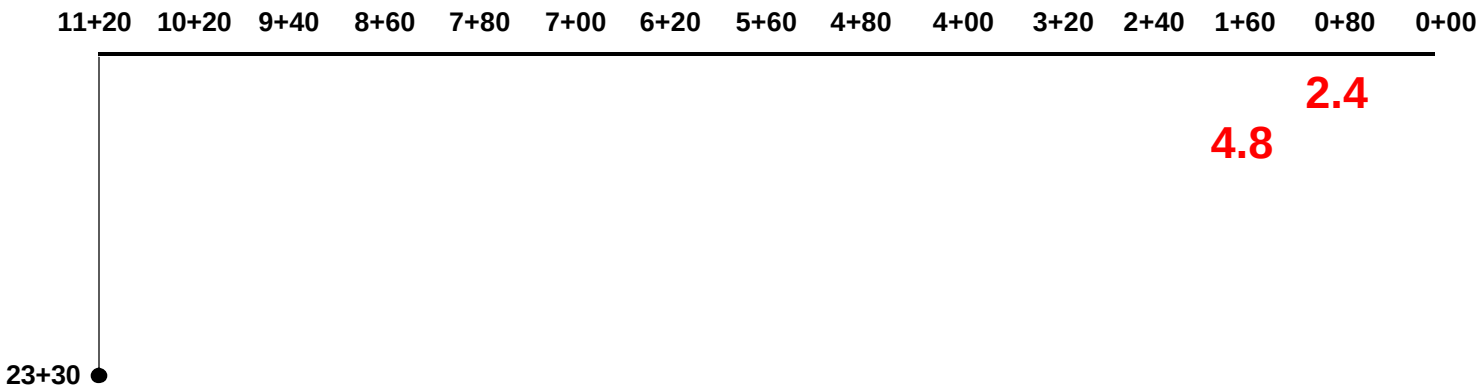
Main Sizing (cont.)

- Here are my results:

	4”	6”	8”	10”	12”
.05%	2.3	7	15	24	39

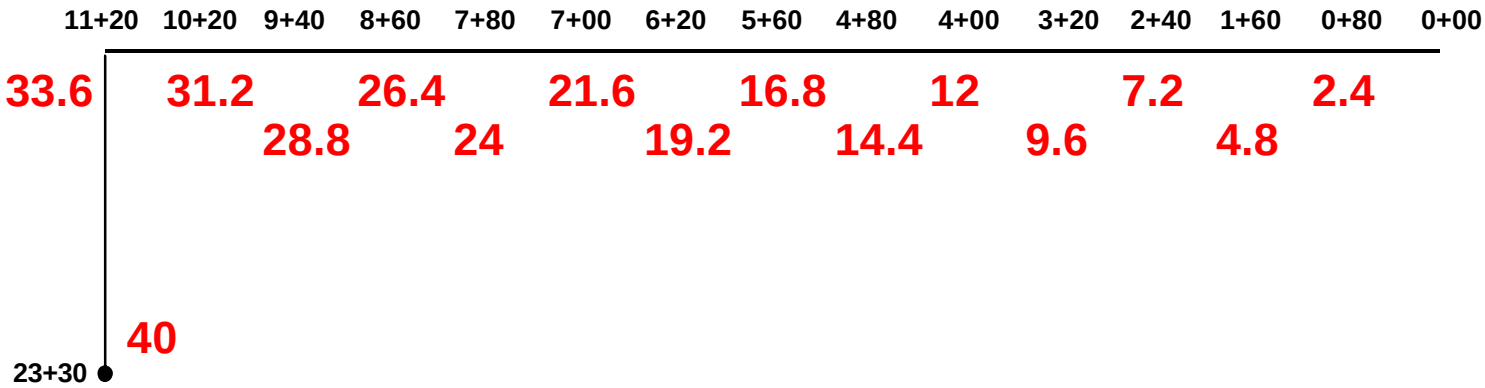
Main Sizing (cont.)

- Now look at the main and write down how many acres you have at each section
  - Recall, 2.4 ac per section



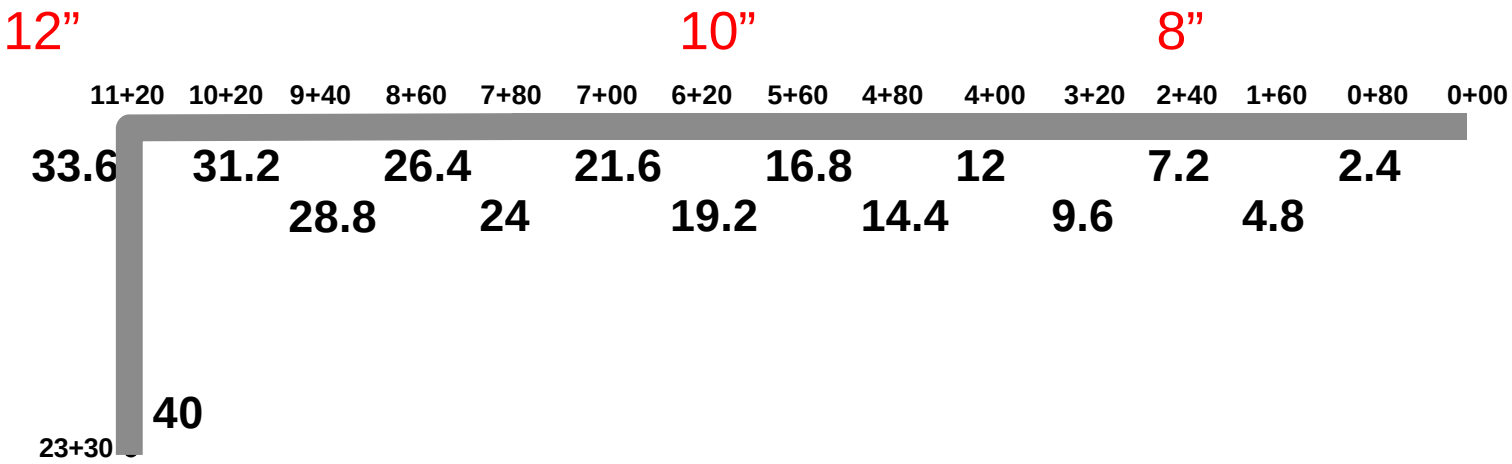
Main Sizing (cont.)

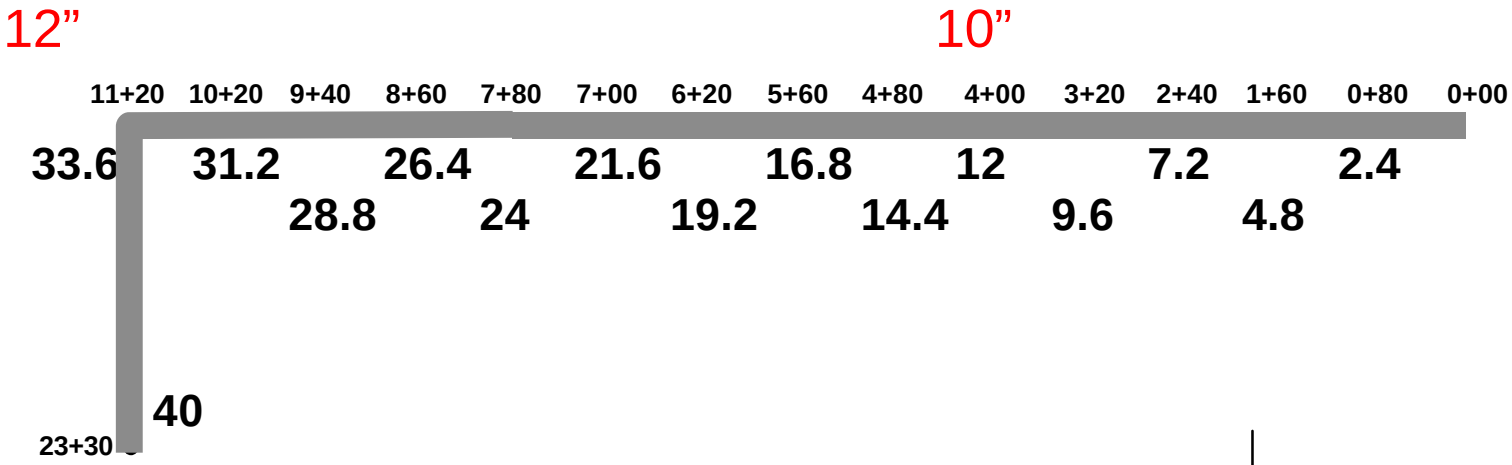
- Compare with the acres drained chart to select pipe sizes
  - What are the possibilities?



	4”	6”	8”	10”	12”
.05%	2.3	7	15	24	39

Potential Main Configurations





You Decide!

	4”	6”	8”	10”	12”
.05%	2.3	7	15	24	39

System Cost

Installed Cost

Description	$/ft installed	Installed Feet	$
4”			
6”			
8”			
10”			
12”			
Fittings			
Hookups			
TOTAL			

Estimate Cost of System

- Tally up feet of pipe for all sizes
- How many fittings needed
- Estimate cost for project
  - Add $50 per hookup