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Drip Tubing Hydraulics During Pressurization

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Drip Tubing Hydraulics During Pressurization

- Subsurface wastewater dispersal using drip irrigation techniques
  - Advantages
    - application of effluent is about 1/2 gallon per hour per emitter
    - pressure-compensated emitters provide tremendous uniformity across field
    - can be installed without massive soil disturbance
    - with dosing and resting, can control soil moisture for aerobic and anaerobic microbial activity

Drip Tubing Hydraulics During Pressurization

- Subsurface wastewater dispersal using drip irrigation techniques
  - Disadvantages
    - effluent must be filtered before tubing
    - tubing must be forward flushed to scour biological growth
    - not very forgiving

System Design

- Relatively easy
  - match application rate to the soil type
    - average daily application rate
    - instantaneous application rate
  - ensure that pump and supply-piping can provide the minimum pressure for the emitters
  - install tubing on contour
  - each dose should last long enough to make the non-steady state time insignificant compared to the steady state time

Steady State Operation

- System is at design pressure and producing water at the design rate
- How much time is required from pump-start to steady state?
  - volume within supply piping
  - volume within tubing
  - flow rate of pump
  - volume emitted once water enters tubing

Thus, the Questions

- how much water is emitted
  - during tubing pressurization?
- on a given length of tubing,
  - is the water volume produced by the first set of emitters significantly different than the last emitters?
- in a marginal soil,
  - would this difference cause surfacing of effluent?

Measurements

- Volume
  - water meter
    - 0.1 gallon precision
    - used stop watch and datalogger to get flow rate
- Pressure
  - indication of pressure build up and friction loss
    - pressure transducers every 50 feet
    - pressure measured in one-second intervals with datalogger

Laboratory Procedure

- Read meter
- Begin “dose”
  - open ball valve
  - start stop watch
- Wait for tubing to fill
  - air/vacuum valve “snaps” at distal end
    - stop timer
    - read meter
    - close valve
- Three replications

Data Collected

- Volume
  - volume of water required to fill tube
- Time
  - time required to fill tube
- Calculations
  - average flow rate
  - average velocity within tubing

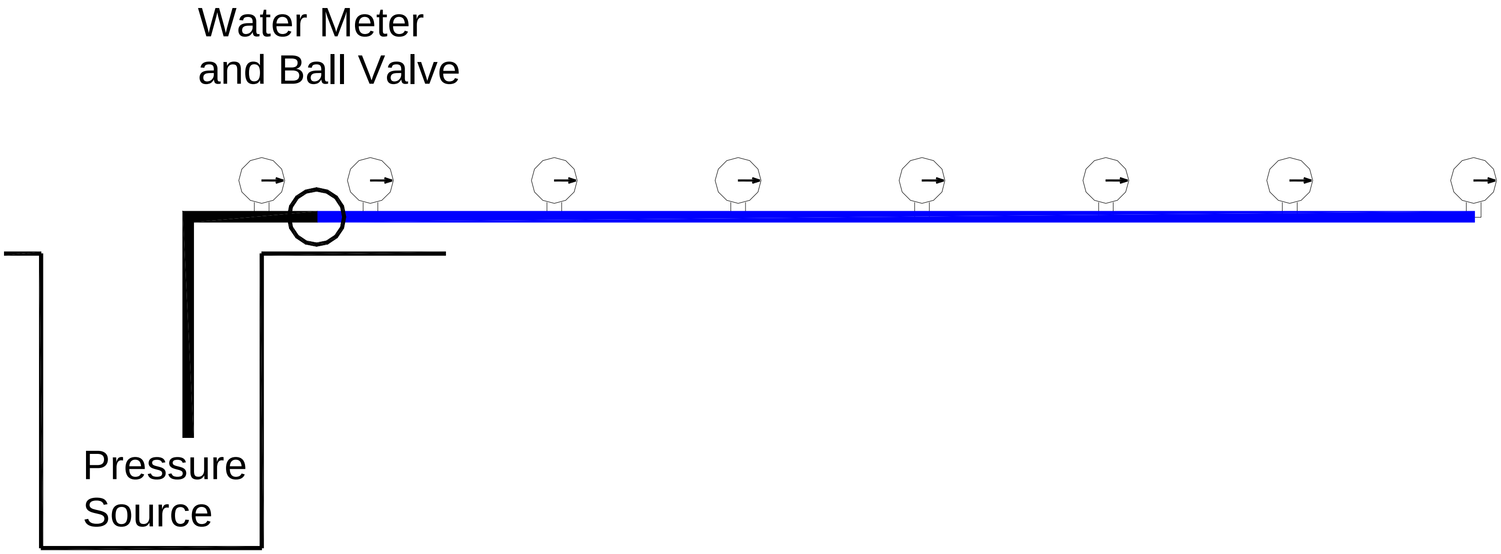
Tubing

- Geoflow
  - Wasteflow PC
  - 0.53 gph per emitter, 24-inch emitter spacing
  - internal diameter 0.55”
- Netafim
  - Bioline PC
  - 0.63 gph per emitter, 24-inch emitter spacing
  - internal diameter 0.57”

Tubing and Friction

- Test lengths
  - 100, 200, 300, 400, 500, & 600 feet
- Pressure transducers
  - before ball valve on supply side
  - beginning of tubing
  - every 50 feet
  - distal end
  - 100-foot test had 4 pressure transducers
  - 300-foot test had 8 pressure transducers

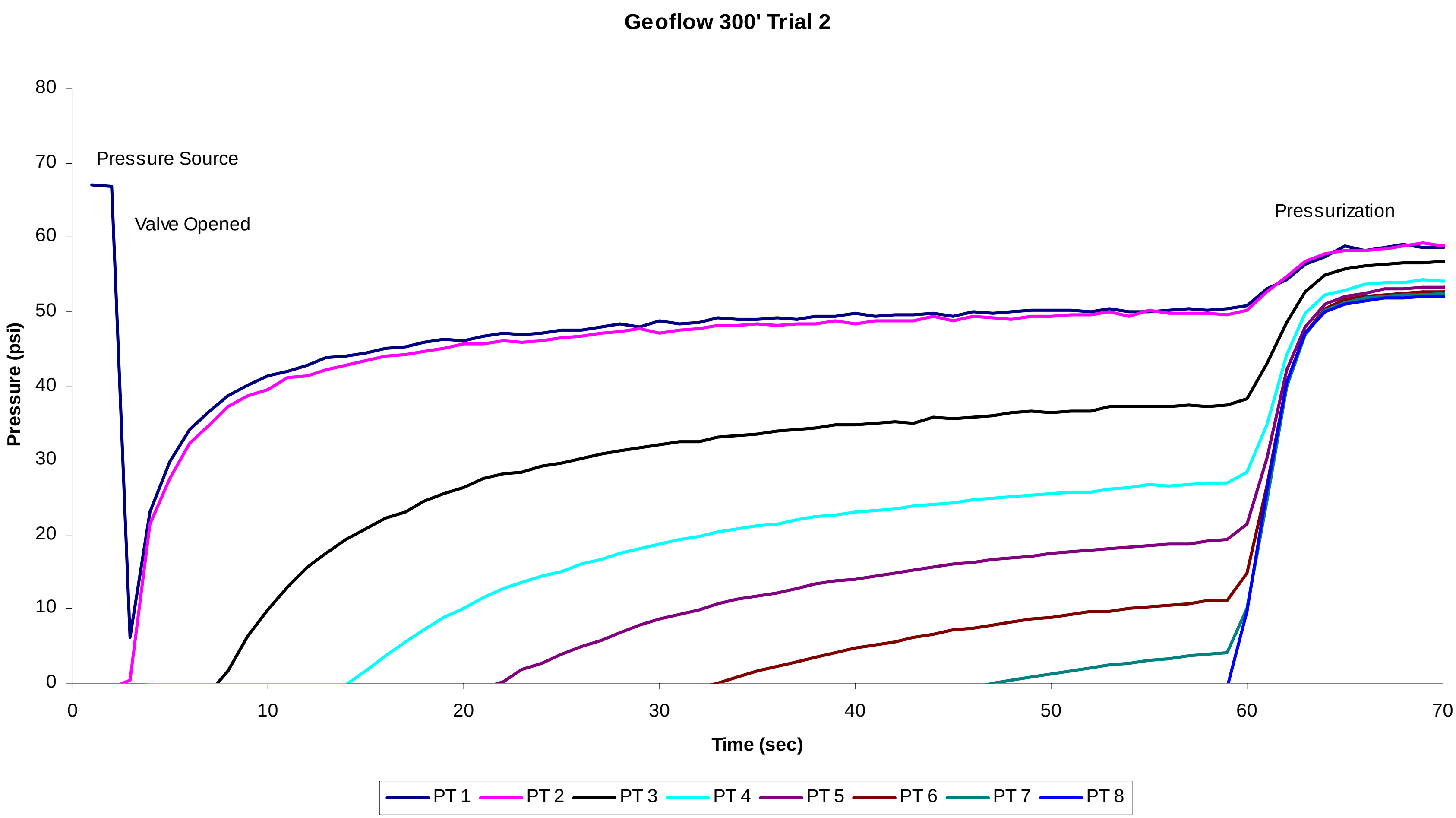
Layout



Remember
This is not a Comparison

- The tubing is not a variable in this study
  - we collected information about the two types of tubing
  - this information is needed to understand the non-steady state component of drip design
  - this information is lacking in the literature of both manufacturers

Example Output



Time and Velocity

Table 1. Average in-flow rates and water velocities in tubing during pressurization.

Manufacturer	Length (ft)	Mean Pressurization Time (sec)	Mean Flow Rate (gpm)	Average Velocity (fps)
Geoflow	100	13	5.9	8.0
	200	29	5.2	6.9
	300	57	4.3	5.3
	400	93	4.1	4.3
	500	140	3.7	3.6
	600	201	3.7	3.0
Netafim	100	11	7.4	9.4
	200	26	6.5	7.6
	300	47	6.0	6.4
	400	69	5.4	5.8
	500	100	5.2	5.0
	600	141	5.0	4.3

Volume to Fill Tubing

Table 2. The volume of water required to fill the tubing as compared to the tubing volume is listed for various lengths of tubing.

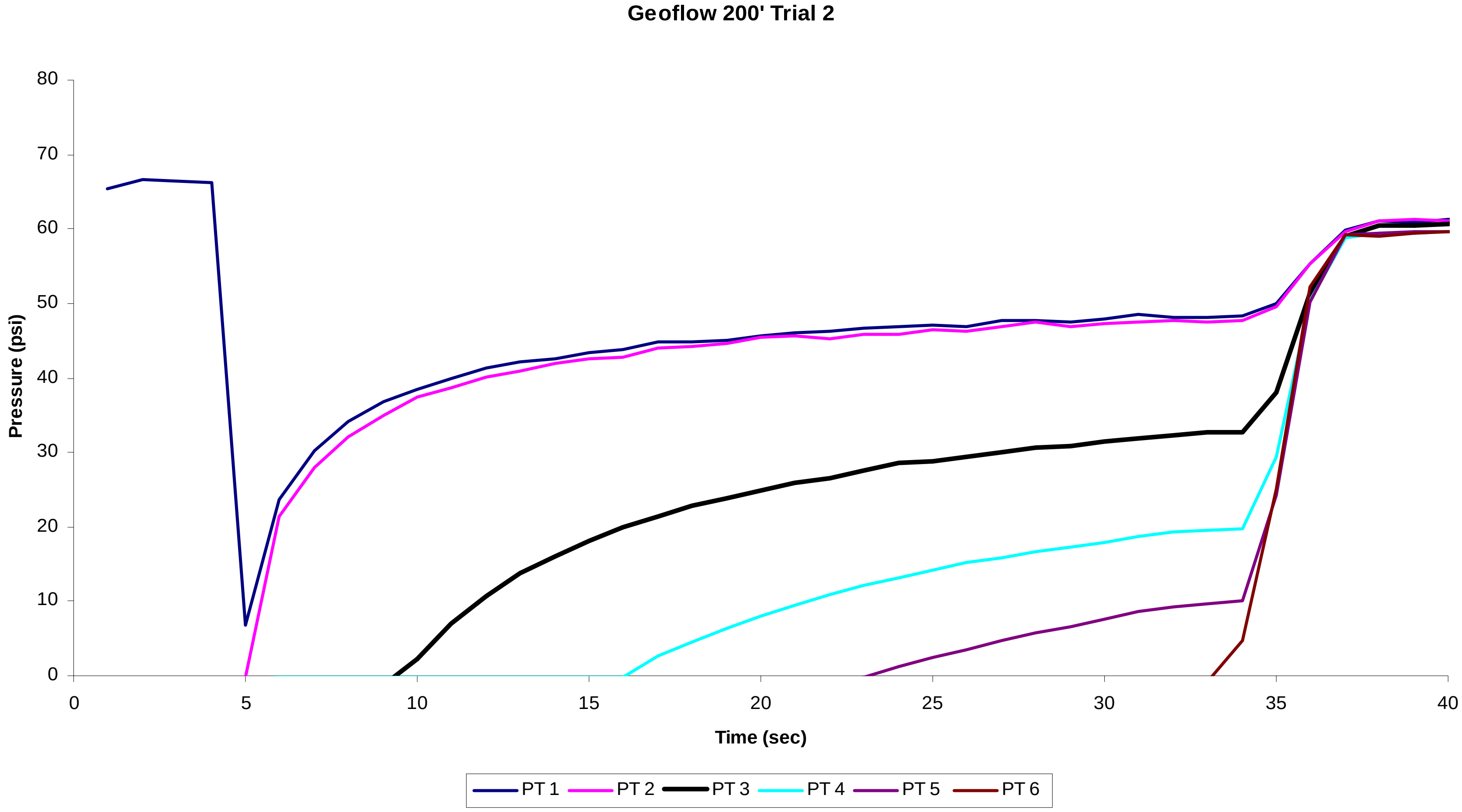
Manufacturer	Length (ft)	Average Volume Required to Fill Tubing (gal)	Volume of Tubing based on Length and Diameter (gal)	Estimated Volume Emitted during Pressurization (gal)
Netafim	100	1.3	1.33	below detection*
	200	2.9	2.66	0.2
	300	4.7	3.99	0.7
	400	6.1	5.32	0.8
	500	8.7	6.65	2.1
	600	11.7	7.98	3.7
Geoflow	100	1.2	1.23	below detection
	200	2.5	2.46	below detection
	300	4.1	3.69	0.4
	400	6.3	4.92	1.4
	500	8.6	6.15	2.5
	600	12.4	7.38	5.0

* The resolution of the water meter was 0.1 gallon

Emission Volume before Full Pressurization

- Using the Netafim results as an example
  - the emitted volume of 200 feet of tubing is only about seven percent of the tubing volume
  - for a 600-foot length, the emitted volume is approximately 46% of the tubing volume.

Timing Along Length



Pressurization Wave

- It is reasonable to expect the water wave velocity to decrease exponentially with lateral length
  - The friction head will increase with length and flow from the pump decreases exponentially with an increase in head (pressure)
  - a function of the pump’s performance curve

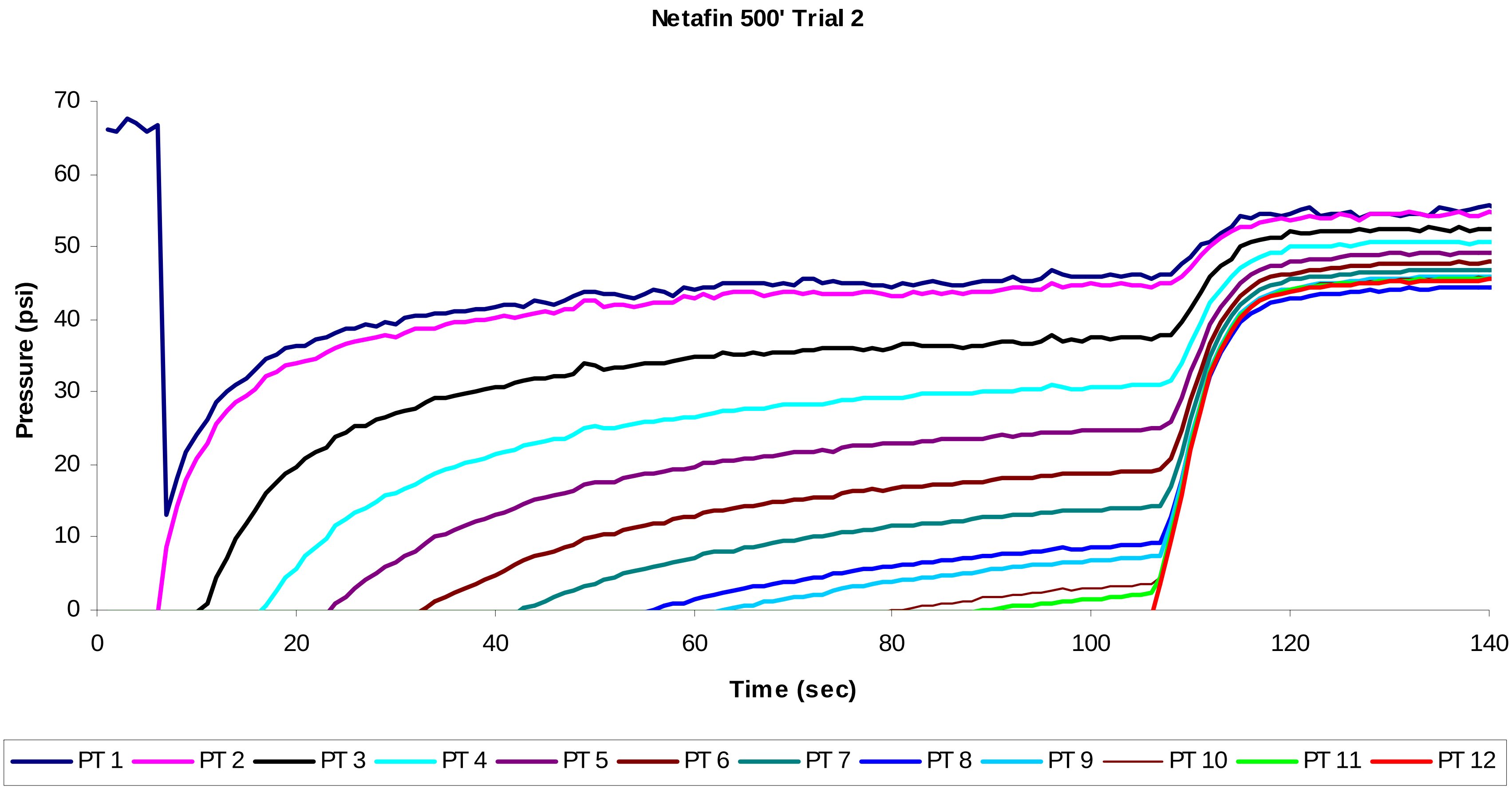
Instantaneous Velocities

- 200-foot length of Geoflow tubing
  - the velocity was approximately 9 fps in the first 50 feet,
  - 8 fps in the second 50 feet
  - 6 fps in the third 50 feet
  - 5 fps in the last 50 feet
  - Overall the average fill time was 29 seconds to move 200 feet or 6.9 fps.

Scour during Pressurization

- These pressurization velocities are greater than 2 fps (a widely recognized scour velocity)
  - It is likely that solids within the tubing will be progressively moved to the distal end with each dosing cycle
  - This effect improves the effectiveness of the periodic forward-flush of the drip laterals

Emitter Location and Operating Pressure



Pressure on Proximal Emitters

- As the water wave passes each emitter
  - the velocity head and friction head (energy required to move the wave forward) is converted into a static pressure that will force water out of the emitters
  - This “back pressure effect” increases with the tubing length.

Once the Wave Passes the Emitter

- The near-end emitters will be at operating pressure before the distal emitters receive water
  - the design minimum operating pressure for Geoflow and Netafim is seven and five pounds per square inch, respectively.
  - the emitters within the first 50-foot segment are already at operating pressure a full 45 seconds before the emitters located in the last 50-foot segment of a 300-foot Netafim tube.

Significantly Different?

Geoflow tubing (0.53 gph/emitter)		
Length	Time (sec)	First Emitter Volume (gal)
100	13	0.002
200	29	0.004
300	57	0.008
400	93	0.014
500	140	0.021
600	201	0.029

Five Minute Dose

Geoflow tubing (0.53 gph/emitter)			
Length	First Emitter (gal)	Last Emitter (gal)	Percent Reduction
100	0.044	0.042	-4.5
200	0.044	0.040	-9.1
300	0.044	0.036	-18
400	0.044	0.030	-32
500	0.044	0.024	-46
600	0.044	0.015	-66

Ten Minute Dose

Geoflow tubing (0.53 gph/emitter)			
Length	First Emitter (gal)	Last Emitter (gal)	Percent Reduction
100	0.088	0.086	-2.3
200	0.088	0.084	-4.5
300	0.088	0.080	-9.1
400	0.088	0.074	-16
500	0.088	0.068	-23
600	0.088	0.059	-33

Likewise - Netafim

Netafim tubing (0.62 gph)		
Length	Percent Reduction	
	5-min dose	10-min dose
100	-3.7%	-1.8%
200	-8.7%	-4.2%
300	-16%	-8.0%
400	-23%	-12%
500	-33%	-17%
600	-47%	-24%

But, is this Significant?

- The proximal emitters (and soil) will receive the design dosage
  - the distal emitters (and soil) will receive less than design dosage
  - the longer the dose, the less difference
- If system is designed for the soil
  - then pressurization non-uniformity should not cause any surfacing of effluent

However,

- My assumptions are that the tubing is placed **“on”** or **“very near”** contour
  - Pressure compensated emitters are no excuse not to put the tubing on contour
  - until emitters are developed that will not allow discharge any water until operating pressure
    - then we still have to put the tubing on contour
    - and hydraulically isolate each lateral

Cuss and Discuss Time

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